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Ho Thi Thao Nguyen	Doctor of Philosophy in Social Science and Humanities	http://utpedia.utp.edu.my/id/eprint/27332

Annotated Bibliography

Master Theses

Safira, Nine (2024) *Advanced Seismic Reservoir Characterization Of Angsi Field, Malay Basin, Using Stochastic Inversion And Sqp-Sqs Transformation.* Masters thesis, Universiti Teknologi PETRONAS.

This research addresses the limitations of deterministic methods in reservoir characterization, which often fail to accurately represent complex geological structures due to their lack of linearity and uniqueness. Emphasis is placed on integrating stochastic inversion methodologies with rock physics properties to enhance reservoir analysis. Stochastic seismic inversion, a pivotal method in this approach, contrasts with deterministic inversion by not conforming to a single model. Instead, it adopts a probabilistic approach, employing iterative applications of a forward model and leveraging stochastic optimization techniques. This method is particularly suitable for complex geological contexts, as it accommodates a broader range of uncertainties and variabilities. It utilizes pre-stack data, integrating various incidence angles with corresponding wavelets, and includes well data. The application of stochastic seismic inversion yields vital physical rock properties, including P-wave acoustic impedance (Zp), S-wave acoustic impedance (Zs), and the Vp/Vs ratio, alongside density properties derived from simultaneous seismic inversion. These properties are integral to the analysis of fluid content and lithology beneath the surface. Moreover, the transformation of the Scale of Quality Factor of P-wave (SQp) and S-wave (SQs) further refines the rock physics model, significantly enhancing the accuracy in discriminating lithology and pore fluid types in hydrocarbon reservoirs. The primary goal of this study is to provide an accurate representation of hydrocarbon prospects and geological characteristics in hydrocarbon-indicated zones, with a specific focus on the depositional facies and geometry in the I-35 Reservoir of the Angsi Field, Malay Basin. The results show low values in Pimpedance, density, and Vp/Vs ratio as indicators of hydrocarbon anomalies, while S-impedance consistently reflects the rock framework's impedance. Furthermore, the analysis and interpretation identify the depositional environment of the research area as a fluvial meandering system, offering comprehensive insights into the geological history of the reservoir.

Verba, Albi (2024) *Advanced Seismic Processing And Imaging Utilizing Fwi And Tomography To Image Shallow Gas Clouds And Complex Geology In The Sepat Field, Malay Basin.* Masters thesis, Universiti Teknologi PETRONAS.

This dissertation presents an in-depth study on the application of advanced seismic processing and imaging techniques, specifically Full Waveform Inversion (FWI) and tomography, to effectively image shallow gas clouds and complex geological structures in the Sepat Field, Malay Basin. The research embarked on a comprehensive literature review to understand the geological and geophysical characteristics of the Sepat Field, forming the foundation for subsequent investigations. This preparatory stage was crucial for formulating effective methodologies tailored to the unique challenges of the study area. Seismic data, sourced from the Centre of Subsurface Imaging & Hydrocarbon Prediction (CSI) of Universiti Teknologi PETRONAS, constituted the primary dataset for this study. The data encompassed two sub-subsurface lines recorded using flip-flop sources and single streamer cables, necessitating rigorous processing and analysis using advanced seismic software tools such as Reveal, Omega, and Petrel. The research workflow was meticulously designed to enhance the signal-to-noise ratio, remove unwanted noise and multiple energy, and ultimately prepare the data for migration and imaging. Key techniques employed in the data processing phase included Statistical Debubble, Noise Attenuation (encompassing Direct Arrival Noise Suppression, Anomalous Amplitude Removal, Dip Filter in FX Domain, Signal Protected Noise Attenuation, and Non-Uniform Coherent Noise Suppression), Zero Phase and Deghosting, Deterministic Water-Layer Demultiple, and 3D Surface Related Multiple Prediction. These techniques were instrumental in refining the data quality, thus facilitating the development of a robust earth model.

Ahmad Fuad, Muhammad Izzuljad (2024) *Elastic Properties Prediction Via Rock Physics Constraint Deep Learning Seismic Inversion On Angsi Field, Malay Basin.* Masters thesis, Universiti Teknologi PETRONAS.

The conventional seismic inversion approach is practical for operational work, as it only uses simple linearized algorithms and assumptions, but may be less applicable when dealing with a complex geological setting, especially Angsi field in the Malay basin, as it may introduce non-linear noises and non-unique solutions. In the Malay basin, a scarcity of reliable well data is frequently encountered when performing seismic inversions. This makes finding an accurate initial model for inversion challenging and contributes to high uncertainty in properties estimation. Implementation of deep learning for seismic inversion has become routine and has shown increasing capability in addressing nonlinearity in inverse problems. In this work, a robust approach to deep learning-based seismic inversion is developed to predict elastic properties from seismic data. The approach incorporates synthetic well and seismic data generation from a set of rock physics knowledge called the rock physics library, which plays a significant role in dataset input for network training, validation, and testing to improve elastic properties in this field. The deep learning network architecture comprising UNET and RESNET-18 with weak supervision networks has proven to be useful to enhance computational work efficiency and prediction accuracy while handling the non-linearity of the data and the non-uniqueness of the solutions. The proposed method was successfully validated on actual field data from a clastic fluvialdominated field in the Malay basin. Overall, the successful achievement of these objectives marks a significant advancement in seismic inversion technology, offering a more efficient, accurate, and reliable method for predicting subsurface elastic properties. This breakthrough has the potential to greatly benefit subsurface exploration in the oil and gas industry.

Anuar, Astriyana (2024) *Improvement On Wax Modelling Methodologies For Microcrystalline Wax Hydrocarbon Mixtures.* Masters thesis, Universiti Teknologi PETRONAS.

Wax deposition in pipelines poses a significant risk to the transportation of crude oil. Wax modelling methodologies leveraging lab characterization and empirical models have been used widely, however produced unreliable results when compared to field data. The Matzain wax deposition model, commonly used for industry applications, often results in over and under-prediction of wax deposition. Simulated fluid properties in the wax thermodynamic and viscosity models are critical input parameters for wax deposition modelling. However, the presence of high microcrystalline waxes at low concentrations and steep viscosity trends from 9o C to 15o C below Wax Appearance Temperature (WAT) particularly in Malaysian crude oils challenges the accuracy of these models. This research investigated the wax deposition modelling errors by using the application of the micro-Differential Scanning Calorimetry (DSC) method coupled with a modified Simulated Distillation – Detailed Hydrocarbon analysis (SIMDIS-DHA) method and proposed fluid model tuning methods specifically on the Pedersen and Coutinho wax thermodynamic models and the Pedersen and Ronningsen wax viscosity model, to enhance the performance of wax deposition prediction. Specifically, the proposed improvements to the Pedersen model demonstrated WATs simulation within ±1°C and matched Wax Precipitation Curves (WPC). Additionally, the proposed tuning applied on the Pedersen and Ronningsen wax viscosity model reduced errors ranging from 8.92% to 15.21%. The improvements in both of the fluid models have shown a reduction in wax deposition prediction errors with error improvement ranging from 12.80% to 87.52% when compared to measured data. The research highlights the necessity for improved modelling methods to optimize wax management strategies, given the high prediction errors when dealing with crude oils containing microcrystalline waxes and their atypical dynamic viscosity behaviors below WATs. The findings highlight the significance impact of these factors on wax deposition modelling performance and the potential benefits of the proposed adjustments.

Misman, Nurul Nadiah (2024) *Geological Assessment Of Modern Coral Characterisation On The Reef System In Pangkor Island.* Masters thesis, Universiti Teknologi PETRONAS.

Coral reefs are important ecosystems that are known to provide many ecological services. Unfortunately, this ecosystem is increasingly threatened by anthropogenic activities and environmental stressors. Coral characterization studies are crucial for conservation, delving deeper than biological observations by examining the underlying geological and environmental influences on reefs growth. To conduct the geological assessment, Teluk Segadas and Pantai Pasir Giam, Pangkor Island were selected as study areas in this study. Lack of spatial information and geochemistry input lead to insufficient coral reefs database in Pangkor Island. To address this gap, this study attempts to conduct drone mapping for geospatial distribution patterns, identify the geochemical and mineralogical properties of coral reefs and generate a map of reef in Pangkor Island. Utilized drone (DJI Phantom 4 Pro) and SfM processing (Agisoft) which analysed by machine learning (eCognition), extracting information on spatial distribution and health status of coral reef. Reef level map and benthic habitat map were produced from resulting orthomosaic using MRS algorithm and KNN supervised classification. The classified map on Teluk Segadas and Pantai Pasir Giam had overall accuracy 72% and 73%, respectively. Coral cover in Teluk Segadas was 63%, while in Pantai Pasir Giam was 38%. Addition to that, XRF and XRD analysis was performed on coral and sediment samples. XRF analysis identified Ca as major element (>270ppm) in all samples. Teluk Segadas has a higher total concentration of elements; however, Pantai Pasir Giam had a higher concentration of certain heavy metal elements such as Cu, Fe, Mn, Ni, and Al. XRD analysis have confirmed aragonite was the primary mineral component in coral skeletons (>97%) and sediments collected from Teluk Segadas (88%). A map produced from integration of geospatial data and geochemistry analysis showed the relation between these two datasets. This study is an important first geological assessment on coral reef in Pangkor Island, hopefully could contribute to future reef management.

Putra, Maulana Hutama Rahma (2024) *Rock Properties Prediction And Uncertainty Quantification Using Gaussian Process.* Masters thesis, Universiti Teknologi PETRONAS.

Porosity and density are important parameters to numerous studies, i.e., porosity for the reservoir's oil/gas volume estimation and density to identify the reservoir fluid content based its sensitivity fluid. However, an approach to estimate those properties using elastic property from the inversion propagates its error which affect the result's accuracy. On the other hand, direct estimation from seismic data is another approach to estimating porosity and density, but it poses a high non-linear problem. Thus, Gaussian Process (GP) as a non-parametric machine learning approach is proposed which draws distribution over the function to solve the high non-linear problem between seismic data with these properties and quantify the prediction uncertainty simultaneously. The Recursive Feature Elimination using Random Forest (RFE-RF) is employed to select the best features, and the training process uses 10-fold cross validation to optimize the model. To begin with, the study implements the GP model for porosity prediction in the well log dataset to test model robustness with accuracy more than 80%. Then, The GP is implemented on two seismic datasets, synthetic Marmousi model and Angsi field dataset. Using seismic attributes, the GP predictions show excellent results in the blind test, a well that is completely removed from the training data. The uncertainty, standard deviation from GP prediction, can act as a quantitative evaluation of the prediction result. Moreover, the study generates a new attribute based on the quartile of the standard deviation to delineate the anomaly zones. High anomaly zones are highlighted and associated with high porosity from GP and low inverted P-impedance from inversion results. Thus, the study shows the development workflow on optimizing GP to estimate rock properties alongside its uncertainty. Also, the application of GP using seismic data shows its potential to characterize the reservoir property spatially, and the uncertainty offers insights into quantitative and qualitative evaluation for hydrocarbon exploration and development.

Rasul, Adnan (2024) *Optimization Of Internal Ring And Structural Joint Parameters For Fatigue Life And Strength Enhancement Of Kt-Joint.* Masters thesis, Universiti Teknologi PETRONAS.

Stress concentration factors (SCFs) are important to determine the fatigue life based on the S-N curve methodology, where the lower the SCFs, the higher the fatigue life. This research proposed internal ring-reinforced KT-joints, one of the commonly used joints in the offshore industry, for the most practical ranges with the least SCFs, followed by the formulation of a novel set of parametric equations for determinations of SCFs of internal ring-reinforced KT-joints. Using numerical investigation based on a finite element model and response surface approach with eight joint and ring parameters (λ, δ, ψ, ζ, θ, τ, γ, and β) as input and eleven outputs (SCF 0° to SCF 90° and peak SCF), the stress at ten locations around the brace was evaluated, since efficient response surface methodology has been proven to give comprehensive and accurate predictions. The KT-joint with the following parameters: λ=0.951515, δ=0.2, ψ=0.8, ζ=0.31, θ=45.15°, τ=0.60, γ=16.25, and β=0.40 had the least SCFs. The KT-joint with the optimized parameters was validated against finite element analysis. The resulting percentage difference was less than 6%, indicating the applicability of the response surface methodology with high accuracy. Additionally, the study addresses a noticeable gap in prominent offshore codes and design guides regarding the ultimate strength and the strength ratio of internal ring-reinforced KT joints. By deriving equations to determine the ultimate strength and the strength ratio of internal ring-reinforced KT joints, incorporating internal rings and KT-joint parameters, the study provides crucial insights. Utilizing similar methodologies, the study identifies KT-joint with optimal configurations for maximum ultimate strength and strength ratio. KT-joint with parameters λ=0.9111, δ=0.2, ψ=0.7030, ζ=0.3, θ=45°, τ=0.90, γ=16.25, and β=0.6 had the maximum ultimate strength and the KT-joint with parameters: λ=1, δ=0.2, ψ=0.8, ζ=0.5697, θ=45°, τ=0.61, γ=24, and β=0.41 had the maximum strength ratio. Validation through finite element analysis reaffirms the accuracy of the approach with a percentage difference below 1.7%. Overall, these findings contribute significantly to enhancing design practices for offshore structures.

Nasir, Muneeb (2024) *Hyperclass Transformer For Rss-Based Indoor Localization With Network Sparsification Methods For Reduced Latency And Storage.* Masters thesis, Universiti Teknologi PETRONAS.

The demand for location-based services (LBS) continues to soar, driven by the extensive adoption and proliferation of smartphones and IoT-enabled devices. Simultaneously, the appeal for edge computing has risen due to improved latency and data privacy over cloud-based deployment. LBS depends on precise position estimates; while GPS is popular for outdoor localization, heavy signal attenuation and multipath effects render it useless indoors. Meanwhile, due to multipath propagation, signal fading, and interference from the complex and dynamic indoor environment, indoor localization using received signal strength remains challenging in complex multi-building, multi-floor environments. Deep neural networks (DNNs) are preferred for their scalability and require minimal feature engineering but are difficult to deploy on resource and compute-constrained edge devices. Existing DNNs for indoor localization have been developed and trained on small datasets, leading to overfitting, poor generalizability, and transferability. Performing inference on edge devices using trained DNNs for indoor localization is mainly unexplored, nor do existing techniques address it. We present the Hyper-class Transformer, HyTra, an encoder-only Transformer neural network with multiple classification heads accompanied by learnable position embeddings to determine the relative locations of WAPs and improve classification performance. We propose a secondary network, HyTra-HF, which examines class-specific feature representations with multiple Encoders and exploits hierarchical relationships between classes by refining the attention-filtered value. Testing networks across three datasets of varying sizes confirms the robustness and that performance scales positively with dataset size. HyTra-HF outperforms the state-of-the-art deep neural network CNNLoc, obtaining 96.7% floor classification accuracy, and performs comparably with over a ten-fold reduction in model size using Sparsity Aware Orthogonal initialization.

HALIM, NOR HADHIRAH (2024) *DEVELOPMENT OF GUIDELINES FOR THE SELECTION OF DEMULSIFIER BY INCORPORATING PROPERTIES OF CRUDE AND DEMULSIFIER.* Masters thesis, Universiti Teknologi PETRONAS.

The most common demulsification method is the use of demulsifier chemical in which bottle test is a recommended procedure in evaluating the effects of the demulsifier injection. The past demulsifier selection guideline reported in the literatures had limitations and non-suitable for Southeast Asia region. The present research developed a new demulsifier guideline and as resulting from this, a Dual Function Demulsifier (DFD) was developed to resolve the emulsion. In developing the selection guideline, four (4) types of synthetic crude were used with crude API ranging from 27˚ to 40˚. 16 demulsifiers with Relative Solubility Number (RSN) ranging from 11 to 21 were evaluated comprising of resin alkoxylate and modified polyol base demulsifiers. Emulsion test matrix was developed by creating emulsion of different amount of wax, asphaltene and solid in the crude then proceed with demulsifier screening for all the matrices. Based on the recommended RSN values of demulsifiers from the demulsifier selection guideline, the research then pursued in combining the demulsifiers with solvent to become a formulation. DFD formulation comprises of resin alkoxylate with RSN of 21 and ester with RSN of 17 has proved to work in resolving both nonEnhanced Oil Recovery, (non-EOR) emulsion and Chemical Enhanced Oil Recovery (CEOR) emulsion at the same time improved its water clarity. At 20 ppm injection of DFD 122 demulsifier, the chemical was able to treat the emulsion to 0%. DFD also reduced the Oil in Water (OIW) content to 85 ppm from 148 ppm which the reduction is about 43%. For EOR induced emulsion study, 50 ppm of DFD A13 has proved to work successfully at both static and dynamic condition. The emulsion has been resolved from 60% to 0% and the Oil in Water content was reduced from 226 ppm to 125 ppm. These two cases have proven the dual function capability of this chemical which is unique from the commercial demulsifier. In addition, the future researchers may utilize the guideline in formulating a suitable demulsifer to resolve different kind of emulsion behavior within Southeast Asia fields.

Hisham, Nur Faiqah (2024) *Sedimentology And Paleodepositional Environment Study Of The Early-Middle Miocene Kalabakan And Tanjong Formation, Southeast Sabah.* Masters thesis, Universiti Teknologi PETRONAS.

In the southeast of Sabah, sedimentary deposits from the well-exposed Early to Middle Miocene Kalabakan and Tanjong Formations are being studied using an integrated approach. This study integrates organic geochemical and palynological investigations with the first thorough sedimentological facies analysis of the studied Formations within the Kalabakan region. The integrated facies analysis, elemental CHNS, Fourier-transform infrared spectroscopy (FTIR), and palynological data are vital to more accurately assess the origin of organic matter (OM) and reconstruct the palaeoenvironmental architecture. In the Kalabakan Formation, from five identified lithofacies, three facies associations have been determined ranges from deltaic to shallow marine environment: KBFA1 – Tidal flat facies association; KBFA2 – Delta front facies association and KBFA3 – Prodelta facies association. Accordingly, the Tanjong Formation comprised twelve lithofacies and seven facies associations that have been interpreted as ranging from the fluvialdeltaic to the shallow marine environment: FA1 - Floodplain facies association; FA2 – Fluvial channel facies association; FA3 – Coastal peat mire facies association; FA4 – Tidal flat facies association; FA5 – Delta front facies association; FA6 - Mouthbar facies association and FA7 - Upper shoreface facies association. The elemental CHNS analyses of the Kalabakan Formation resulted in a C/N ratio of majority below 10 and total sulfur content ranges from 0.1 to 1.42 suggesting that the organic matter originates from fresh marine plankton or algal-derived. Comparatively, the evaluation of the C/N ratio ranges 4 to 48 and total sulfur content ranges 0.5 to 3, from elemental CHNS analyses suggest that the organic matter in the Tanjong Formation originates from terrestrial plants to fresh marine plankton for coal and mudstone. Accordingly, the FTIR spectra for Kalabakan and Tanjong Formation display the three most abundant spectra from the coal and mudstone such as OH functional group stretching, the absorption spectrum of Aromatic C=C stretching, and Aromatic in plane/out of plane C–H bending. The predominance of aromatic compounds suggests that the genesis of terrestrial organic matter is possible. While the investigated Kalabakan and Tanjong mudstone samples imply deposition within a lower coastal plain setting with proximity to the marine environment, the palynomorphs of the studied Tanjong coal samples produced rich mangrove and freshwater types of pollen assemblage. The existence of Florschuetzia trilobata and Florschuetzia levipoli (Sonneratia caseolaris) point to an Early Miocene or younger age.

Lay, Ng Chong (2024) *A Modified Vector Fitting Technique to Extract Coupling Matrix From S-Parameters.* Masters thesis, Universiti Teknologi PETRONAS.

This thesis introduces a modified approach for extracting coupling matrices from S-parameter data by employing a modified vector fitting technique for microwave filter tuning. The microwave filter tuning process is labor-intensive and lacks guidance for engineers to complete the process. To resolve the issue, this research focuses on improving vector-fitting equations that can accurately extract rational polynomials representing bandpass filter responses. The proposed method incorporates two enhancements to improve the accuracy and reliability of the vector fitting process. Firstly, introducing focus fitting helps avoid overfitting spurious poles during vector fitting procedure. Secondly, a technique called pole forcing ensures that all Sparameters share the same pole configuration, further enhancing the method's overall performance. By applying the modified vector fitting technique to the S-parameter responses, the rational polynomials required for extracting the desired coupling matrix configuration are obtained directly. Importantly, the extracted matrix elements continue to exhibit a one-to-one relationship, accurately representing the coupling values of resonators. To demonstrate the effectiveness of the proposed variation of VF, the fourth-order simulated Chebyshev filter and fifth-order measured Chebyshev filters are presented as examples. These examples showcase that fitting accuracy improved compared to conventional vector fitting especially the poles within the passband. Overall, this research contributes a valuable method for efficiently extracting coupling matrices from S-parameter data, enabling designers to analyze and optimize circuit topologies without the need for complex matrix transformations. This helps to reduce the amount of work required in microwave filter tuning processes.

Hussnain, Syed Muhammad (2024) *Characterization And Damage Modelling Of Hygrothermally Aged Resin-Infused Thermoplastic E-Glass Fibre-Reinforced Composites.* Masters thesis, Universiti Teknologi PETRONAS.

Fibre-reinforced composites (FRCs) are widely utilised in structural applications owing to their superior strength-to-weight and stiffness-to-weight ratios. In service, FRCs are exposed to hydrothermal conditions, which decrease their structural performance under static and dynamic loads. To predict hygrothermal response in FRCs, researchers have developed progressive damage models, which are limited to unidirectional composites. Thus, the objectives of this research are to determine the effect of hygrothermal ageing on the mechanical and viscoelastic properties of FRCs and to develop a hygrothermal progressive damage model for multiaxial FRCs. The specimens were immersed in seawater under two different ageing conditions, i.e., 35°C and 70°C until they reached their saturation limits, followed by mechanical testing. The specimens immersed at 70°C showed a significant drop of 46.7%, 39.7%, 22.6%, and 16% in static properties (tensile, compression, flexural, and ILSS) mainly due to plasticization, matrix cracking, and fibre/matrix debonding. The specimens immersed at 35°C showed a reduction in tensile, compressive, and flexural strength of 10%, 14.7% and 1.9% respectively, with no significant effect on interlaminar shear strength (ILSS). Additionally, impact testing revealed a 30% reduction in peak force with increasing moisture content, with matrix cracking and fibre-matrix debonding being the primary failure modes in unaged composites and fibre failure and fibre pull-out in aged composites. In addition, dynamic mechanical analysis (DMA) reveals that prolonged ageing induces an increase in glass transition temperature (T□) due to polymerization reactions. A hygrothermal progressive damage model is developed based on the coupled volume averaging method and rule of mixture to predict the damage of multiaxial FRCs. The model predicted the quasi-static response of unaged and aged FRCs, with up to 1.4% and 0.1%, and 5.9% and 10.6% deviations in tensile and compressive response, respectively. Whereas, in the dynamic response, the model successfully reproduced the force/time and force/displacement responses, which highlights the accuracy of the proposed model.

Muhammad Hasni, Danial Ilman (2024) *Collaborative Visualization Framework For Cross-Field Working Group.* Masters thesis, Universiti Teknologi PETRONAS.

Collaboration has always been picked up as a solution for organizations to eradicate challenges related to technical, geographical, and sociological differences among team members. This has resulted in tormented development and innovation which would later cost productivity, efficiency, and profitability. Some key facilitating factors of collaboration are often overlooked especially in synthesizing the problems related to infrastructure that supports collaboration, team member's awareness to collaborate and collaboration settings. This study aims to address these factors by looking at the incorporation of four major aspects: media synchronicity theory (MST), shared mental model (MM), collaborative components (CC), and common understanding (CU) into the evaluation of collaborative endeavours. This study was conducted quantitatively, via the distribution of questionnaire, developed in prior through the process of adaptation and adoption from previous reliable research. A conceptual research model was developed, aligned with the objectives of this study. With 158 reliable feedback gathered from professionals in oil and gas firms, and research groups at Universiti Teknologi PETRONAS, the survey had recorded approximately 85% response rate. Results were then analysed using Smart-PLS, a reliable tool that utilized partial least squares – structural equation modelling (PLS-SEM). Through the analysis, significant relationships had been found between MST, MM, and CU with CC was found to be a remarkable mediator to improve the model's success. This model was later transformed into the final framework proposed by this study. This proved the model's capabilities in defining the unification of media synchronicity and perceived common understanding to promote group effectiveness. This has become a major highlight on the importance of concentrating collaboration infrastructure and team dynamics in achieving organizational objectives. Nonetheless, this study also possessed certain limitations which would open-up opportunities for future research to delve into. Among them would be the distinctions between two types of shared mental models, and how task nature and complexity would either promote or dissuade the relationship between MST and CU.

Yau, Wen Jae (2024) *Assessment Of Alongshore Sediment Transport Of The Teluk Nipah Shoreline, Pulau Pangkor, Perak.* Masters thesis, Universiti Teknologi PETRONAS.

Alongshore sediment transport gradients within a surf zone are the primary cause of morphological and shoreline changes on a coast. Quantification of longshore sediment transports (LST) using the typical measurement techniques involves installation of some temporary structures or measurement devices, which are costly and laborious. Very often, LST for a coast is estimated using the established empirical equations due to the ease of application; however, the discrepancies with the measured values could be substantial, i.e., more than 50%. Hence, quantification of LST for a coast at high accuracy has been a challenge to scientists and engineers for many decades. The accuracy of empirical equations developed for estimation of LST vary with the site conditions. One may estimate the LST very well at a site; however, it may be an irrelevant tool for some other sites. In this study, an attempt is made to determine the appropriate empirical tool in estimation of LST in Teluk Nipah Beach, Pangkor Island, Malaysia. The beach has been undergoing serious erosion since 2010, resulting in a drop of beach level of more than 1 m, and a shoreline retreat of more than 3 m/year. The cause of the sediment losses has not been identified; hence, it is worth further investigation through this study. This present study aims at proposing an empirical equation that would appropriately reflect the LST of Teluk Nipah through validation with the measured results. This study adopted the two commonly used LST empirical equations, i.e., CERC and Kamphuis equations, for estimation of the LST at the foreshore of Teluk Nipah. The empirical results were subsequently validated with the measured LST, in which the longshore sediment was collected by means of an array of streamer traps aligned perpendicular to the shoreline. Streamer traps were developed and installed within the foreshore of Teluk Nipah Beach. The collected sediment from each streamer trap was integrated using a numerical means to yield the measured local LST. The wave period and wave height has a positive correlation with the measured LST, with higher wave period have a strong tendency to produce plunging waves concentrated a specific point of the shoreline, which results in greater measured LST. Based on the observation, the LST is generally more dominant near the seabed of the foreshore and is less dominant as it moves vertically upwards within the water column. Both CERC and Kamphuis formula provided good correlation at 0.97 at 0.98 respectively, with the overestimation of up to 43% and 30% of the measured LST rates iii based on the overall measurements. Prediction of LST rates using CERC formula improves drastically when factor in the sediment grain sizes, which resulted in lower overestimation rates as compared to the recommended K coefficient at 0.39 by Shore Protection Manual, which is further improvised based on the obtained site data as the K values are subject to site specific conditions. The obtained K values based on the site measurements ranged between 0.01 to 0.06 while the values derived from the formulation by Kamphuis et al. (1986) ranged from 0.04 to 0.09.

Earnest, Praise (2024) *Experimental And Analytical Analysis Of Freestanding Riser System Under Waves And Current Effects.* Masters thesis, Universiti Teknologi PETRONAS.

Free-standing hybrid risers are becoming a more important tool for deep-field projects around the world and are made of vertical steel pipes that are pulled together by buoyancy can. There are various loads and vibrations on these peaks, which leads to fatigue damage. In this thesis, the analytical analysis of wave forces and model tests with independent steps were done in the wave basin. Different specimen sizes, wave heights and wave periods were analyzed along with different current speeds, regular waves, wave-current combinations and random waves. These various diameters of specimens (D) were examined in terms of their effects in the analytical and experimental examination. The Morison equation is used to figure out the hydrodynamic forces acting on a riser with a buoyancy can as the wave height and period change. Separate discussions were also held for the lift force. So, at these different water levels, the investigation's results show higher values that are in line with the parameters of a riser with a buoyancy can. The tests on the vertical riser model were also done at a water depth of 1m and the model was scaled geometrically to 1:70. Three different diameters of buoyancy cans (0.290m, 0.370m, 0.455m) and risers (0.120m, 0.150m, 0.255m) were taken into consideration. The current speeds are between 1.934m/sec and 5.362m/sec and the specimen move faster as the speed goes up. When wave periods of 8.366sec, 5.5780sec, 4.183sec, 3.466sec and 2.78858sec are considered at, the wave-current condition shows bigger displacements. In the analysis of random wave motion of specimens, the JONSWAP and Pierson-Moskowitz spectrums are examined. This research aims to determine the behavior of a buoyancy container on a riser through analytical and experimental studies of freestanding hybrid risers (FSHR).

Hasan Bensaad, Nora Elbahlul (2024) *Assessing The Ability Of Geophysical Data To Identify The Low Resistivity Pay Zone In Dahra Southeast Reservoir Of Mabruk Oil Field, Libya.* Masters thesis, Universiti Teknologi PETRONAS.

A low resistivity pay zone has been defined as an oil or gas bearing zone that looks like a water zone based on deep resistivity readings. LRPZ intervals exhibit strong hydrocarbon show on mud logs and produce hydrocarbon with very low or no water cut from core data, pressure and production tests. This phenomenon has been described to be as a result of the coating of water in micropores consequently giving a low resistivity value in the pay zone. This study presents a comprehensive analysis of the geophysical properties essential for identifying and characterizing low resistivity pay zones (LRPZ) in the Early Paleocene Dahra SE reservoir of the Mabruk Oil Field, Libya. The study leverages a robust dataset, combining existing seismic data with new synthetic seismogram generation and horizon mapping techniques to pinpoint and delineate these elusive LRPZs. The investigation focuses primarily on how seismic attributes can be utilized effectively to reveal these zones, which are crucial for optimizing hydrocarbon extraction. The methodology involves a detailed examination of seismic attributes, including Root Mean Square (RMS), Sweetness, and General Spectral Decomposition (GSD), to assess their effectiveness in detecting the amplitude anomalies associated with LRPZs. The research provides a nuanced understanding of the seismic responses attributable to various geological features, thereby enabling more precise identification of LRPZs. Each attribute's impact on the seismic profile is scrutinized, with particular attention to their ability to reflect the complex interplay between geological formations and fluid contents. The results of the study are significant, demonstrating that specific seismic attributes, notably RMS and Sweetness, are particularly useful in highlighting areas with potential hydrocarbon presence obscured by low resistivity readings. These findings underscore the potential of advanced geophysical tools in overcoming the challenges posed by the reservoir’s complex geology, which traditionally complicates the exploration and development of hydrocarbon resources.

Lim, Sook Fun (2024) *Characterisation And Delineation Of Karst In The F14 Carbonate Platform Of Central Luconia Province, Sarawak.* Masters thesis, Universiti Teknologi PETRONAS.

Karst in carbonate rocks could contribute to the improvement of the porosity and permeability of a hydrocarbon reservoir. However, it could pose a geological challenge and be hazardous for subsequent drilling and production activities. The distribution and patterns of karst are tedious and uncertain because its formation is subjected to the influence of depositional setting, sea level fluctuations, and the influence of the meteoric water on the carbonate rocks. Some carbonate gas fields in the Central Luconia Province have experienced unpredicted high-water production and early water breakthrough during the field's gas production phase. The assumption was that one of the few contributing elements to the unpredicted early water breakthrough was the strong aquifer beneath the gas interval and the high internal carbonate reservoir heterogeneity. To address the strong heterogeneity and the complex carbonate field architecture, this study aims to provide a comprehensive interpretation of the carbonate interval of the F14 field, to map and characterise the different karst on the F14 carbonate platform, and lastly to produce quantifiable 3D geobody karst grids which will be input into the static and dynamic models. By integrating and utilising well data, seismic data, and geological reports, the karst features on the F14 platform were delineated using the following steps: (1) building the structural framework of the F14 field; (2) characterisation of karst through multi-seismic attributes; (3) application of Principal Component Analysis and Neural Network; and (4) delineation of the 3D geobody karst grids. The results show that the majority of the karst in the F14 platform was dominated by approximately 88% of lateral cavern networks and 12% of dissolutional sinkholes (restricted to the H12 level). With the thickness of the studied carbonate interval being approximately 200 meters, the vertical dissolutional sinkholes were noticeably prominent in the shallower 100-meter section; collapsing into the lateral cavern system below it. Through an integration of sophisticated methods and various data, the distribution of karst gridsi.e., vertical dissolutional sinkholes and lateral cavern systems viii in the F14 platform has been delineated and quantifiable 3D geobody karst grids have been produced which can later be populated into the static and dynamic models with distinct volumetric and reservoir properties.

Zahidy, Aniq Asyranie (2024) *Road Users' Perceptions On The Relationships Of Road Service Quality And Road Traffic Accidents Along The East Coast Expressway Phase 2.* Masters thesis, Universiti Teknologi PETRONAS.

The main objective of this study was to explore the perceptions of road users on road service quality (RSQ) and its relations to road traffic accidents (RTAs). The East Coast Expressway Phase 2 (ECE2) was selected as the case study. An empirical study through the use of questionnaire-based survey was employed for data gathering. The measurement constructs consisted of five dimensions of RSQ (road surface, road drainage, road furniture, rest area, road maintenance) and RTAs. Four groups of road users: motorcyclists, motorists, bus operators, and truck drivers were identified to representing the population. All logistic issues were well addressed prior to the actual study. In total, 174 respondents consisting of 52 motorcyclists, 41 motorists, 41 bus operators, and 40 truck drivers participated in the study. The descriptive analysis showed that bus operators, truck drivers, and motorists perceived the overall RSQ of the ECE2 as poor, whilst motorcyclists perceived as good. The ANOVA analysis indicated that only road surface has a significant difference in perception between the road users' groups ($F = 3.008$, $p < 0.05$) compared to other constructs. The Pearson correlation coefficient analysis showed that road surface ($r = 0.226$, $p < 0.05$), road drainage ($r = 0.159$, $p < 0.05$), and road maintenance ($r = 0.280$, $p < 0.05$) have a significant positive correlation with RTAs. The multiple regression analysis revealed that all RSQ dimensions were the predictors of RTAs accounted for 7.6% of the variance contributing to RTAs. Road maintenance ($\beta = 0.186$, $p < 0.05$), road surface ($\beta = 0.167$, $p < 0.05$), and road drainage ($\beta = 0.109$, $p < 0.05$) were the most significant predictors of RTAs. Policymakers can gain a better understanding of the safety outcomes of RSQ and should consider it when formulating any road safety policies and regulations, especially in Malaysia.

Elashmawy, Mohamed Ahmed Abdelmotagaly Mohamed (2024) *A Hybridized Pre-Processing Method for Detecting Tuberculosis using Deep Learning.* Masters thesis, Universiti Teknologi PETRONAS.

Tuberculosis, sometimes known as TB, is an infectious disease brought on by the bacterium Mycobacterium tuberculosis. Although it mostly affects the lungs, it can also have an impact on the kidneys, the spine, and the brain. Computer aided diagnosis (CADx) and computer aided detection (CADe) systems also known as CAD systems, have been shown to improve the accuracy of medical diagnoses, reduce false positives and false negatives, and potentially reduce the time needed for interpretation of Chest X-Ray (CXR) images used for detecting TB. Classifiers in a CAD system make the final determination regarding the patient's health state. As the field of AI research developed, many classification algorithms, including Decision Trees, Support Vector Machines (SVM), Genetic Algorithms (GAs), and Fuzzy Algorithms (FA), flourished. However, Convolutional Neural Networks (CNNs), perhaps more significantly, have recently demonstrated their reliability. Limitations from previous research works such as not utilizing more than one pre-processing method when training their classifier affected the classification performance and the accuracy rate of classifiers are needed to improve for the highest accuracy of classification. The objective of this research is to investigate the effects of combining two main methods of pre-processing. Binary and multiclass classification methods such as shear, zoom and flipping for augmentation and the robustness of U-Net mask for ROI segmentation on the training set of pre-trained CNN classifiers was carried out to achieve a high accuracy and AUC. Distinct improvements in binary and multiclass classification can be seen in contrast to the other simulations conducted with no pre-processing applied to the datasets and a single pre-processing method applied to the datasets. The results shown for the proposed pre-processing method with a VGG-16 CNN model and using the Shenzhen and Montgomery CXR datasets for binary classification has the best AUC and accuracy of 0.935 and 90% respectively in comparison to previous comparable research. For multiclass classification the ResNet50V2 CNN model and the NIH CXR dataset were used and yielded the highest achieved AUC for the Consolidation class of 0.855 using the proposed pre-processing methods. This pre-processing method can be used in CADe systems which can help radiologist to make diagnosis based on the chest X-ray image of the patient.

Abd Dzubir, Faizul Azly (2024) *Stress Analysis Of Non-Standard Y-Tee Pipe Fittings For The Design Conformance With Stress Classification Approach.* Masters thesis, Universiti Teknologi PETRONAS.

All processed fluids in the oil and gas industry are generally transferred from one (1) point to another via complex piping networks, consisting of several pipe fittings of welding/fabricated equal tee, weldolet, sweepolet and etc. The process temperature and the pressure of the fluids may vary between -21 ºC to 816 ºC and from atmospheric, 1.013 barg to 431 barg respectively. Under the operating temperature and pressure conditions, the entire piping networks are exposed to thermal expansion and contraction resulting in high mechanical bending stresses and are susceptible to failures. When using standard pipe fittings such as welding tee, it has distinctive flexibility characteristics with a stress intensification factor (SIF) is well defined in the stress analysis as in ASME B31.3. However, when a non-standard Y-tee fittings is used in the piping system, the distribution of stress intensification factor (SIF) to the nonstandard Y-tee fittings has not exclusively been specified and determined in the standard approach. In addition, there is no specific stress classification lines (SCL) approach that has been established in literature to use for quantification of the membrane and primary stresses of the fittings. Therefore, this study aims to establish the procedural methodology for stress evaluation of the non-standard Y-tee fitting using SCL approach. The finite element model of non-standard Y-tee fittings subjected to external piping and operational loadings was developed and the sensitivity of curve radius of the Y-tee fittings to the stress distribution was studied for design optimization. In addition, the current work focused on the development of Stress Classification Lines to deduce the stress components for the design evaluation in accordance with the allowable defined in ASME VIII Div. 2 Standard. The current work on the non-standard Y-tee fittings is limited to Finite Element Analysis using ABAQUS and FEPipe software with validation was performed for model validation. The crotch radii angle of the Y-tee studied for design optimization Open viii was limited to 45°, 50°, 55° and 60°. The Y-tee fittings have been analysed using elastic analysis with no plasticity model consideration. The proposed Stress Classification Lines for non-standard Y-tee fittings successfully used to quantify the non-standard Y-tee design against the stress allowable value. For as-built non-standard Y-tee design, all assessment criteria for both protection against plastic collapse and local failure are satisfied. The optimum design of non-standard Y-tee was determined with 60° crotch radii angle, where the minimum principal stress value was significantly lower than the allowable limit. The optimum crotch radii angle was found at 45° and 60°, at minimum SPS and Sa values which defined the optimum design of the Y-tee.

Abdul Khadir, Fatin Khalida (2024) *Ot Analysis On The Implementation Of Sustainable Stormwater Management Practices For Landed Residences In Perak, Malaysia.* Masters thesis, Universiti Teknologi PETRONAS.

Massive developments have resulted in the incapacity of conventional stormwater management practices to effectively regulate excessive runoff, resulting in unexpected incidents that also impact residential areas. The objective of this study is to identify suitable Sustainable Stormwater Management Practices (SSMPs) and analyze the Strengths, Weaknesses, Opportunities, and Threats (SWOT) factors for their implementation in landed residences situated in Perak, Malaysia. The focus is on assessing the SWOT factors associated with selected SSMPs, and aims to gauge the suitability of the proposed SSMP and gather respondents' opinions regarding its implementation in the observed landed residences. A questionnaire, featuring a Likert scale, was distributed via a Google Forms link to 118 respondents representing government and private agencies involved in stormwater management. Additionally, on-site observations were carried out in five residences in Ipoh and three residences in Sri Iskandar, Perak. Subsequently, interview sessions were conducted virtually with three engineers from the government agency. The interpretation of the distributed questionnaire indicated that most respondents expressed agreement with most of the SWOT factors related to the proposed SSMPs. The analysis revealed that green roofs and rain garden/bioretention systems exhibited a strong positive correlation, with r-values ranging from 0.503 to 0.931 for Strength (S) and Opportunity (O) factors, and a weaker positive correlation, with r-values ranging from 0.505 to 0.940, for Weakness (W) and Threat (T) factors. The ANOVA tests yielded p-values for all SWOT factors that were less than 0.05, indicating statistically significant results. The findings support the alternative hypothesis, indicating that Strength (S) and Opportunity (O) factors promote the adoption of SSMPs. Conversely, Weakness (W) and Threat (T) factors do not inherently hinder implementation efforts, as suggested by the results. However, rain garden/bioretention system was found more suitable for implementation based on on-site observations and interviews sessions.

Azhar, Aisyah Nur Hanis (2024) *Optimization Of Ultrasonic Extraction Of 2-Acetyl-1- Pyrroline (2ap) From Pandan Leaves (Pandanus Amaryllifolius Roxb.).* Masters thesis, Universiti Teknologi PETRONAS.

Pandanus amaryllifolius Roxb, also known as pandan leaves, is a plant species with fragrant leaves. It holds commercial interest in the flavour industry and can be found abundantly in Southeast Asia, such as Malaysia, Thailand, Indonesia, and India. The primary compound that contributes to pandan leaves' flavour characteristics is 2-acetyl-1-pyrroline (2AP). The current extraction method involves long extraction time and using a large amount of solvent. Furthermore, there is little to no study on the optimization of 2AP extraction and the kinetic study of ultrasonic extraction. Hence, this study aimed to optimize the extraction of 2AP in from pandan leaves using an ultrasonic extraction process with water and ethanol as solvents. Subsequently, the study also explored the kinetic involved in the extraction process. The parameters optimized in this study was the solvent concentration, solid-tosolvent ratio, sonication amplitude and extraction time. The amount of 2AP contained in the extract was determined by GC-FID, while GC-MS was used to analyse the compound present in the extract. The kinetics of the extraction process was evaluated using first order and second-order extraction models. RSM analysis was carried out and it was found that the optimum conditions of ultrasonic extraction process of 2AP from pandan leaves was found to be at extraction time of 40 minutes, 60% of solvent concentration, amplitude at 25% and 7.5 g of pandan leaves. The average value of concentration of 2AP was found to be 1.43 ppm. The predicted value was at 1.77 ppm and the error is 19.1%. The mathematical regression coefficients (R2 >0.99) confirmed that the second-order kinetic models fit all the experimental data. It was discovered that the solid-to-solvent ratio significantly impacts the kinetic parameters. Overall, this research highlights the effectiveness of UAE coupled with RSM in optimizing the extraction of 2AP from pandan leaves. The finding of this study can be used to enhance the rice flavour and be used as one of the flavour enhancers for cooking or baking.

Kamel, Muhamad Aizuddin Bin Mohd (2024) *The Development an Algorithm Of Magnitudes Changes Of Frequency Response Analysis For Transformer.* Masters thesis, Universiti Teknologi PETRONAS.

The transformer is among the most costly equipment in a power system network. One of the most crucial elements of a transformer that requires monitoring is the mechanical state of the windings and core. An effective method to accomplish this is to conduct the Frequency Response Analysis (FRA) test on the transformer. To interpret the data of FRA correctly, this research is conducted by investigating and analyzing the FRA trends. The research starts by collecting a historical dataset of power transformer, 30MVA and the data was examined and evaluated using the Chinese Standards DL/T911-2004. Simultaneously, the FRA data was acquired for distribution (500KVA,750KVA and 1000KVA) and power transformers (5MVA and 7.5MVA) using FRA testing. This approach aims to analyze the variation of the frequency response analysis (FRA) transfer function of both distribution transformers and power transformers. The statistical methods were applied to the FRA data using the Correlation Coefficient, Comparative Standard Deviation, and Absolute Logarithmic Error, as shown by the available FRA data. This thesis aims to be investigating and analyzing magnitude changes in Frequency Response Analysis (FRA) trends for transformers, with the goal of enhancing the existing FRA interpretation scheme. The data is collected using transformer manufactured by Malaysia Transformer Manufacturing Sdn. Bhd. This study demonstrates that the radial deformation results in substantial alterations in the magnitude response at 35mm. Besides, it has been determined that an axial deformation does not result in significant alterations to the magnitude response. Research is done to assess and investigate the impact of windings from different phases on the tested winding. Furthermore, an experiment is conducted to analyze the level of severity in the winding response by applying manual force deformation. The deformation winding of the experimental transformer was verified by tests such as Voltage Ratio, Winding Resistance, and Excitation Current. These tests were conducted to assess the insulation and overall condition of the winding. Overall, the findings from this thesis have the potential to enhance the comprehension of many elements that can impact FRA measurement and then analyze frequency responses utilizing the suggested technique. The Correlation Coefficient technique can be apply to the FRA data set to make the established confirmation to the Engineers or Technician whether the transformer can be energize in the electrical network or vice versa.

Nordin, Millatina (2024) *Industrial E-Waste Generation And Management: A Case Study On The Oil And Gas (O&G) Sector In Malaysia.* Masters thesis, Universiti Teknologi PETRONAS.

In the era of escalating electronic consumption, the mounting challenge of electronic waste (E-waste) has become a global concern. This study takes a focused lens to scrutinize the intricate realm of Industrial E-Waste within the Oil and Gas (O&G) sector of Malaysia, acknowledging the unique complexities that characterize this specialized industry. Employing a qualitative research design and embracing the single-case study approach, the research centers on Plant X owned by Company A within the Malaysian O&G sector. This research aims for an exhaustive exploration of the distinctive challenges inherent in managing Industrial E-Waste. Guided by the Driving Forces-Pressures-States-Impacts-Responses (DPSIR) model, the study's objectives encompass (1) To study current practices of Industrial E-Waste management for the Oil and Gas (O&G) sector, (2) To investigate the forces and pressures in managing Industrial E-Waste for an Oil and Gas (O&G) plant in Malaysia, and (3) To recommend an annex of good practices for Industrial E-Waste management for the Oil and Gas (O&G) sector in Malaysia. The key revelation highlights that while Malaysia possesses guidelines for E-Waste management, these lack the requisite specificity for the intricate industrial settings, emphasizing the pressing need for industry-tailored regulatory frameworks to ensure effective and sustainable Industrial E-Waste management practices within the Oil and Gas sector. Therefore, an Annex documentation that could be supplementary to the main waste management document of Malaysia which is the Environmental Quality (Scheduled Waste) Regulation 2005 is developed and presented through this work.

Ong, Zhen Liang (2024) *Ultimate Strength Of Hybrid Repaired Structural Tubular Sections With Various Slenderness Ratio Subjected To Through-Thickness Pitting Corrosion Under Axial Compressive Loading.* Masters thesis, Universiti Teknologi PETRONAS.

Structural tubular sections such as offshore pipelines are susceptible to various types of corrosions where pitting corrosion is generally considered the most severe. This study aims to study the effect of ratio of Carbon Fiber Reinforced Polymer to Glass Fiber Reinforced Polymer and wrapping patterns on the repair performance of composite repair system for offshore pipelines subjected to pitting corrosion. Four sets of samples with different slenderness ratios are subjected to axial compression, where the peak loads are recorded as the performance indicator of different repair schemes. Based on the experimental results, the average repair index, which is the ratio of repaired strength to intact strength, increases from 1.06 to 1.40 as the ratio of CFRP to GFRP increases. However, 1G3C repair schemes experience brittle failure while other repair schemes show different extents of ductility upon failure. Longitudinal wrapping pattern achieves the average repair index of 1.19 while Alternate and Horizontal yields the average repair index of 1.18 and 1.15 respectively. Furthermore, Longitudinal wrapping pattern exhibits the highest rigidity followed by Alternate and Horizontal. A higher slenderness ratio can contribute to a lower repair index where the cross-sectional properties have a more prominent effect compared to sample length. The theoretical results calculated based on equations provided in ASME PCC-2 show good agreement with the experimental results as there is only a percentage difference of 5.5% between them. On the other hand, Modified Perry-Roberson's formula tends to underestimate the buckling strengths of the corroded samples due to the high percentage reduction in the Euler's buckling load calculated based on the corroded section. However, the degree of underestimation decreases from 72% to 15% as the slenderness ratio decreases from 87.5 to 45.0, as percentage reduction in the corroded Euler's buckling load decreases.

Saaid, Husainni Mohd (2024) *Analysis And Planning For Supply Demand Sales Gas Transportation In Peninsular Malaysia.* Masters thesis, Universiti Teknologi PETRONAS.

Department of Gas control center have experienced challenging tasks of coordinating various type of scenario planning as to satisfy all the required demands and existing network constraints such as deviations by major customers, weather season, and emergence of alternative fuel mix. Previous planning approach was simply based on operators' experience and rules of thumb which provide room of errors and inconsistent results. Consequently, gas network pipeline have experienced low utilization and extreme fluctuation of pressure in gas transmission network which consistently impacted business profitability. In this research, a gas transportation model specific to Peninsular Malaysia was developed using General Algebraic Modeling System (GAMS) to increase network profitability and utilization of pipeline system. Problem related to the scenario planning under uncertainty towards demand deviations and fluctuations were solved with linepack management, pipeline studio software and real time transient monitoring (RTTM). The findings from this research study provide highest confidence level at 0.98 with maximum production of gas supply up to 4000 MMscfd with 87.5% utilization of the gas transmission network. The profitability achieved is MYR 21.94 million under normal case scenario. Next, the uncertainty problems were solved using abovementioned solutions where the network was able to sustain operational threshold within 40 – 50 barg inventory and imbalance +/- 100 MMscfd. Implementation of these methods have improved 6% linepack level, 7% average pressure buffer and maintain 58% pipeline utilization despite of mitigated uncertainty. These methods provide essential input to operation engineers for decision making in term of short-term planning and long-term planning by having inventory output, real time analysis and survival time whenever deviation occurs from supply and demand side.

Adamu, Shamsuddeen (2024) *Optimised Convolutional Neural Network Classifier Based on the MRFO Metaheuristic Algorithm for Skin Cancer Classification.* Masters thesis, Universiti Teknologi PETRONAS.

Skin cancer is the most prevalent cancer globally, with accurate and timely diagnosis critical for successful treatment. This study proposes an enhanced hyperparameter optimization strategy specifically designed to improve skin cancer classification. The Manta Rays Foraging Optimizer (MRFO) algorithm is employed to fine-tune a Convolutional Neural Network's (CNN) hyperparameters, maximizing its performance. To further enhance the model's effectiveness, effective image preprocessing techniques, including bicubic interpolation, are utilized. The efficacy of the MRFO-based approach is comprehensively evaluated using three diverse skin cancer datasets: ISIC 2019, PH2, and HAM10000. The model achieves exceptional accuracy: 99.96%, 99.26%, and 97.70% on the PH2, ISIC 2019, and HAM10000 datasets, respectively. This remarkable performance is accompanied by significantly reduced losses compared to other methods. On the ISIC 2019 dataset, the model further excels with an outstanding Area Under the Curve (AUC) of 99.6%, an F1 score of 90%, and a precision of 94%. Similar exceptional performance is observed on the PH2 and HAM10000 datasets, solidifying the generalizability of the MRFO approach. This work surpasses the accuracy of other optimization algorithms and state-of-the-art architectures, including Grey Wolf Optimizer (98.33%), Whale Optimization Algorithm (96%), Grasshopper Optimization Algorithm (97.2%), and African Vulture Optimization Algorithm (92.7%), as well as established models like EfficientB1, EfficientB7, EfficientNetV2B0, NesNetLarge, ResNet50, VGG16, and VGG19. The Markov's Correlation Coefficient (MCC) further confirms the model's effectiveness, showcasing a strong positive correlation across all three datasets. Narrow 95% confidence intervals (CIs) observed across all datasets solidify the exceptional performance of the model. Tight confidence intervals (CIs) across HAM10000 (97.60%-97.80%), PH2 (99.92%-99.99%), and ISIC 2019 (99.40%-99.46%) indicate high model reliability and generalizability across diverse data landscapes, supporting MRFO's effectiveness in hyperparameter optimization for accurate skin cancer classification. This paves the way for early diagnosis and improved patient outcomes.

Ahmed, Mohd Izamudin Bin Itam (2024) *Experimental and Numerical Investigation On The In-Cylinder Air Flow In A Curved-Cylinder Crank-Rocker Engine.* Masters thesis, Universiti Teknologi PETRONAS.

The study aims to provide a comprehensive characterization of in-cylinder airflow dynamics by investigating swirl and tumble motions in both traditional straight and novel curve cylinder configurations of a crank rocker engine under steady-state conditions. Two distinct cylinder geometries, designated as type A for swirl motion and type B for tumble motion, were analysed. Experimental investigations focused on type A geometries, utilizing 2D-2C Particle Image Velocimetry (PIV) measurements at varying valve lifts and pressure differentials. Simultaneously, numerical simulations were conducted to replicate experimental conditions and select suitable turbulence models with RNG k-ε subsequently chosen as the validated turbulence model for further analysis. Airflow characteristics, including average air velocities, turbulent kinetic energy (TKE), swirl, and tumble ratio, were thoroughly analysed. The study on type A geometry analysed swirl planes S1 and S2, observing peak velocities typically at 4mm valve lift, which decreased at 5.4mm. Notably, the curve cylinder demonstrated higher velocities at S1 but lower at S2 under 150mmH2O pressure. At 1mm valve lift, the curve cylinder reduced airflow, while at 600mmH2O pressure, the straight cylinder exhibited a smaller velocity difference at S1. Average TKE peaked at 4mm valve lift and decreased at 5.4mm. Similarly, the swirl ratio favoured the curve cylinder at S1, peaking at 3mm and 4mm valve lift and declining at 5.4m. In type B geometry, minimal differences in average velocities were observed at lower valve lifts between both liners across various pressure differences. However, significant differences emerged at higher valve lifts, particularly at 150mmH2O pressure, with velocity increases of 12.9% and 14.28% at 4mm and 5.4mm valve lifts, respectively. At 600mmH2O pressure, a substantial difference of 15.67% was noted at a 5.4mm valve lift. Notably, the curve cylinder exhibited higher average TKE, with increases of up to 11.44% and 10.09% at pressure differences of 150mmH2O and 600mmH2O, respectively. Particularly at higher valve lifts, the curve cylinder recorded higher differences in average TKE viii ranging from 6% to 7%, suggesting the curve liner may improve fuel-air mixing and combustion efficiency. Additionally, the curve cylinder's higher tumble ratio enhances airflow direction within the cylinder, potentially boosting engine efficiency. In summary, this study suggests that the crank rocker engine is suitable for oversquare engine designs with lower cam lobe configurations. Further analysis is necessary to fully understand its potential. Moreover, oversquare engine designs promote higher RPM limits, with the curve cylinder performing well, especially in generating tumble, particularly under higher pressure differences.

Amir, Ku Amirul Asyraf Bin Ku (2024) *An Integrated Feature Selection Approach For Remaining Useful Life Prediction Of Industrial Machinery.* Masters thesis, Universiti Teknologi PETRONAS.

Data-driven predictive maintenance commonly uses machine learning algorithms to conduct prognostics of an asset's condition over its life cycle. Asset information and domain knowledge are essential in data-driven predictive maintenance to support maintenance-related decisions. Feature selection has been the favoured approach to reduce the number of features, but a thorough literature study has shown that there are gaps with current approaches, including the interpretation of feature characteristics and challenges in identifying and retaining domain knowledge from asset data. Using a general feature selection approach in data-driven prognostics can cause misinterpretation, removal, or loss of domain-specific information of assets. The high dimensionality characteristics of asset data due to a large number of features sourced from various sensor measurements can affect the performance and reliability of machine learning algorithms. This paper proposes an integrated filter feature selection approach to overcome the challenges of retaining domain-specific asset data information in the feature selection process. The asset information obtained from domain knowledge is combined with the filter method to reduce the high dimensional aspects of asset data for application in equipment's remaining useful life prediction while reducing the dimensionality of features. Through detailed discussion and literature study, the proposed feature selection approach is demonstrated on an oil and gas equipment dataset that contains multiple run-to-failure situations of a gas compressor and is tested with four performance evaluation metrics: RMSE, MAD, MAE and R 2 . The proposed method demonstrably improved prediction accuracy, achieving a 29% reduction in RMSE, a 17% reduction in MAE, and a 32% increase in correlation score compared to the baseline model.

Amosa, Temitope Ibrahim (2024) *Visual Tracking Of Multiple Objects In Distributed Non-Overlapping Multi-Camera Setting Via Zero-Shot Transformer-Based Approach.* Masters thesis, Universiti Teknologi PETRONAS.

Existing multi-object tracking algorithms for multiple non-overlapping camera systems form the task of visual tracking as a combined problem of single camera tracking (SCT) and object re-identification (re-ID). These sub-tasks are, however, conceptually and computationally demanding due to a variety of challenging factors, including but not limited to object appearance variances caused by various photometric and geometric alterations like uneven illumination, occlusions, viewpoint changes, background clutter, abrupt target motion, deformation, etc. The significant impact of these challenging factors are indicatively seen as a drop in the overall performance of the tracking framework leading to ID switch or target loss within and/or across the camera network. To this end, this current study proposes to address the problem of appearance variances in visual object tracking from distributed multi-camera setting. This research aim to develop a robust and highly-accurate tracking model for multiple camera system by exploiting the rich feature representation capability of Transformer network via generalized zero-shot learning. The main contribution of this thesis is a novel multi-camera multi-object tracking approach named zero-shot transformer-based multi-camera tracker (ZMCT). Furthermore, the study extensively investigates the significance of the popular non-maximal suppression (NMS) algorithm on the proposed zero-shot transformer-based tracker, particularly under non-overlapping field of view. The proposed ZMCT without NMS obtained about 3.88% improvement in HOTA against the best performing baseline, and 24.33% improvement when reinforced with NMS. In terms of IDF1 and MOTA, the tracker without NMS obtained improvement of 2.84% and a drop of 11.01%, respectively. To sum up, the competitive performance of the proposed ZMCT makes it suitable for applications where real-timeliness as well as accuracy is required.

Ardo, Fatima Musa (2024) *[Enhanced Hydrogen Production From Attached Chlorella Vulgaris Onto Polyurethane Foam Support While Simultaneously Bioremediating Domestic Wastewater.]* Masters thesis, Universiti Teknologi PETRONAS.

The transition from fossil based-based energy to renewable energy sources is a global imperative, with microalgae and hydrogen emerging as a promising alternative. On the other hand, a large amount of wastewater discharges has increased the environmental pollutions; and the conventional wastewater treatment is also costly and often prone to secondary pollutions. This work focused on the pressing needs by harnessing microalgal hydrogen production with domestic wastewater treatment simultaneously. Dark fermentation utilizing domestic wastewater and optimized conditions to maximize hydrogen productions were investigated. Experimental conditions revealed 1 cm3 to be the optimum polyurethane foam cube size for microalgae immobilization among various sizes, for its high cell retainability and potential for recycling. Investigations carried out by employing various light intensities and photoperiods revealed that 200 μmol/m2 s and 12:12 h light and dark cycles are the optimum light conditions for hydrogen productions. Exploiting domestic wastewater, the attached microalgae onto polyurethane foam cube produced 862.64 mL/g-microalgae of hydrogen under these optimum conditions and achieved a BOD5 removal of 97%, 88% of NH4 + − N,73% of NO2 − − N and 78% of NO3 − − N removals for the domestic wastewater treatment. For the modelling study, the Python software was employed to modify the Monod equation in developing a new Monod equation for the prediction of hydrogen productions from various photoperiods under the optimum light intensity of 200 μmol/m2 s. The model was able to predict the hydrogen production from microalgae at a particular time interval from attached microalgae onto polyurethane foam cubes and domestic wastewater with a coefficient of variation (R2) of 0.9838 had obtained. Accordingly, this research had confirmed the potential of microalgae-based system as a viable option for simultaneous renewable hydrogen production and wastewater treatment.

Basith, Mohammad Sobir Abdul (2024) *Vibrational Behaviour of Piping Systems Under the Influence of Induced-Vibrations Due to Varying Internal Pipe Pressures Caused by Two Phase Slug Flow.* Masters thesis, Universiti Teknologi PETRONAS.

This paper addresses the challenge of managing and controlling hazardous vibrations caused by slug flow in pipelines, a complex two-phase flow pattern. While previous research has extensively explored the behavior of pipes conveying singlephase fluid, investigations into unsteady two-phase flow and its vibrational characteristics remain relatively scarce. Moreover, the majority of studies on pipes carrying multiphase flows have leaned toward experimental approaches, with limited exploration of numerical methods and Fluid-Structure Interaction (FSI) techniques in pipelines handling two-phase flows. The research centers on comprehending vibrational responses and resonance effect within both perspex and metal pipes, commonly deployed in industrial settings conveying two-phase slug flow. It delves into various structural stiffness conditions and the dynamic internal pressure fluctuations caused by slug flow. To address gaps in prior research, this study delves into slug flow phenomena in pipes with diverse structural stiffness configurations, with a keen focus on the induced vibrations and effect of resonance towards piping system. Employing Altair® AcuSolve™, coupled with Altair® OptiStruct™ and employing a two-way FSI through a hybridized finite difference method (FDM) based on the developed equation of motion, the research transcends studies using non-metallic materials by utilizing solid metal pipes for comparison with Perspex pipes. Altair® AcuSolve™ which is based on finite element method could model slug flow and characterize its fluid characteristics with a good agreement to published experimental data and findings by CFD codes with similarity up to 98.37%. A nuanced distinction emerges in the extent of fluctuation induced by Perspex compared to stainless steel. Perspex, characterized by its low modulus of elasticity which 98.43% lower than stainless steel, induces more pronounced fluctuations in the vibration response. This material-specific behavior accentuates the influence of elasticity on the dynamic response, with Perspex exhibiting a greater propensity for oscillation due to its less stiffness compared to stainless steel. The incorporation of the revised Equation of Motion emerges as a potent analytical tool, streamlining and expediting the computation of vibration responses in piping systems. This comprehensive approach contributes invaluable insights to understanding slug flow-induced vibrations in industrial pipelines. Despite the precise slug frequency from CFD simulation, its substantial difference from the natural frequencies of Perspex with 1.108 Hz and stainless steel pipes with 3.442 Hz suggests that resonance is unlikely under typical damping conditions. However, resonance could occur under specific conditions due to higher harmonics, nonlinear effects, or localized structural features, so these factors should be considered.

Beddelee, Aizat Akmal Bin A.Mohamad (2024) *Instrumented Pile Load Test with Distributed Fibre Optic Sensor: Automation In Data Processing.* Masters thesis, Universiti Teknologi PETRONAS.

Pile analysis using the data from instrumented pile load test with Distributed Optical Fibre Sensing (DOFS) by Brillouin Optical Time Domain Analysis (BOTDA) method has been adopted in Malaysian soil. This instrumentation has gained popularity since the performance was verified to, and outdo the typical conventional sensor e.g., vibrating wire strain gauge (VWSG). However, the data processing of this instrument is labyrinthine, and a few research gaps had been identified include processing standardisation, verification of the pile analysis, and process automation. Tolerating these gaps jeopardises the instrument's reliability. Hence, this research aims to address the gaps by developing a data processing tool for the DOFS instrumented pile load test. The data processes to yield the pile analysis are clustered into initial and post-processes. It was identified that the initial processes only include trimming, positioning, and averaging as it is sufficient for pile load test application. The Pelecanos and Soga numerical model is employed to verify the pile analysis by back analysis during the post processing. A standard processing algorithm had been established and this framework was developed on the MATLAB programming platform to automate the processes. This tool was validated to literature cases with a sensitivity of 0.97 (Rsquared). The tool had been packaged as a desktop-based application for better usability, as handling raw computation source code is complex for an average user. The software passed the functionality test with over 90% success rate. Subsequently, the tool was validated to six (6) real field site data located within Malaysian soil. Besides bored piles, precast piles and micropile are among other piles applied with this tool. Overall, the sensitivity of the verification exercise of these sites' data is more than 0.9. This work is significant as it systematically investigates the instrument data processing that has never been truthfully (clear and concise) reported by previous work. Besides, this work provides a basis for creating a further intelligence processing tool for the pile analysis by DOFS instrumented pile load test and potentially solved problems from past ix work. This automation has improved the instrument productivity (i.e., reduced the manhour at multifold faster interpretation time) and perhaps is further improved by incorporating artificial intelligence.

Chowdhury, Nasimul Eshan (2024) *Mitigation Of Mild H2s Corrosion On Carbon Steel Structures In Hydroelectric Power Plants, Using Toxic Compound Reduced Lignin-Epoxy Coating.* Masters thesis, Universiti Teknologi PETRONAS.

The prevalence of geriatric diseases and unforeseen accidents often necessitates the support or replacement of human bones with metallic components. This challenge becomes daunting when it involves load-bearing bones intended for a lifetime of service. Additionally, the significant mismatch of elastic modulus between bone and implant can lead to stress-shielding effects. To tackle these challenges, the goal of this study was to create an economically viable material by incorporating hydroxyapatite (HA) and titanium (Ti) into a 316L stainless steel matrix, thereby enhancing biocompatibility while maintaining a relatively lower modulus. Powder injection molding was utilized for its capability to handle dissimilar metals and metal-ceramic composites, along with its effectiveness in near-net shape fabrication. Initially, 1, 3, and 5 vol.% of Ti to 316L were added to determine the optimal composition for the subsequent addition of HA. A 65% powder loading and wax-based binder were used with three sintering temperatures of 1300, 1350, and 1380°C in a vacuum atmosphere. A comprehensive range of tests, including XRD, SEM, tensile, bending, compression, and corrosion tests, was conducted, and results revealed evidence of beta-titanium formation inside the matrix. 3 vol.% Ti-316L sample performed overall balanced result. Consequently, the composition of 3 vol.% Ti-316L was chosen for further 1, 2, and 3 vol.% HA inclusion. A sintering cycle with a maximum temperature reach of 1340 °C with 920 °C pre-sintering temperature and hold at 1300 °C was identified as best for retaining maximum HA with 95.74% density. The mechanical tests unveiled, 3 vol.% HA-3 vol.% Ti-316L SS achieved 435.5 MPa tensile strength, 456.2 MPa flexural strength, and 653.5 MPa compressive yield strength, with a bone-like compressive modulus of 21.5 GPa. In electrochemical testing, the 3 vol.% HA samples showed a highly promising corrosion rate of 0.0382 mpy, which is below the acceptable 1 µm per year (0.0394 mpy) for permanent biomedical implants.

Ganasan, Jayasankari (2024) *Formulation of Gestural Interaction Design Model to Support Car Drivers Interaction with Smartphone User Interfaces Using AHP Technique.* Masters thesis, Universiti Teknologi PETRONAS.

The present-day transportation system has witnessed a distressing increase in car accidents, leading to numerous fatalities and injuries. Much of this tragic surge has been attributed to drivers' irresponsible behaviour, particularly their tendency to use smartphones while operating vehicles, even in situations where minimal distraction is critical. Recognizing the challenge of completely preventing drivers from using their smartphones, various solutions have been introduced to mitigate the duration of distraction caused by smartphone usage while driving. For instance, Google Glass, Head-up, and In-Vehicle Information Systems (IVIS), among others. These solutions were found to achieve their targets; however, they are designed for modern cars only or have adopted voice recognition technology which is not supported by all applications on the smartphone. Voice recognition suffers from environmental factors such as noise and bad weather. As a result, touchless or mid-air was introduced using the gestural interface, still, they require the right ambience. Therefore, depth research into the possibilities of gestural interfaces was required, as well as a critical investigation of how they facilitate driver interactions. Consequently, the primary goal of this research was to develop a gestural interaction design model that enables drivers to interact with the smartphone user interface while driving, consideringthe constraints imposed by the driving environment. To achieve this, an extensive interview and usability testing have been conducted with 30 drivers from 3 different age groups; 18-35 years old, 36-50 and more than 50 years old to understand how the drivers interact with the smartphone user interface while driving cars. Furthermore, the Analytic Hierarchy Process (AHP) has been utilized to assess and assign levels of significance to the components that are to be integrated into the conceptual model. This approach assisted to prioritize and weigh the importance of these components effectively. An expert review has been conducted for the model validation and an empirical study for the model verification. The outcome of this work was an interaction model that outlines the necessary elements for enabling drivers to use gestural interactions with smartphone user interfaces in confined spaces x with minimal distraction. The potential target audience of the model would be the different age groups of drivers who engage with smartphones while driving. This study contributed to the ongoing efforts to reduce car accidents caused by smartphone usage while driving.

Hamdoon, Ahmed MohamedSalih Musa (2024) *Interactive Model for Detecting Multiple Chan Patterns to Diagnose Excessive Water Production.* Masters thesis, Universiti Teknologi PETRONAS.

Water is one of the major associated fluids produced in the oil industry operation cycle. To some extent, it has evolved into a secondary yield that might be carefully considered in treatment facilities and economic analyses. Many methods have been developed over the years to identify water sources ranging from trustworthy and expensive ones like well-logging records and analytical less accurate methods using available production data and water-oil ratios to differentiate between the water sources. Chan diagnostic plot has proven highly effective in industry as a powerful tool for diagnosing and monitoring excessive water production in oil wells. Chan identified various distinct water problem patterns exhibited by wells during their production lifecycle based on slope features: Constant water-oil ratio (WOR), Normal Displacement, Coning, Channeling, depletion, and Multilayer Channeling. While machine learning models were developed to automate Chan plot interpretation and reduce human bias, they often failed to capture the evolution of water production over time, typically detecting only a single pattern or capturing patterns after its fully materialized, reducing the chance of early diagnosing. This study investigates the effectiveness of incorporating the rolling window function for recognizing patterns dynamically, aiming to distinguish the various water problem patterns for quick actions and optimal workover selection. Alaska oil wells public production data were analyzed illustrating each pattern's manifestation. A successful interactive model with the rolling window feature was developed to track slope changes in Chan signatures, resulting in a 7 - 10% improvement in pattern detection accuracy compared to static features. Throughout, an iterative optimization process, window size was determined as seven points, considering pattern duration. Eight algorithms were evaluated, with Support Vector Machines (SVM) and Random Forest (RF) achieving a remarkable 94% F1 score while the remaining algorithms averaged 93%.

Hasan, Md Mahmudul (2024) *Bidirectional Direct Current Circuit Breaker Capable of Regenerative Current Breaking.* Masters thesis, Universiti Teknologi PETRONAS.

Direct current circuit breaker (DCCB) is extensively employed in DC microgrid applications to protect the network during faults. However, numerous DC converters are combined in parallel to form a DC microgrid, which creates a large network inductance. It stores energy during normal operation, which repels instantaneous current breaking, and this stored energy needs to be eliminated after current breaking. Conventionally, DCCB topologies use different energy absorption methods to dissipate the stored energy after breaking the current. Recently, a concept called regenerative current breaking has been integrated with DCCB technology to extract and reuse this energy instead of dissipating it. This concept of energy regeneration has initiated a paradigm shift in DC circuit breaker technologies. In spite of that, it possesses several limitations, including unidirectional power flow, long tripping time, voltage stress, and high peak of regenerated current. In this research work, an efficient bidirectional DC circuit breaker (EBDCCB) topology has been proposed, aiming to address the aforementioned limitations. The proposed EBDCCB has drastically improved the performance in terms of current breaking time, voltage stress, regenerated current, and recovered energy compared to the conventional DCCB topology. Additionally, it has bidirectional power flow capability to meet the requirements of the DC microgrid. The sizing of the breaker components used in the EBDCCB is elaborately explained, and detailed performance testing is presented along with extensive PSIM software simulation. Additionally, the performance of EBDCCB is tested and analyzed on a laboratory-scale 48V/1A network.

Hashwan, Abdulrahman Abdullah Omar Ba (2024) *Multi-Site Lean Blowout Prediction Technique for Dry Low Emission Gas Turbine Using ADA-LSVM.* Masters thesis, Universiti Teknologi PETRONAS.

The modern Dry Low Emission (DLE) gas turbine offers ultra-low NOx emissions to meet stringent environmental regulations. However, operating at ultra-low temperatures to achieve these emissions renders DLE gas turbines susceptible to lean blowout (LBO), a critical issue causing system instability, increased CO emissions, component damages, and financial losses. Traditional prediction approaches based on semi-empirical or physical simulation at the design stages often fail to eliminate LBO events due to the thermodynamic, physical, and chemical complexity of gas turbines. Nevertheless, real-time data-driven LBO prediction approaches based on actual DLE gas turbine datasets have shown robustness, high accuracy, and the capability to early predict LBO. Conversely, existing methods exhibit limitations in achieving high performance across multiple sites and lack generalization ability. To address these shortcomings, this study proposes a data-driven multi-site LBO prediction model based on an actual DLE gas turbine dataset, leveraging the competitive advantages of both adaptive boosting (AdaBoost) and Linear Support Vector Machine (LSVM) to improve generalization capability as well as prediction accuracy. The proposed algorithm is trained using a real-world DLE gas turbine dataset and validated for generalization ability and multi-site performance using five additional gas turbine datasets. Based on the results, the optimized Ada-LSVM model accomplished high accuracy and robustness, achieving above 99.9% accuracy and a 0.9 Mathew's Correlation Coefficient (MCC) score in multi-site validation across all DLE plants. Furthermore, the final tuned optimized Ada-LSVM model set a new benchmark for Early Detection Time (EDT) for multi-site LBO prediction, surpassing 12 seconds.

Haw, Chung Yee (2024) *A Cross-Layer Contention/SNIR-Based Forwarding Protocol for Wireless Sensor Network.* Masters thesis, Universiti Teknologi PETRONAS.

Wireless Sensor Network (WSN) deploys numerous resource-constrained sensor nodes which have limited power supply, memory and computation capability in an environment to remotely monitor the specific phenomenon. Inefficient routing strategies result in degraded network performance in terms of reliability, latency and energy efficiency. In this thesis, a novel cross-layer design, contention-based MAC and routing protocol is proposed, termed Contention/SNIR-Based Forwarding (CSBF) protocol. CSBF utilizes the geographical information of sensor nodes to effectively guide the routing direction towards the destination, thereby enhancing reliability. Furthermore, Signal-to-Noise-plus-Interference Ratio (SNIR) metric is utilized as a routing parameter to guarantee high quality link for data transmission. Moreover, a contention-winner relay scheme is used to reduce the delays caused by the contention procedure. Energy efficiency is improved by incorporating the sleep mode strategy and this technique allows only the selected nodes to remain active while others sleep. Effective data retransmission scheme ensures one-hop data retransmission and it reduces packet loss probability. Duplicated data elimination scheme discards the repeated data packets. The simulation work is carried out via OMNeT++ network simulator. The performance of the CSBF is compared with the existing routing protocols such as AODV and DSDV in terms of packet delivery ratio (PDR), End-toEnd (ETE) delay and energy consumption per data packet. Simulation results highlight that CSBF outperforms AODV and DSDV protocols in respect of PDR and energy consumption per packet under different payload size, number of nodes and packet interarrival time. The average PDR performance gains of CSBF over DSDV and AODV are 5.47% and 1.96%, respectively. Moreover, the average energy consumption per data packet for CSBF, AODV and DSDV are 87.163 mJ/packet, 103.071 mJ/packet and 117 mJ/packet, respectively.

Hira, Noor E (2024) *Molecular Simulation of Arsenic Adsoprtion From Water Using Metal Oxides and Hydroxides.* Masters thesis, Universiti Teknologi PETRONAS.

Arsenic in groundwater is a harmful and hazardous substance that must be removed to protect human health and safety. Adsorption, particularly using metal oxides and hydroxides, is a cost-effective way to treat contaminated water. Experimental research has been the primary emphasis of prior work, which is time-consuming and costly, while also restricted to a limited range of operating conditions. In this work, a computational framework using Molecular Dynamics Simulation based on the Monte Carlo principle has been developed to investigate arsenic adsorption. The molecular structures have been optimized and proceeded with sorption calculations to observe the adsorption capabilities. In this study, 15 selected metal oxides/ hydroxides were screened at a pressure of 100 kPa and a temperature of 298 K for As(V) in the form of HAsO4 at pH 7. Ferric hydroxide (FeOOH) has been simulated as a benchmark and the computational results were found comparable with previously published literature with a percentage error of <10%. Based on adsorption capacity of aluminum hydroxide (Al(OH)3), FeOOH, and lanthanum hydroxide La(OH)3 recorded at 197, 73.6 and 151.0 mg/g, respectively, they were revealed to be the most effective adsorbents for arsenic removal. The effects of pH from 1 to 13, temperature from 281.15 to 331.15 K, and pressure from 100 to 350 kPa were studied. Results revealed that adsorption capacity decreased for the high-temperature applications while an increment in pressure promoted adsorption to some extent. Furthermore, Response Surface Methodology (RSM) has been employed for the optimization study of the operating variables for the screened adsorbents in arsenic removal. The RSM models utilizing Central Composite Design (CCD) were developed for Al(OH)3 (R1), La(OH)3 (R2) and FeOOH (R3) having R2 values of 0.93, 0.77, and 0.94, respectively. The RSM model demonstrated the optimum pH (3.68, 3.88, and 3.98), temperature (283.5, 287.8, and 285.3K) and pressure (197.3, 193.9 and 220.1 kPa) for R1, R2 and R3 respectively. This study contributes to design of new generation adsorbents for water treatment.

Hizam, Sara Maira Binti Mohd (2024) *Development of Ammonium Ion Sensor Based on Metal-Organic Frameworks-Derives Tungsten Oxide/Reduced Graphene Oxide.* Masters thesis, Universiti Teknologi PETRONAS.

Ammonium (NH_4^+) ions are a primary contaminant in the river and waterside near agriculture area; therefore, necessitating sensitive detection of pollutants before irreversible damage done to the environment. Herein, a new approach of metal-organic frameworks-derived tungsten oxide/polypyrrole-reduced graphene oxide (MOFsWO3/Ppy-rGO) electrochemical sensor is introduced. The Ppy-rGO interacts with WO3 as an organic linker through a simple hydrothermal process, whereby the MOFsWO3/Ppy-rGO nanocomposites was produced through hydrogen bonding. The synergistic combination of WO3 and Ppy-rGO provides three-fold advantages; stabilization of Ppy-rGO for extended usage, enable NH_4^+ detection at ambient temperature, and availability of multiple pathways for effective detection of analytes. The novelty of the research is the incorporation of WO3 and Ppy-rGO in the newest MOFs derivation for development of outstanding NH_4^+ detector at ppb level. The optimized MOFs-WO3/Ppy-rGO was drop-coated on screen-printed electrode (SPE) by incorporating fluoropolymer-copolymer, Nafion as a binder. The MOFs-WO3/Ppy-rGO nanocomposites was characterized with FTIR, XRD, XPS, Raman, FESEM and HRTEM analyses. The bonding interaction can be seen clearly in HRTEM images, Raman peak shifting and intensity ratio, as well as the presence of WO3 bonding in XPS and FTIR. The optimized MOFs-WO3/Ppy-rGO nanocomposites was a remarkable NH_4^+-electrochemical sensor which can be observed by the optimized analyses through EIS and CV. The detection limit (LOD) and quantification limit (LOQ) of the optimized nanocomposites was calculated to be 0.183 µM (6.413 ppb) and 0.554 µM (19.415 ppb), respectively. This novel nanocomposite was surprisingly extremely selective against Na^+ and K^+ analytes, good repeatability, and stability up to 4 weeks. The remarkable sensing performance of the MOFs-WO3/Ppy-rGO nanocomposites provides an excellent platform for early detection of contamination and hazardous material and preserving the water resources and ecosystem for future generations.

Isa, Noor Hidayah Mohamed (2024) *Multivariate Matrix Analysis For Fuzzy Linear Regression Model.* Masters thesis, Universiti Teknologi PETRONAS.

Fuzzy plays an essential role in daily life activities especially regarding economy, finance and technology. The traditional regression model is lengthy, and the computation is complex. Fuzzy linear regression can be used to cater to the uncertainty and vagueness of the data to reduce the complexity in computation. The multivariate matrix fuzzy linear regression for symmetrical triangular fuzzy number model is developed to address the above drawbacks. This research work has been conducted based on two objectives and those objectives have been accomplished and achieved. The main objective is to develop a multivariate matrix fuzzy linear regression for symmetrical triangular fuzzy number model and subsequently apply the developed model in the following two case studies (i) palm oil production and (ii) tax revenue. The developed models have been successfully validated by applying in both case studies. The model validation used the coefficient of determination to examine how accuracy the model. Based on the result, for case study (i) For palm oil production, the total matured area and crude oil positively influence the palm oil price; higher or lower total matured areas and crude oil quantities affect the price. Respectively, for case study (ii) In the case of tax revenue, inflation and unemployment have a significant impact on tax revenue. Next, the second research objective is to validate the developed model in prediction. The result shows that the model was applied successfully in the prediction of both case studies. In conclusion, those two objectives have been successfully accomplished and it gives a good indication that multivariate matrix for fuzzy regression for symmetrical triangular number model can be used as tool for application in predicting in other application.

Karim, Malik Abdul (2024) *Hoop, Stiffness And Axial Tensile Properties Of The Single Layered Braid-Reinforced Thermoplastic Pipe For Oil And Gas Applications.* Masters thesis, Universiti Teknologi PETRONAS.

Reinforced thermoplastic pipes (RTPs) are being broadly scrutinized as a feasible surrogate for metallic pipes due to surpassing corrosion resistance, low weight, and less maintenance worth. The RTPs face various failures and deterioration in their three-layer structure, but most likely in the fiber reinforcement layer. Processing technique and parameters of the reinforced layers are critical to enhance the mechanical properties of the RTP. Since the braiding technique is relatively new for bonded RTPs, the processing parameters need to be scrutinized to determine their mechanical abilities. Hence, this study evaluated the hoop, stiffness, and tensile performance of the braid-RTP prototype and assess the effects and contribution of braiding angles and matrices on the performance. The braid-RTP prototypes with a range of braiding angles of 55o -60o , 65o - 70o , and 75o -80o and matrices of epoxy, vinyl ester, and polyester were fabricated. High density polyethylene (HDPE) liner and glass fiber were used for the braid-RTP prototypes. The hoop tensile, stiffness, and axial tensile tests were done according to their respective ASTM standards. The best possible combination of braiding angle and matrix was determined by the analysis of variance (ANOVA) with validation process and presented via the main plot effect analysis. The highest hoop tensile strength and modulus were 47 MPa and 391 MPa, respectively, manufactured using the epoxy with a braiding angle of ±75o , while the lowest hoop tensile strength and modulus were 19 MPa and 202 MPa, respectively, recorded for a polyester matrix with a braiding angle of ±55o . Similar trends were observed for the radial compression and axial tensile strength. ANOVA results suggested that both matrices and braiding angles were significant, but braiding angles had more impact on the performance of the braid-RTP prototype. The composite with epoxy matrix and ±75o braiding angle was considered the best combination and there was no dependency of the parameters on each other.

Khan, Muhammad Basit (2024) *Development Of High-Performance Structural Concrete Repair System Using Graphene Nano Platelets.* Masters thesis, Universiti Teknologi PETRONAS.

The increasing deterioration of concrete structures worldwide presents an immediate demand for solid and sustainable repair techniques. Recent years have witnessed an increase in concrete defects, which has prompted a reevaluation of rehabilitation techniques. To reevaluate concrete restoration, this research seeks to develop a high-performance structural repair system. This study addresses the aforementioned constraints by proposing a transformative approach that focuses on the development of a Fiber Reinforced Composites (FRC) including Graphene NanoPlatelets (GNPs). This composite material is ideal for present-day infrastructure repairs. Bonding capacity becomes more important when replacing deteriorated concrete with a more durable material. Any repair method must seamlessly integrate repair materials with concrete substrates to provide a durable bond. As a result, the primary objective of this study is to perform a comprehensive evaluation of the bonding strength between FRC and normal concrete. Repair material (FRC) was developed by inclusion of varying percentages of GNPs (0%, 0.02%, 0.03% and 0.08%), mechanical characteristics were evaluated and found that addition of 0.02%, 0.03%, 0.08% of GNPs results in enhancing the compressive strength by 7.24%, 11.59% and 30.72% respectively on 28 days curing. Tensile strength increases by 3.96%, 17.95% and 57.56% respectively after 28 days curing. For evaluation of bonding strength slant shear test were conducted on different angles such as 15°, 30°, 45°, 60° & 90° and surface of specimen were prepared with wire brush, drill holes and by hammer to investigate the ideal angle and ideal surface for optimum bonding strength. It was found by the investigation that the highest bonding strength was attained by casting repair material at 15 degrees onto the NSC (normal substrate concrete) and hammering the surface. Additionally, adding 0.08% GNPs to repair material increases bonding strength, but adding very little amount of GNPs does not have much effect as increasing the GNPs content results in increasing the surface area that results in enhancing the bonding viii strength. The FRC with 0.08% GNPs cast on NSC at 15 degrees with hammer surface preparation had 52.64 MPa bonding strength, 11.15% higher than the control composite specimen.

Maheshwari, Vikash Chander (2024) *An Adaptive Ensemble Framework For Concept Drift Detection And Adaptation In Streaming Data Analysis.* Masters thesis, Universiti Teknologi PETRONAS.

Data-centric applications, such as those involved in credit card transactions and IoT devices, frequently rely on data streams for various machine learning objectives. However, real-world streaming data presents challenges, including infrequent occurrences like concept drifts and anomalies that significantly impact the efficacy of learning models. While Machine Learning (ML) techniques have proven effective in tasks like credit card fraud detection and IoT data analytics, applying them to dynamic data streams poses complexities. Accurate recognition of events in data streams is challenging due to the characteristics of real-world streaming data: limitless volume, rapid arrival rate, dynamic behavior, and challenges associated with the cost and limited accessibility of labeled information. To address these challenges, machine learning models in data streams must adhere to the one-pass criterion, adapt to dynamic data with an adaptive learning property, and optimize resource usage due to the cost and limited availability of labeled information. This thesis introduces the Adaptive Ensemble Framework (AEF-CDA) to address these challenges in credit card transactions and IoT data streams. The framework comprises four phases: In the initial phase, data preprocessing techniques enhance the quality of incoming credit card and IoT data streams. The second stage involves adaptive feature selection through the driftcentric approach (DA-FS). The third stage includes online base model learning and adaptive model selection (AMS). Six foundational online learners are trained using preprocessed data streams. In the final stage, a weighted method combines outputs from chosen learners for the online ensemble, considering prediction probabilities and realtime error rates. The experimental results demonstrate that AEF-CDA excels in handling dynamic data streams, particularly in scenarios with concept drifts. On a credit card dataset, AEF-CDA achieved the highest performance with 99.54% accuracy, 98.69% precision, 98.87% recall, and a 99.30% F1-score, outperforming other models. It also led among online learning models on the CICIDS2017 dataset, with a 99.16% viii accuracy and 97.58% F1-score, showing robustness against six instances of concept drift. Similarly, on the IoTID20 dataset, AEF-CDA ranked highest with a 99.14% accuracy and second highest F1-score of 99.37%, effectively handling four minor concept drifts. This thesis addresses machine learning challenges in dynamic data streams with the AEF-CDA approach, which unifies the detection and interpretation of concept drifts and anomalies, demonstrating effectiveness both theoretically and practically.

Moorthy, Navanitha A/P (2024) *Macro to Nano: The Influence of Technology, Internet, and Self-Motivation on Learners' Attainment of Digital Badge for Micro-Credential Computing Courses.* Masters thesis, Universiti Teknologi PETRONAS.

The educational landscape is experiencing a shift towards nano-learning, driven by technology and evolving learner needs. Micro-credentials play a key role in this shift. Despite the increasing attention to micro-credentials and digital badges, there's a lack of empirical research on learners' intentions to obtain digital badges in microcredential courses in Malaysia. This study fills this gap by examining learners' intentions from both technological and non-technological perspectives. Adapting several theories, including Technology Self-Efficacy, Internet SelfEfficacy, Self-Determination Theory, and Instant Gratification, a research framework consisting of eight key constructs was developed. A total of 435 questionnaire responses were collected and analyzed using the Partial Least Square Structural Equation Modeling (PLS-SEM) approach. The results highlight the significant role of Internet Self-Efficacy and self-motivation in the pursuit of digital badges. Learners who exhibited intrinsic motivation and a strong desire to acquire new skills and knowledge were more inclined to earn digital badges as a means of recognition for their achievements. The study also found that learners motivated by instant gratification and immediate rewards were more actively engaged in earning digital badges. In addition to these findings, the research provides practical guidelines for implementing digital badge systems in micro-credential courses. These guidelines serve as a roadmap for educators and institutions, helping them effectively integrate digital badges into their micro-credential offerings. By examining both technological and non-technological factors and proposing a robust framework and practical guidelines, this research contributes significantly to the advancement of the digital badge ecosystem in educational contexts. Therefore, serves as a comprehensive resource for those interested in promoting and enhancing nano-learning experiences through micro-credentials and digital badges.

Olutoki, John Oluwadamilola (2024) *Integration of Petrophysics, Seismic Attributes, Rock Physics, Geostatistical Inversion And Machine Learning In Reservoir Properties Prediction: A Case Study Of Mckee Formation, Taranaki Basin, New Zealand.* Masters thesis, Universiti Teknologi PETRONAS.

Characterizing reservoirs is a crucial stage in hydrocarbon development projects that influences the ultimate drilling choice. Among the most crucial data sources for determining the distribution of reservoir attributes is seismic data. To locate fresh drilling locations for exploration, this analysis inverts for the acoustic impedance and porosity. The study examines the integration of machine learning and Geostatistical Inversion Approaches to reduce uncertainty in forecasting subsurface conditions across scales. It involves creating a structural framework map, selecting horizons, editing and correlating logs, extracting wavelets, building a low-frequency model, and conducting Geostatistical inversion for acoustic impedance. Porosity analysis uses Extreme Gradient Boosting models with seismic attributes and cross-plot analysis of reservoir properties. Focused on the McKee Formation in the Taranaki Basin during the Late Eocene, the study demonstrates how seismic inversion aids in understanding reservoir characteristics and enables thorough basin examination for prospect evaluation by integrating the full range of frequencies in the initial model. The study showcased minimal fault displacement in seismic interpretation results. It emphasized the importance of Root Mean Square (RMS) Amplitude in identifying bright spots for hydrocarbon exploration. Petrophysical analysis of wireline logs described reservoir quality, while Geostatistical Seismic inversion indicated varying acoustic impedance due to cementation. Seismic attribute data, analyzed using extreme gradient boosting, inferred subsurface porosity, reducing uncertainty for petroleum engineers during drilling. Overall, the integrated methodology highlighted the significance of quantitative analysis, enhancing understanding of subsurface characteristics, lithology, and fluid behavior. The study's findings, including datadriven machine learning techniques, offer valuable insights for both industry and future research in the field.

Ricky, Sumayema Kabir (2024) *Hierarchical Permissioned Blockchain for Traceability of Mid-Development Requirement Change.* Masters thesis, Universiti Teknologi PETRONAS.

Requirement elicitation plays a crucial part in success rates of a software project. Now a lot of project management methods are moving towards agile development which allows changes in requirement specification in any phase of project lifecycle. In a project there are many stakeholders. However, not all of them have the same relevancy to the software requirements. Sometimes some requirement changes happen with the wrong stakeholder source. These changes cause problems later. Such as unused function or missing function and increases unnecessary cost for the project. Furthermore, change is inevitable in agile development. With frequent changes, it is difficult to trace all the changes made. On the other hand, in this era of the fourth industrial revolution and with the rise of remote working, researchers are leveraging the immutable, traceable, decentralized platform of Blockchain to aid in requirement engineering. In a hierarchical permissioned blockchain, the level of permission can be defined for different groups. Therefore, a hierarchical permissioned blockchain is recommended for stakeholder authorization and traceability of mid-development requirement change. A simple JavaScript blockchain was developed for storing requirements. A procedure was developed to assign weight for stakeholder groups per requirement types. The procedure was integrated in the blockchain hierarchy to control permission for changing a requirement. Furthermore, a web interface was developed with Angular for stakeholders to interact with the blockchain. The prototype was validated by testing different flows of the system and variables. The results successfully reflect the expected permission for different requirement changes.

Rouf, Hifza (2024) *Synthesis Of Ce-Zr Based Mixed Oxide Catalyst For Microwave-Assisted Oxidative Depolymerization Of Kenaf Stalk Into Vanillin.* Masters thesis, Universiti Teknologi PETRONAS.

Lignin's unique structure makes it a promising source for aromatic chemicals like vanillin. Extracting lignin yields high purity, but the process is time-consuming. This study investigated the direct oxidation of kenaf stalks (a type of lignocellulosic biomass) to vanillin using microwave-assisted technology without removing cellulose and hemicellulose. Three catalysts, cerium oxide (CeO2-CA), zirconium oxide (ZrO2- CA), and mixed oxide (CeZrO2-CA) were synthesized using the citrate complexation method. The physicochemical properties of the catalysts were analyzed using X-ray Diffraction (XRD), Fourier Transform Infrared (FTIR), Field Emission Scanning Electron Microscopy (FESEM), Transmission Electron Microscopy (TEM), BrunauerEmmett-Teller (BET), and Temperature Programmed Oxidation (TPO). The XRD and BET analysis of the synthesized catalysts confirmed that CeZrO2-CA has a small crystallite size, suggesting a large surface area. This large surface area is beneficial for the breakdown of lignin bonds to produce an aromatic compound. The morphological properties of the catalysts also confirmed that CeZrO2-CA has a spongy morphology, which further increases its surface area. The nitrogen gas adsorption isotherm of the synthesized catalysts represents the type IV isotherm according to the IUPAC classifications. This indicates that the catalysts have a mesoporous structure which is ideal due to its ability to offer a high surface area, and efficient adsorption capacity. The effect of reaction temperature, reaction time, and catalyst loading on vanillin production was studied. The results showed that CeZrO2-CA was the most effective catalyst for the direct oxidation of kenaf stalks to vanillin. The highest vanillin yield of 10.01% was obtained for 5 wt.% of CeZrO2-CA at 160 °C for 30 minutes. The production of vanillin from extracted lignin using CeZrO2-CA catalyst under the same operating parameters resulted in a vanillin yield of 14.3%. The effect of pH on the vanillin yield was also investigated. Furthermore, the recyclability of the catalyst was also studied, and it was found to be stable after four consecutive runs. The SEM analysis viii of the used CeZrO2-CA catalyst showed that it maintained its initial spongy shape, with holes or bubbles separating it. This study presents a microwave-assisted method using a synthesized CeZrO2-CA catalyst for direct vanillin production from kenaf stalks, demonstrating high efficiency, recyclability, and a sustainable alternative to traditional methods.

Rozaiddin, Siti Aishah Mohd (2024) *Titanium Oxyhydroxide Enhanced Regeneration of Carbon Dioxide Rich Methyldiethanolamine Solvent.* Masters thesis, Universiti Teknologi PETRONAS.

The urgent global issue of climate change caused by rising carbon dioxide (CO_2) levels has led to the widespread use of alkanolamine solutions for CO_2 separation. However, high energy consumption during CO_2 desorption from the amine solvent hinders its practical application. Catalysts such as titanium oxyhydrate ($TiO(OH)_2$), have been studied to enhance desorption performance. In this study, the objective was to evaluate the stability of $TiO(OH)_2$ catalyst to enhance the desorption of CO_2 in methyldiethanolamine (MDEA) and piperazine (PZ) solvent, examining the influence of operational parameters on the CO_2 desorption performance and evaluating the regeneration energy, expressed as sensible heat duty per released CO_2.The stability of the catalyst was characterized and synthesized using FTIR (Fourier Transform Infrared Spectroscopy), FESEM (Field-Emission Scanning Electron Microscopy), XRD (X-Ray Diffraction), and TGA (Thermogravimetric Analysis). The results indicated good stability of $TiO(OH)_2$ as no changes were observed between fresh and cycled $TiO(OH)_2$ sample. Next, the desorption tests were conducted in a solubility cell. The study results showed that increasing the temperature from 80°C to 110°C leads to a substantial 93.13% increase in the desorption rate while also reporting a 29.08% reduction in sensible heat, indicating improved energy efficiency. Conversely, increasing the PZ concentration from 0 wt% to 5 wt% resulted in a 15.89% increase in the desorption rate, but also led to 19.60% increase in sensible heat reflecting higher energy consumption. Notably, increasing the $TiO(OH)_2$ concentration from 0 wt% to 5 wt% resulted in a notable 19.81% increase in the desorption rate and a substantial 42.24% reduction in sensible heat, making this the most favorable outcome among all three parameters, as it signifies improved desorption efficiency and reduced energy consumption. These findings highlighted the potential of $TiO(OH)_2$ to enhance desorption efficiency and reduce energy consumption in CO_2 capture processes.

Saadon, Syazmi Zul Arif Hakimi Bin (2024) *Pretreatments of Napier Grass for Lignin Extraction Via Cellulolytic Enzymatic Method.* Masters thesis, Universiti Teknologi PETRONAS.

Lignin is a vital component of biomass, with potential applications in various chemicals and fuels. This study investigated the pretreatment of lignin from Napier grass using thermal and mechanical means, as well as extraction of lignin via cellulolytic enzymatic hydrolysis to determine the optimum condition for feedstock pretreatment. Varied drying conditions were applied to different Napier grass components and particle sizes, investigating their effects on moisture content, functional groups, crystallinity indices, and surface morphology. Lignin was then extracted from the pretreated Napier grass via Klason and cellulolytic enzymatic hydrolysis methods where the latter was examined for its yield, functional groups, and thermal degradation. The results showed that moisture content decreased with increasing drying conditions. The FTIR results showed that higher drying conditions resulted in lower peak intensities, while ballmilling also showed a reduction in peak intensities in smaller amounts. All pretreatment conditions exhibited evidence of partial delignification and deterioration of surface and cell structures. Klason lignin could be extracted more with higher drying conditions, ranging between 4.48-38.2%. The study noted that extraction using Klason was influenced by drying conditions and sample type, with moisture impeding acid hydrolysis. Enzymatic lignin yielded higher amounts (52.9-86.9%) compared to Klason, indicating incomplete holocellulose degradation. The FTIR spectra of enzymatic lignin were found to be closer to lignin, but there are evidence of presence of cellulose. TGA analysis confirmed the presence of holocellulose, which was more abundant in the leaves than in the Napier stems. Comparing between lignin extracted, Klason lignin amount is almost similar to amount from TGA (19.3-34.5%) but much lower than enzymatic lignin. Despite leaf samples producing more lignin at lower drying conditions, high cellulose composition and lower crystallinity might hinder pure lignin extraction. In conclusion, this study offers valuable insights into Napier grass pretreatment effects on lignin properties, suggesting potential improvements in yield viii and quality, but underscores the need for further optimization tailored to specific applications.

Salleh, Putra Ahmad Khalifa Bin Mohamed (2024) *Development of A Converter For Wave Energy Conversion System Using Modified Sepic Circuit.* Masters thesis, Universiti Teknologi .

The notable rise in electrical energy consumption could result in the depletion of nonrenewable resources; hence, it is imperative to harness renewable resources such as solar, tide, wind, wave, and others as a sustainable alternative. This thesis focuses on wave energy as a renewable source for electricity generation. Wave energy exhibits a non-uniform pattern and is heavily influenced by weather conditions and the surrounding environment. The Wave Energy Converter (WEC), a generator that harnesses wave energy is utilised as it produces electrical energy with non-uniform frequencies and amplitudes. Furthermore, current technologies are robust and capable to only stabilise large amounts of non-uniform electrical energy. However, there is a gap in research of small-scale, portable stabiliser for use with pico-scale generators. There are various approaches employed in existing technologies to stabilise nonuniform electrical energy such as Partial-Scale Frequency Converter, Full-Scale Frequency Converter, Diode Rectifier Converter, Pure AC Converter, DC/AC Converter, Pure DC Converter and others. These technologies typically comprise multiple sub-converters such as AC-DC converters, DC-AC converters, and their combination. This project aims to design a prototype of a portable stabiliser specifically for a pico-scale linear wave generator, which typically generates up to 5 kilowatts (kW) of electricity, making it suitable for remote and rural areas. Moreover, it can convert small amounts of non-uniform electrical energy into a clean DC signal suitable for powering small electrical appliances. The proposed design is simulated using MATLAB Simulink software to understand its operation and obtain preliminary results. Furthermore, component ratings and specifications are determined through these simulations and subsequently used in prototype fabrication.

Saaid, Husainni Mohd (2024) *ANALYSIS AND PLANNING FOR SUPPLY DEMAND SALES GAS TRANSPORTATION IN PENINSULAR MALAYSIA.* Masters thesis, Universiti Teknologi PETRONAS.

Department of Gas control center have experienced challenging tasks of coordinating various type of scenario planning as to satisfy all the required demands and existing network constraints such as deviations by major customers, weather season, and emergence of alternative fuel mix. Previous planning approach was simply based on operators' experience and rules of thumb which provide room of errors and inconsistent results. Consequently, gas network pipeline have experienced low utilization and extreme fluctuation of pressure in gas transmission network which consistently impacted business profitability. In this research, a gas transportation model specific to Peninsular Malaysia was developed using General Algebraic Modeling System (GAMS) to increase network profitability and utilization of pipeline system. Problem related to the scenario planning under uncertainty towards demand deviations and fluctuations were solved with linepack management, pipeline studio software and real time transient monitoring (RTTM). The findings from this research study provide highest confidence level at 0.98 with maximum production of gas supply up to 4000 MMscfd with 87.5% utilization of the gas transmission network. The profitability achieved is MYR 21.94 million under normal case scenario. Next, the uncertainty problems were solved using abovementioned solutions where the network was able to sustain operational threshold within 40 – 50 barg inventory and imbalance +/- 100 MMscfd. Implementation of these methods have improved 6% linepack level, 7% average pressure buffer and maintain 58% pipeline utilization despite of mitigated uncertainty. These methods provide essential input to operation engineers for decision making in term of short-term planning and long-term planning by having inventory output, real time analysis and survival time whenever deviation occurs from supply and demand side.

Shobri, Nurul Nadia Shuhada Binti Mahamad (2024) *Finite Element Analysis and Characterization of Aluminium-Copper Weld Joint in Friction Stir Spot Welding Process.* Masters thesis, Universiti Teknologi PETRONAS.

This study investigates the performance of the aluminium-copper (Al-Cu) weld joint during the plunge phase in the Friction Stir Spot Welding (FSSW) process. The problems identified include challenges in joining dissimilar materials due to the presence of oxide layers, lack of comprehensive finite element analysis (FEA) of the Al-Cu weld joint, and neglect of the impact of the individual phase, particularly the plunge phase. The objective is to develop a validated finite element modelling (FEM) based on Coupled Eulerian-Lagrangian (CEL), Coulomb's frictional law, and Johnson Cook's plasticity model to predict the temperature profile of Al-Cu weld joints during the plunge phase in the FSSW process. Furthermore, the current study aims to investigate the effect of the welding parameters on the mechanical properties of the AlCu weld joint. It also aims to quantify the influence of the FSSW process parameters on the temperature profile of the Al-Cu weld joint in the FSSW process. The current study employed FEA based on full factorial design and experiments based on the L9 orthogonal array. The findings were analyzed using statistical tools such as analysis of variance (ANOVA), regression analysis, and response surface methodology (RSM). The results established a strong correlation between the FEA and the experimental of the current study, where the error percentages between them were 1.69% and 5.41% at two different locations. Further validation was made based on the experiment from literature by Regensburg et al. [1], which resulted in an 8.3% error percentage. From the findings in the current study, the optimal welding parameters were identified as rotational speed of 1600 rpm, plunge rate of 50 mm/min, and plunge depth of 1.6 mm to yield superior weld performance. The key finding emphasizes that precise temperature control, affected by the tool rotational speed, plunge rate, and plunge depth, is crucial to achieving high-quality weld joints. In conclusion, maintaining an appropriate temperature during the plunge phase of the FSSW process is necessary to prevent the formation of failed weld joints.

Yong, Melvin Tai Jia (2024) *Flexible Laser Scribed Graphene Electrode for Selective Bio-Capture in Rapid Detection of Mycobacterium Tuberculosis.* Masters thesis, Universiti Teknologi PETRONAS.

Flexible laser scribed graphene electrodes, with their selective bio-capture and rapid detection capabilities, hold promise as a revolutionary tool in tuberculosis (TB) diagnostics. TB, caused by Mycobacterium Tuberculosis, poses a significant global health challenge due to ineffective diagnostic methods. Innovative approaches like graphene-based biosensors are urgently needed for accurate and timely TB detection. By adjusting the laser beam intensity during synthesis, we studied the morphology, structure, and impedance of laser scribed graphene (LSG). Field-emission scanning electron microscopy (FESEM) and transmission electron microscopy (TEM) images revealed the highly porous nature of LSG with fibrous morphology produced at higher laser power and 500 PPI, named LSG nanofiber (LSGNF). The Raman spectrum reveals varying degrees of graphitization with ID/IG ratios of 0.94, 0.76, and 0.74, respectively. Despite this variation, the I2D/IG ratio, below 1, supports the presence of multilayered graphene in all samples. Additionally, the impedance study confirmed the higher resistivity. Furthermore, we produced a green LSGNF biosensor decorated with oil palm lignin-based synthetic silver nanoparticles (AgNPs). The resulting composite morphology was observed by FESEM, revealing the effective adaptation of the AgNPs to the LSGNF surface. The successful attachment of AgNPs and LSG-NFs was also evident from X-ray diffraction and Raman spectroscopy studies. In order to verify the sensing efficiency, a selective DNA sample captured on AgNPs was investigated for specific binding with M. tuberculosis target DNA through selective hybridization and mismatch analysis. Electrochemical impedance studies further confirmed sensitive detection of up to 1 fM, with a detection limit of 10−15 M. Successful DNA immobilization and hybridization were confirmed by the detection of phosphorus and nitrogen peaks based on X-ray photoelectron spectroscopy and Fourier-transform infrared spectroscopy. The stability and repeatability of the analysis were high. This approach offers an affordable potential sensing system for the determination of M. tuberculosis biomarkers, representing a new direction in medical diagnosis.

Ul Hasnain, Syed Muhammad Wajahat (2024) *Development of Single Metal Promoted Ni/SBA-15 Catalyst from Low Cost POFA for Dry Reforming of Methane.* Masters thesis, Universiti Teknologi PETRONAS.

Palm oil fuel ash (POFA) has been massively produced by numerous palm oil mills and constitutes an environmental waste disposal problem. Furthermore, the rise in energy demand and environmental problems arising from harmful greenhouse gases (GHGs) necessitate their conversion into valuable syngas via dry reforming of methane (DRM). However, the major challenge associated with the industrialization of DRM is catalyst deactivation. This underscores the need to discover efficient, environmentally friendly and durable catalysts, addressing the key hurdle to make the process feasible for industrial use. The current study investigated the effect of various promoters such as Zr, La, Ce, and Cr 1wt.% loading on 10wt.%Ni/SBA-15-POFA catalyst including reaction testing and characterization of fresh and spent catalyst and optimizing reaction parameters for DRM reaction. The support was prepared by the alkali fusion method using POFA, harmful waste that could cause environmental problems in the long run. The catalysts were synthesized using the sequential impregnation method. The fresh catalysts were characterized by XRD, FESEM, H2-TPR, XPS, and CO2-TPO to examine their physical properties, metal support interaction, basicity, and reducibility. The catalytic performance was tested in a tubular fixed bed reactor at 800 °C with an equimolar feed ratio. Adding promoters significantly altered the base catalyst properties, influencing its performance. Overall, the Zr-promoted catalyst depicted the best catalytic performance with CH4 conversion of 90%, CO2 conversion of 94% and H2:CO of 0.91, maintaining stability for the 8-h reaction. Spent catalyst characterization shows that promoter addition significantly reduced the carbon deposition. Amorphous carbon was formed on an unpromoted catalyst, while the Zr-promoted displayed stable performance due to the formation of MWCNTs as depicted by TEM. The DRM reaction parameters over the Zr-promoted catalyst were optimized using the rotatable central composite design (RCCD) tool of response surface methodology (RSM). At optimized conditions, the reaction temperature, CH4/CO2 ratio, and TOS were obtained as 811.86 viii °C, 1.46, and 90 min., respectively, resulting in CH4 conversion, CO2 conversion, and H2:CO of 80.41%, 97.37%, and 0.95 respectively. Finally, the stability test was conducted for the Zr-promoted catalyst at optimized conditions, and the catalyst showed stability with a low deactivation rate (10.08%) for a 30-h DRM reaction. It can be inferred that Zr-promoted Ni/SBA-15-POFA catalyst can be used to enhance the syngas production via DRM and improve catalytic activity by suppressing the carbon deposition.

Bashir, Ahsan (2023) *Performance Measurement Of Dynamic Control For Piston Trajectory In A Free-Piston Linear Electric Generator By Load Current Modulation.* Masters thesis, Universiti Teknologi PETRONAS.

A sustained, continuous operation of a free-piston linear engine-generator (FPLG) requires sufficient compression ratio, displacement and speed of single-moving piston assembly for combustion to occur. The problem arises due to inherent characteristics of the FPLG, which are inconsistent displacement endpoints, absence of mechanical flywheel and no misfire support. Piston motion in an FPLG is dynamically coupled to and governed by balance of forces and energy between combustion and generation processes. The free-piston nature and absence of mechanical flywheel lead to a condition of irregular and unassisted piston motion, which can cause operation stoppage. Installation of an auxiliary mechanical system to assist piston motion and counter misfires is impractical. Assistance in the form of electrical energy is the only viable solution, considering the device is an electric generator with accessible stored electrical energy. This research studies viability of controlling the output load current, via pulse-width-modulation (PWM) of output load current, to assist piston motion and achieve sustained operation. A complete simulation model of the electro-mechanical system for the FPLG is developed using MATLAB-Simulink. It consists of an electrical subsystem model, combustion model for single-cylinder engine, cogging force and friction force model. System operation is analyzed using different parametric variations and load optimization, which include combustion variation and load current modulation by PWM duty cycle variation during simulation runtime. Results are compared and validated with both mathematical model and actual electrical model for the Linear Electric Motor (LEM). Using PWM technique and rule-based heuristic control, this research has investigated a viable strategy to vary the output load current based on piston velocity and displacement, for real-time control of piston trajectory. Results and analysis show that sustained and continuous operation of the FPLG can be achieved by controlling the output load current during generation mode, to achieve minimum displacement of the piston assembly in the face of combustion variations.

Halil, Norsuzieanah (2023) *The Enhancement of Control Banding for Nanomaterials Risk Assessment in Paint and Coating Industry.* Masters thesis, Universiti Teknologi PETRONAS.

In this study, the Bayesian Network (BN) model and the existing Nanomaterials Risk Assessment by Department of Occupational Safety and Health (NaRA DOSH) guideline were integrated to develop a quantitative Nanomaterials Risk Assessment (NanoRisk) framework for predicting the hazard potential in the paint and coating industry. The existing qualitative control banding approach by the NaRA DOSH guideline has the following limitations: (1) less sensitivity of qualitative control banding approach, due to uncertain characterization, toxicological measurement, and exposure tests, (2) limited operating parameters and variables in Nano-BN model development, and (3) inadequate information on the control band. Therefore, the data collected is deemed to be unreliable and will complicate the risk assessment process. As a result, these limitations have neglected the safe work practices and will expose workers to life threatening working environment. On the other hand, the NanoRisk framework mitigates the limitations of the control banding approach in NaRA DOSH guidelines through

(1) the development of the Nano-BN model (ability to capture the inter-relationship between the physicochemical properties, route of exposure, potential biological effects, and nanomaterials hazard level), (2) the incorporation of additional parameters (physicochemical properties, mass, humidity, and temperature), and (3) the proposal of the detailed control measure. In addition, the flexible analytic approach of Nano-BN model allows a high accuracy prediction (85.51%) in predicting the hazard exposure of nanomaterials in supporting human decisionmaking and closing the gaps of missing nanomaterials data that are crucial for nanosafety assessment. The application of the Nano-BN model has been carried out in the nano-silica, nano-silver, and nano-titanium in the paint and coating industry. By applying the Nano-BN model, the nanomaterials risk assessment can be conducted at viii various stages in paint production process. The distinctive features of Nano-BN model in modified NaRA DOSH generate a comprehensive analysis and accuracy of prediction as compare to the control banding method of Stoffenmanager Nano.

Khalili, Amirul Amin (2023) *Evaluation Of Chemical Vapour Deposition Coated Friction Stir Welding Tool Performance In Duplex Stainless Steel Welding.* Masters thesis, Universiti Teknologi PETRONAS.

Friction stir welding is a three-decade-old technology patented by The Welding Institute in 1991. The welding technique was originally intended to join aluminium alloys but has now become common for high-strength materials such as duplex stainless steel. As the main component, the welding tool plays an important role during the welding process since heat is generated through the rubbing action between the tool and the workpiece. Joining a duplex stainless steel plate using friction stir welding is challenging since the workpiece material is abrasive. One of the options for strengthening the welding tool found in the literature is applying a coating material. However, the growth characteristics of the coating material bonded to the tool substrate have not been widely discussed in the literature. Thus, the main objective of this research is to investigate the improvement of FSW tool life in joining the duplex stainless steel, through surface enhancement. To achieve this objective, four thin protective coatings were chosen and coated on the tool's substrate using the chemical vapour deposition method. To evaluate their characteristics, microstructure analysis and hardness testing have been deployed. A welding test matrix was designed to compare the performance of the coated tools against the duplex stainless steel workpiece. The results of the wear measurement indicate that the pack and condense coatings yield a better welding distance, with an increment of 1165 mm for the titanium aluminium nitride, reducing wear by about 4.97 % to 19.76 % with titanium aluminium nitride and microcrystalline diamond, respectively. In conclusion, the performance of the coating materials indicates that the coatings serve the purpose of protecting the tool's substrate, and it was found that titanium aluminium nitride prolonged welding performance effectively up to 1250 mm joining distance. These findings are in close agreement with the previous experimental work.

Kharul Anuar, Nur Akila Syakida Idayu (2023) *Synthesis Of Ce/Mgo Catalysts For Direct Oxidation Of Kenaf Stalks To Vanillin Under Microwave Irradiation.* Masters thesis, Universiti Teknologi PETRONAS.

Lignin is a promising resource for producing a variety of aromatic chemicals because of its unique structure with a complex phenolic polymer with randomly crosslinked C9 units. For those reason lignin can be converted into high value-added chemical such as vanillin. Etraction of lignin possess high purity, however the extraction process was lengthening. One possible method of producing vanillin from biomass is through controlled oxidation of lignin. Direct oxidation of kenaf stalks was chosen without separating the cellulose and hemicellulose components from the lignocellulosic biomass. This makes the process greener, as well as saves time. In this research, Ce/MgO catalysts were developed to oxidize kenaf stalks and kenaf lignin under microwave irradiation. The catalysts were characterized for their physicochemical properties using XRD, N2 adsorption-desorption isotherms, CO2- TPD, TPO and XPS. The synthesized MgO showed the presence of diffraction peaks that could be assigned to cubic MgO, while the Ce/MgO catalysts showed the presence of cubic fluorite of CeO2. N2 adsorption-desorption isotherms showed that all catalysts possess a combination of Type II and Type III isotherm according to IUPAC classification, indicating a nonporous structure. The total basicity of the Ce/MgO catalyst increased as the ceria content was increased from 10 to 30 wt.%. Temperature desorption oxidation revealed that the O2 consumption of the Ce/MgO-48 catalyst increased as the impregnated Ce increased. Furthermore, the XPS spectra analysis showed the interaction between the core level of Mg1s and O1s for MgO-48 catalyst while Ce3+ and Ce4+ oxidation states of CeO2 were proved in 30Ce/MgO-48 catalyst. All catalysts were tested for direct oxidation of kenaf stalks under 100–500 W of microwave irradiation using H2O2 as the oxidizing agent at pH 11.5 and temperatures between 160 to 180 °C for 10–30 min with 5–15% catalyst loading. The optimized reaction conditions were used to study vanillin production on extracted lignin using 2N of NaOH as homogeneous catalyst. The highest vanillin yields of 3.70% and 2.90% for viii extracted lignin and direct biomass oxidation were achieved using 30Ce/MgO-48. In comparison, 7.80% and 4.45% were obtained using 2N of NaOH homogeneous catalyst for extracted lignin and direct biomass, respectively, at 170 °C for 20 minutes under 300W of microwave power output. Other compounds detected were 4-vinylguaiacol, syringol and syringaldehyde.

Merdeka, Mohammad Galang (2023) *Reservoir Performance Prediction In Steam Huff And Puff Injection Using Proxy Modelling.* Masters thesis, Universiti Teknologi PETRONAS.

The problems of cost and time inefficiency during reservoir simulation persists in designing a steam huff and puff injection scheme. Therefore, developing predictive proxy models using machine learning algorithms is a suitable solution to address this concern. This study employed polynomial regression (PR) and artificial neural network (ANN) models to develop predictive models of the steam huff and puff injection scheme. Using a one-well cylindrical synthetic reservoir model, a total of 6084 experimental observations were simulated, each with 28 different features as input parameters. For each experiment, cumulative oil production and maximum oil production rate were extracted as the output parameters for developing the models. Reservoir properties which could change after an injection cycle, were also modelled. The developed models were evaluated based on the fitting performance from adjusted R-square ($Radj$ 2), the mean absolute error (MAE) and the root mean square error (RMSE). Thereafter, the significance of the input parameters was determined using Sobol analysis. Results show that ANN models had better performance when compared to the PR models. The cumulative oil production model obtained from ANN had $Radj$ 2 values of 0.993 and 0.979, MAE of 1.26 MSTB and 1.71 MSTB and RMSE of 1.85 MSTB and 2.86 MSTB for the training and testing data in that order. For the maximum oil production rate, $Radj$ 2 values of 0.962 and 0.934, MAE of 62.7 STB/D and 73.9 STB/D and RMSE of 95.5 STB/D and 122.1 STB/D were obtained for the training and testing data, respectively. Sobol analysis revealed that initial reservoir water saturation and oil viscosity are the most significant parameters for predicting the reservoir production performance. In computations of reservoir parameters at the end of the injection cycle, the most influential parameters were the initial values of the output reservoir characterization parameters. Lastly, case studies were conducted to validate the models using blind simulation dataset and field implementation reports. Results from the validation with case studies showed that the model developed can be applied practically within an acceptable range of error. Thus, viii these predictive models can be used as a screening tool to assist users in designing simulation scenarios and saving huge time.

Mohd Aszemi, Nurshazlyn (2023) *Comparative Study Of Surrogate Techniques For Hyperparameter Optimization In Convolutional Neural Network.* Masters thesis, Universiti Teknologi PETRONAS.

Optimizing hyperparameters in CNN is tedious for many researchers and practitioners. it requires a high degree of expertise or a lot of experience to optimize the hyperparameter and such manual optimization is likely to be biased. Hyperparameters in deep learning can be divided into two types which is those associated with the learning algorithms, such as determining what learning rate is appropriate, after how many iterations or epochs for each training and the other type of hyperparameter is related to how we design deep neural networks. For example, how many layers we need for our network, how many filters in given convolutional layers needs, etc. Choosing different values and setting these hyperparameters correctly is often critical for reaching the full potential of the deep neural network chosen or designed, consequently influencing the quality of the produced results. Currently, different methods or approaches have been introduced in mitigating the issues of manual optimization. These methods are such as Grid Search, Bayesian optimization, Genetic Algorithms (GA). However, these methods are still computationally expensive, largely due to the hyperparameter evaluations required. Recently, Random search has proven to be the most efficient method in hyperparameter optimization due to its simplicity, ease of implementation, and the ability to handle integer and categorical hyperparameters that naturally increase the chance of finding better hyperparameter configuration in high dimensional search space. However, what makes the adoption and application of a deep learning-based solution even more complex is that (1) all feasible hyperparameter configurations form a huge space, from which we need to choose optimal combination, (2) Different datasets require different hyperparameter configurations (3) hyperparameter is optimized by only one type which is the design of deep neural network while the learning algorithms value is fixed, and that (4) evaluating even a single hyperparameter configuration point in the space is often very time consuming (i.e., training one deep neural network using modern GPU usually takes hours, days, or even weeks). One way of alleviating this burden is by constructing surrogate models, viii or known as a statistical model, metamodels or emulators, that is trained using a datadriven approach to approximate the simulation output accurately. Since a single evaluation of the trained surrogate model is generally faster than a single evaluation of the original simulation, performing hundreds and thousands of outputs evaluations with various combinations of design hyperparameters is no longer a problem.

Vijaya Kumar, Pradeep Menon (2023) *Performance Monitoring Algorithm For Optimizing Electrical Power Generated By Using Photovoltaic Systems.* Masters thesis, Universiti Teknologi PETRONAS.

Power generation by harnessing the energy received from sunlight is a fastgrowing industry that despite its benefits in terms of sustainability, is plagued with issues that very often go unnoticed and subsequently unattended to. Given the vast area needed to generate a plausible amount of electricity, it is substantially difficult to trace where the fault has occurred or more importantly what fault is it that is inhibiting the power generation capacity. The main aim of this research work is to develop a suitable performance monitoring and fault detection mechanism that can effectively communicate errors that have taken place to the user. The 5 main faults that were identified for this research are encapsulation failures, module corrosion and hotspots, which are the two most critical faults, and the others were broken interconnections, cell cracking and dust buildup on the surface of the panel. The electrical factors such as operating voltage, current and maximum power that are affected when the faults are in effect were identified and the sensor and auxiliary electrical and electronic components were selected around the parameters that need to be monitored. Subsequently a test miniature rig was developed using twelve 3W polycrystalline cells that was arranged into 4 separate strings and connected in parallel to produce power that was readable by the data acquisition and monitoring system that was developed for this research work. The design was arranged and executed in a manner that it would assist the experimentation process such that the identified faults could be simulated with ease. The system was used a Python software that runs on a micro-computer and functions to distinguish the faults and report the relevant error messages to the user. The method used for fault detection was by getting the calculated values using a one-diode model in MATLAB and comparing those to the actual data that was retrieved through field testing conducted under controlled conditions. Subsequently the database was developed and used as a benchmark to compare against fault states that were simulated using the fabricated miniature test rig which is the element that distinguishes this research work from others as many only did so by means of simulation software such as MATLAB. Using the system designed for this research work and the methods that were identified, the faults specifically the module corrosion and hot spot failures and the encapsulation failures, were effectively diagnosed and communicated through the Python software to the end user.

Ramlee, Ezwani (2023) *Enhancing The Mechanical Properties Of Low-Carbon Steel By Gas Nitriding: Analysis By Anova.* Masters thesis, Universiti Teknologi PETRONAS.

Corrosion is an unavoidable problem commonly occurs to any small articles, such as fasteners, nuts and bolts, or to industrial equipment and bridges in which the structural components are made up from carbon steel. Although low-carbon steels are produced in the largest amounts compared to other types of steels, low-carbon steels worn and corroded easily thus their useful lifetime was short. Therefore, an experimental research was conducted to improve the corrosion resistance and mechanical properties of low-carbon steel by gas nitriding. However, nitriding process is most likely to be affected by different nitriding parameters and variables. This study involves the nitriding process occurred at various factors which consist of temperature and duration. Low-carbon steel was nitrided under different process temperature (400, 700 and 900°C) and duration (3, 4 and 5 hours) following the Taguchi method. As this study focuses on mechanical properties and corrosion resistance of nitrided low-carbon steel, the nitrided samples were then subjected to tensile test, hardness test, corrosion test, SEM and XRD examinations. Through these tests, the microstructure, composition, mechanical and chemical properties were acquired. All nitrided samples managed to record a higher value of hardness compared to the untreated sample with the highest value of 292.5 HV and up to 110% improvement. Meanwhile, the highest ultimate tensile strength recorded for nitrided samples was 465.8 MPa whereas the lowest was 357.0 MPa. For Young's modulus, the values ranged from 113 to 277 GPa. In addition to that, all except for one nitrided sample had decreased their corrosion rate with 0.047 mm per year as the lowest recorded value which is 37% reduction. Furthermore, magnetite ($Fe3O4$) and hematite ($Fe2O3$) were identified after examining the compound layer. By applying ANOVA, the regression models were developed. Notably, the significant models were tensile strength, Young's modulus and corrosion rate, having the P-values of 0.014, 0.011 and 0.007 respectively. At the end of this work, samples nitrided at 400°C managed to increase in both hardness and tensile strength, viii while reducing the corrosion rate which means that 400°C was the most suitable nitriding temperature.

Ul Haq, Ihtisham (2023) *Effect of Ammonium-Based Ionic Liquids on Thermodynamic Gas Hydrate Inhibitors.* Masters thesis, Universiti Teknologi PETRONAS.

Gas hydrate formation in natural gas transmission causes significant safety and financial losses. Multiple thermodynamic hydrate inhibitors (THIs) are employed in the industry for abatement. The use of compounds that function as hydrate inhibitors can be advantageous. This study uses ammonium-based ionic liquids (AILs) as thermodynamic hydrate inhibitors. Initially, thermodynamic hydrate measurements in a sapphire hydrate reactor were used to assess the selected AILs, mainly tetramethylammonium tetrafluoroborate (TMABF4), tetraethylammonium tetrafluoroborate (TEABF4), and their mixtures with methanol (MeOH) and mono ethylene glycol (MEG). The isochoric T-cycle approach was employed to analyze the hydrate liquid vapor (HLVE) points of CO2+AILs and their mixtures, AILs+MeOH and AILs+MEG. The THI investigation was carried out on CO2 systems at varying concentrations of 5 wt.% and 10 wt.% at a pressure range of 2.0–4.0 MPa, respectively. The thermodynamic hydrate inhibition findings showed that all the examined systems move the HLVE curve toward lower pressure and temperature conditions. The results of this study exhibited that the average depression temperature (ADT) for TMABF4, TMABF4+MeOH, and TMABF4+MEG mixtures was 0.90 K, 3.50 K, and 2.75 K, respectively, for CO2 hydrates at 10 wt.%. The hydrate dissociation enthalpies are determined by using the Clausis-Claypron equation, revealing that none of the AILs and their mixtures with MeOH and MEG was implicated in the development of the hydrate cage. The hydrate liquid vapor data for AILs and their blends, AILs+MeOH and AILs+MEG, were predicted by an electrolyte-based model that matched. As a consequence, the findings of this research are important for preventing hydrate development and dissociation in oil and gas conduits.

Asif, Khadija (2023) *Atomistic Simulation Study Towards Molecular Design Of Amine Funtionalized Silica In Polysulfone Based Mixed Matrix Membrane For CO2/CH4 Separation.* Masters thesis, Universiti Teknologi PETRONAS.

Polysulfone (PSF) based mixed matrix membranes (MMMs) are one of the most widely studied polymeric materials for CO2/CH4 separation. Due to the trade-off between permeability and selectivity, the performance of existing PSF membranes incorporating silica nanoparticles still faces a hurdle for extensive development in industrial applications. Membrane performance has been postulated to be enhanced via functionalization of filler at different weight percentages. Nonetheless, the preparation of functionalized MMMs and its empirical study that exhibits improved CO2/CH4 separation performance is challenging at an experimental scale that needs prior knowledge on compatibility between the filler and polymer. Molecular simulation approaches can be used to explore the effect of functionalization on MMM's gas transport properties at an atomic level which has received less scrutiny to date. In addition, most of the research has focused on pure gas studies while mixed gas transport properties that reflect real separation in functionalized silica/PSF MMMs are barely available. In this study, molecular simulation techniques have been used to elucidate the effect of varying weight percentages (i.e., 15-30 wt.%) of amine-functionalized silica and gas concentrations (i.e., 30% CO2/70% CH4, 50% CO2/50% CH4, and 70% CO2/30% CH4) towards physical and gas transport properties in amine-functionalized silica/PSF MMMs at 308.15 K and 1 atm. Using atom-based selections, the COMPASS forcefield was used to analyze gas transport in the membrane, and parameters like as fractional free volume, XRD, Tg, and binding energy were computed. Functionalization of silica nanoparticles has been found to improve the diffusion and solubility coefficients that contribute to an increment in the overall permeability and selectivity of the amine-functionalized silica/PSF MMMs compared to pure PSF and silica/PSFbased MMMs. The optimal weight percentage at 20 wt.% amine-functionalized silica/PSF MMMs were reflected by the highest permeability and selectivity values of 62 barrer and 10.9, and percentage enhancement by 566% and 56%, respectively. The optimal 20 wt.% MMM displayed increased permeabilities up to 62.9 and 65 barrer viii under high pressure (i.e., 20, 40 atm) and temperatures (i.e., 318.15, 328.15 K). By combining mathematical definitions for solubility and permeability, an empirical model based on a parallel resistance approach was developed. In addition, the proposed empirical model's solubility and permeability differed by 7% and 7.5% under mixed gas conditions, respectively, when compared with the simulation results. The successful findings of this simulation study could help to improve CO2/CH4 separation in the future concept of functionalized MMMs to develop and optimize new generation membranes.

Inn Leon, Lu (2023) *Development Of Microseparator With Daughter Channels For Liquid-Liquid Two Phase Separation Using Computational Fluid Dynamics.* Masters thesis, Universiti Teknologi PETRONAS.

This research aims to investigate the dependence of liquid-liquid phase separation performance in microseparators on the influence of geometrical parameters of daughter channels. Existing microseparators use "comb" geometry for separation that is susceptible to high pressure drop due to its extremely miniaturized dimension. In this research, the performance of liquid-liquid phase separation in microseparators was investigated via computational fluid dynamics approach using three different configurations of microseparators, where daughter channels were employed for separation instead of the "comb" design. The performance of the phase separation was characterized by the purity of oil obtained at the main channel outlet (MC_Outlet) and secondary channel outlet regions (SC_Outlet), where high purity of oil in the SC_Outlet region and low purity of oil in the MC_Outlet region are desired. Oil and water were used as continuous phase and dispersed phase, respectively. At continuous phase flow rate of 0.5 ml/h and daughter channels angle of 90˚, single-sided daughter channels microseparator achieved oil purities of 100% in the SC_Outlet region and 26.79% in the MC_Outlet region at daughter channels interval of 500 μm, whereas double sided daughter channels microseparator achieved oil purity of 19.51% in the MC_Outlet region at daughter channels interval of 1000 μm. Additionally, at continuous phase flow rate of 0.5 ml/h and daughter channels intervals of 500 μm, daughter channels angle of 90˚ achieved oil purity of 26.79% in the MC_Outlet region. Furthermore, results obtained from Analysis of Variance indicated that the effect of DC interval is more significant than the effect of daughter channels angle. Doubtlessly, the current study provides new insights on liquid-liquid two-phase flow separation in a microseparator, notably in the production of biodiesel via transesterification process in microchannel reactor

Rosli, Norhazirah (2023) *[Hydrolyzed Chitosan/Polyvinyl Alcohol Nanofibers Functionalized By Ionic Liquid For Heavy Metal Ions Removal.]* Masters thesis, Universiti Teknologi PETRONAS.

The increasing rates of heavy metal ions pollution such as lead (Pb), manganese (Mn), and copper (Cu) from industrial activities in water bodies is a major threat for the environment. Therefore, the removal of these heavy metals from the environment is very important. Even though there are various techniques to treat metal-contaminated wastewater, adsorption process is known to be an effective and economical technique. Chitosan has been used as a bio-sorbent to remove heavy metal ions as it has amino and hydroxyl group which is known to be the active binding sites for metal ions. However, it has low adsorption capacity, low solubility in many solvents, and has a high viscosity that makes it difficult to be processed. The main objective of this study is to develop electrospun nanofibers chitosan membranes to increase the active site for adsorption and further functionalize by ionic liquid to overcome their limitations of low adsorption capacity. Chitosan is first hydrolyzed to increase its solubility and reduce the viscosity to facilitate the electrospinning process and blend with polyvinyl alcohol (PVA) to produce nanofibers membranes. The nanofibers were further functionalized by ionic liquid namely 1-allyl-3-methylimidazolium chloride (AMIMCl) and crosslinked using glutaraldehyde (GLA). AMIMCl was synthesized and verified using 1H NMR. FESEM images and ATR-FTIR analysis proved that the hydrolyzed chitosan/PVA nanofibers were successfully electrospun and modified by AMIMCl and GLA. The selectivity of the synthesized adsorbent was studied onto Pb(NO3)2, Mn(NO3)2, and Cu(NO3)2 in mono-metal media solutions and found to be favorable towards the Pb(II) ions with the highest adsorption capacity recorded of 166.34 mg/g while 5.84 mg/g for Mn(II) ions and 2.38 mg/g for Cu(II). The adsorption behavior of the synthesized adsorbent onto Pb(II) ions was further studied by varying the pH, initial concentration of Pb(NO3)2 solution, and the contact time. The adsorption favors pH 9 and it can be observed that the adsorption capacity of Pb(II) ions increases with initial concentration of Pb(NO3)2 solution. The studies showed that the pseudo-second order kinetic model and viii Freundlich isotherm model are more compatible for describing kinetic rate of the Pb(II) uptake and equilibrium data of the uptake capacity, respectively. This work indeed demonstrates that the electrospun chitosan nanofibers are good adsorbent for heavy metal ions and functionalization by ionic liquid has increased the adsorption capacity significantly.

Yap, Yun Kee (2023) *Alternating Magnetic Field Assisted Dispersion Of A-Fe2o3/Tio2 Particles In Mixed Matrix Membrane For Co2 Separation.* Masters thesis, Universiti Teknologi PETRONAS.

Mixed matrix membranes (MMMs) are widely studied for CO2/CH4 gas separation. However, the incorporated inorganic fillers tend to agglomerate and disperse poorly in the polymeric matrix due to their high surface energy, resulting in the deterioration of gas separation performances. Unconventional filler dispersion via magnetic field shows potential but requires filler with magnetic properties. Moreover, there were limited studies on alternating magnetic field (AMF) effects on the filler distribution. Also, limited quantitative analyses were performed to analyse the filler distribution in MMMs. The correlation between fillers' degree of dispersion and gas separation performance was also unclear. In this study, magnetic-composite α-Fe2O3/TiO2 filler was synthesized and characterized to verify its physiochemical properties. Then, their distribution in PPOdm polymer was evaluated with/without the presence of AMF at varying frequencies and exposure times. The MMMs were characterized based on their morphology, thermal stability, and degree of filler distribution via qualitative and quantitative analyses. The fillers' degree of dispersion was further correlated with their CO2/CH4 gas separation. Based on the qualitative analyses, the fillers' degree of dispersion among MMM's were observed to be similar. The quantitative analyses on fillers' degree of dispersion ($ADDel$,) area fraction, cluster amount and average cluster size in magnetized MMMs were better compared to unmagnetized MMMs. Additionally, MF2 (3.3kHz) and MT2 (8 mins) had the best degree of filler dispersion. From the pure gas permeation test, the highest ideal gas selectivity was achieved by MT2, followed by MT1 (5 mins) and MT3 (11 mins) in varying AMF exposure time, and MF2, followed by MF1 (330kHz) and MF3 (33Hz) in varying AMF frequency. In conclusion, AMF was found to enhance the distribution of α-Fe2O3/TiO2 fillers successfully, which improved the resulting MMMs' gas separation performance through qualitative and quantitative analyses. The most effective AMF exposure time and frequency were around 5 to 8 minutes and 3.3kHz.

Jamallullail, Syed Harun (2023) *The Role Of Language In Dispersing Bipolar Ideologies And Propogating Ethnocentrism And Ethnic Conflicts In Bosnia And Herzegovina.* Masters thesis, Universiti Teknologi PETRONAS.

Language has a huge impact on sociopolitics, especially regarding ethnic conflicts. This sees how language may amplify conflicts and has severe reprecussions to the sociopolitical setting of a region. This occured in Bosnia and Herzegovina whereby the Bosniaks and Serbs are hostile to one another due to the usage of language on the sociopolitical setting. Consequently, illustrating the role of language as a weapon. Therefore, this study aims to study on how language catalyses the conflicts between the Serbs and Bosniaks and its impact to the sociopolitics of Srebrenica. Thus, the thesis argues that certain terms used by groups were percieved differently by different groups. The thesis employed Critical Discourse Analysis whereby the samples were newspapers from Balkan news portals. However, the study would be focusing more on the socioanalysis stage to emphasise the impact of language on society. News from Balkan news portals on a five-year time frame were collected and analysed. The study discovered that different ideologies were embedded via language. This prompts certain groups to adopt an ethnocentric behaviour. Hence, this sees how language managed to activate the social wrong in Srebrenica causing both Bosniaks and Serbs to enter conflicts due to different perspective on the issue. As a result, the conflicts have severe linguistic and political repercussions on society. The study concludes that the (mis) use of social wrongs amplified conflicts whereby both sides are unable to come to a mutual understanding. Subsequently, damaging the ethnic relations in Bosnia and Herzegovina. The implications of the study implies that language plays a role in furthering ethnic conflicts on the socio-political setting due to the politics and history of Srebrenica. Moreover, the study improve existing theories and provided an understanding from different perspectives that may help to comprehend how language advocates ethnic conflict in a socio-political context.

Mat Ti @ Mokti, Nawwarah (2023) *Kinetic Study Of Co2 Adsorption On Impregnated Pyridinium Ionic Liquid-Activated Rubber Seed Shell Carbon.* Masters thesis, Universiti Teknologi PETRONAS.

Carbon capture and storage (CCS) has attracted researchers' attention due to the increasing emission of CO_2 gases, which leads to global warming and climate change. CO_2 adsorption using solid adsorbents such as activated carbon (AC) derived from lignocellulosic biomass waste is one of the effective approaches to reducing CO_2 emissions. Extensive studies have been conducted to develop ionic liquids (ILs) as activating agents in the synthesis of AC. However, there are still limited studies reported on the kinetic and thermodynamics of CO_2 adsorption utilizing rubber seed shell activated carbon (RSSAC) synthesized in the presence of pyridinium-based ionic liquid as an activating agent. In this study, AC was synthesized using RSS by chemical activation with pyridinium-based ionic liquid, [C4Py][Tf2N] with different impregnation ratios (0.5 - 20%) and temperatures (500ºC - 800ºC) for 60 to 120 min. From the study, the optimum conditions were identified to be at an impregnation ratio of 1%, temperature of 800ºC and a holding time of 120 min, which resulted in a specific surface area of 393.99 m^2 /g, a total pore volume of 0.206 cm^3 /g, and a micropore volume of 0.172 cm^3 /g. The performance of AC samples as an adsorbent for CO_2 adsorption was also studied using a static volumetric technique evaluated at temperature of 25˚C and 1 bar pressure. The CO_2 adsorption capacity for the optimum sample is 2.44 mmol/g. The result also showed that the CO_2 adsorption capacity decreased at a higher temperature between 50˚C to 100˚C and increased at elevated pressure due to its exothermic behavior. Different isotherm models are applied to model CO_2 adsorption mathematically. Based on the regression coefficient (R^2), the adsorption data fit well with the Langmuir isotherm. Besides, the CO_2 adsorption was identified to follow the pseudo-second-order kinetics model, exothermic in nature, spontaneous at low temperatures and controlled by physisorption. This study proves that the AC synthesized using RSS through chemical activation with [C4Py][Tf2N] IL and carbonized at a temperature of 800°C is a promising CO_2 capture, low-cost adsorbent with superior surface area and high CO_2 adsorption.

Mohamad Yasin, 'Ainuddin (2023) *Geological and Geomechanical Investigation of Mangking Sandstone in Maran.* Masters thesis, Universiti Teknologi PETRONAS.

Previous studies of Mangking Sandstone were focused on general geology with limited information on geomechanical studies and also focused on Sungai Tekai area with inadequate coverage in the other parts of Mangking Sandstone. This research is aimed to evaluate the geological and geomechanical properties of Mangking Sandstone in Maran. Geological investigations include discontinuity surveys and petrographical analysis while geomechanical tests include Schmidt hammer test, acoustic velocity test, uniaxial compressive strength test, Brazilian tensile strength test and point load strength test. The information was collected to provide Rock Mass Rating (RMR), Slope Mass Rating (SMR), and correlated to investigate the interrelations. Mangking Sandstone in Maran comprises of very fine to medium-grained quartz arenite and grey quartz wacke. The very fine to medium grain size, moderate to well-sorted texture and equiaxial sand grain shape suggested that Mangking Sandstone was deposited in a continental environment. The structural analysis indicates that compressional forces come from the northeast and southwest directions to form most of the fractures which have similar trends to the Mangking Sandstone in Sungai Tekai based on previous studies. Sandstones from Sungai Tekai do not have many differences compared to sandstones from Maran in terms of geomechanical properties. Mangking Sandstone in Maran is dominated by strong sandstone with RMR values between 60 to 82 which indicates that the rock mass lies in between fair to good quality. The SMR values range between 36.6 to 82. Most of the slopes fall into either fair or good quality with a low probability of failure. Mangking Sandstone's geomechanical properties are not heavily influenced by the mean grain sizes. Grain sorting, matrix percentage, and grain shape are the properties that provide a huge influence on the geomechanical properties of Mangking Sandstone.

Nawas Khan, Muhammad Ekrahm (2023) *Chemical Modification On Kati Formation Shales In Enhancing Co2 Adsorption For Carbon Sequestration With Neural Network Approach.* Masters thesis, Universiti Teknologi PETRONAS.

This study aims to investigate the adsorption properties of low-TOC Permian shales of Malaysia (Kati Formation, Seri Iskandar, Perak, Malaysia) and the effects of chemical modification to increase the selectivity and capacity of adsorption at reservoir temperature and pressure. The physicochemical characteristic of the rock is determined using FTIR, TOC, FESEM, SAP-BET, TPD, XRD and XRF on four samples from same shale formation. From the data, the total organic carbon is in between 1.0 – 2.1 wt%, where the x-ray diffraction shows the sample consists of 35 - 85% clay minerals and 15 - 65% silica. The FTIR spectra proves addition and removal several functional groups, mostly in OH- groups, C=C groups and C-H groups. The treatment is effective in addition in mostly unsaturated bonds and removal of aromatic bonds which facilitates potential sorption sites. FESEM morphology analysis shown the pores and kaolinite surfaces to be porous and able to accommodate adsorption of CO2. With BET characterization, the average surface area on the samples that were tested ranges from 8.87 – 16.90 m2/g and their average pore size range from 17.71 – 26.41 nm, and N2 adsorption shows that a type-III isotherm, and type H3 hysteresis loop. Using Langmuir, Freundlich, Toth and Sips isotherm models, their parameters calculated can be used to determine the monolayer, multilayer and heterogenous adsorption. Findings shows that certain modification shows evidence of chemisorption in support of physisorption. Artificial Neural Network was used to increase the reliability of adsorption isotherms and for prediction of uptake data at reservoir temperature and pressure. The training data supplied with 224 datapoints with 70:20:10 ratio of training, validation, and test data respectively. The model trained was found to be reliable and accurate. Chemical modifications on these shales are found to be effective in increasing its adsorption performance for both injection into producing reservoirs and carbon dioxide sequestration.

Ong, Kai Bin (2023) *Enhanced Symbol Recognition Based on Data Augmentation in Engineering Drawings.* Masters thesis, Universiti Teknologi PETRONAS.

Recognizing symbols has received research interest for image analytics of engineering diagrams recently to improve identification and retrieval of specific symbols. Convolutional Neural Network (CNN) have become a more popular approach for symbol recognition compared to structural, syntactic, and statistical techniques. However, the accuracy of CNN recognition is hindered by shortage symbols in certain domains. To overcome this shortage, data augmentation can be used to generate additional artificial samples from existing datasets. CycleGAN is a promising data augmentation technique that has the potential to improve the accuracy of symbol recognition by CNN model. This study highlights the importance of data augmentation techniques for enhancing the accuracy of symbol recognition in engineering symbols in Piping & Instrument Diagrams (P&IDs) of process plants. To validate its performance, the study conducted experiments and compared the results with those from other methods. The proposed method was called CycleGAN+CNN(CCNN) and it showed promising results, with the highest 92.85% accuracy achieved when the number of synthetic samples matched the original samples in the training dataset. This improvement in accuracy can be attributed to the ability of CycleGAN to generate synthetic samples that augment the training dataset and enhance the model's ability to recognize symbols accurately. However, excessive addition of synthetic samples may lead to decreased accuracy. Further research is needed to determine the optimal number of synthetic samples to prevent decreased accuracy in the proposed CycleGAN+CNN method for digitizing P&ID diagrams.

Ramesh, Vishal Avinash (2023) *Investigation on the bond-slip behaviour and mechanical properties of PVA- Engineered Geopolymer Composite (EGC) cured in ambient temperature.* Masters thesis, Universiti Teknologi PETRONAS.

Engineered geopolymer composite (EGC) is becoming an uprising product to the civil industry as a substitute and solution for conventional geopolymer concrete (GPC) as GPC experiences brittle behaviour and has poor cracking resistance. In this research, EGC is investigated in terms of bonding strength, bond stress- slip curve and bond failure modes as the main part as well as mechanical properties which includes compressive strength, tensile strength and flexural strength. Furthermore, effect of Ground granulated blast furnace slag (GGBS) on compressive strength of EGC is studied with the Response surface methodology (RSM) method. Mix designs were performed in this research using the optimized parameter from RSM where the main factor that varies is percentage replacement of silica fume which includes 5%, 10%, 15%, 20. The main parameters of bond behaviour in this research include varying embedment length and rebar diameter. The mechanical properties and bond behaviour of EGC are compared and analysed with GPC. Results indicate that EGC has better mechanical properties and bond performance compared to GPC, where EGC has approximately 12% higher flexural strength, 150% higher tensile strength, and 11% higher bond strength compared to GPC. In addition, an optimum amount of 2% of PVA fiber present in EGC matrix has greatly improved the flexural, tensile and bond failure modes of EGC sample, where it is observed to be ductile for EGC compared to GPC which has a brittle failure. Other than that, PVA fiber largely influences the bond failure modes where from the pull-out test, EGC specimens fail in ductile manner with the pull-out or pull-out splitting failure compared to GPC which has splitting failure. The bond strength of EGC obtained in this research is validated with the available theoretical approach and the difference between the experimental and theoretical bond strength value is 10%. From this research, the utilization of EGC that was produced could be expanded in the production of eco-friendly construction material and also could be utilized in rehabilitation of structures such as the repair works of structures.

Eliz Ibrahim Mohamed, Mohamed Mamdouh Abou Eliz Ibrahim Mohamed (2023) *Experimental Assessment Of A Solar Still Integrated With Thermal Energy Storage And Compound Parabolic Concentrator.* Masters thesis, Universiti Teknologi PETRONAS.

Sea water desalination is a popular method to produce fresh water for many purposes. In this research, solar energy is considered an alternative to fossil fuels used as an energy source for water desalination to produce drinkable water. The system used is called the solar still, and it uses a thermal process to separate the salt from the water. The developed solar still in the research is a hybrid configuration utilizing direct solar heating in the basin and indirect solar heating by a concentrated collector. The design procedure used a partitioned design to maintain the least amount of contact possible between brackish water and components of the system due to the corrosive nature of saline water. The developed hybrid system has three improvements; usage of Phase Change Material (Paraffin wax) as thermal energy storage, CuO nano-in-black paint, and Compound Parabolic Collector (CPC). The testing was conducted at Universiti Teknologi Petronas solar site (STARC) at 4.4° N longitude and altitude of 24 m. The study looked at the system in 5 configurations, and data was collected 24 hours throughout the day. The study utilized 2 systems for testing, both with the same basin and cover area. The first system, a conventional solar still, acts as the datum for comparison. The second system was operated in 4 configurations (PCM, PCM + CPC, PCM + NP, PCM + NP + CPC). The conventional system was operated along all configurations to provide a datum for the day's weather conditions. The hybrid system was able to produce 7.033 L/m2 .day in the rainy season of Malaysia with low relative solar irradiation when operating the configuration integrating PCM + NP + CPC. It is a 335.1% increase over the conventional configuration. The water produced has been tested using PH, DO, and dissolved solids, and all criteria are within drinkable water from the modified solar still.

Hilmi, Muhammad Zahid (2023) *Comparative Study Of Surrogate Techniques For Hyperparameter Optimization In Recurrent Neural Network.* Masters thesis, Universiti Teknologi PETRONAS.

Long Short-Term Memory (LSTM) models are a type of recurrent neural network (RNN) well-suited for tasks requiring the model to remember long-term dependencies. This makes them a promising approach for ET rate estimation, as ET is a process that is influenced by various factors that may occur over long periods. In this research, the author investigated the efficacy of LSTM models for ET rate estimation. The author first assessed the efficacy of ET models frequently employed to predict ET rates to decide which models are the most suitable given the current situation and data availability. The author then proposed a hybridization technique that involves the LSTM and Gated Recurrent Unit (GRU) architecture. This process optimizes the LSTM-GRU hybrid model for predicting the ET rate through hyperparameter tuning. The research indicates that the hybrid LSTM-GRU model, utilizing optimized Hyperparameter Tuning, exhibits superior performance compared to both the vanilla LSTM and LSTM models with standard Hyperparameter Tuning. Substantial enhancements in forecast precision were noted across diverse assessment criteria. The study analyzed several cases and found that the models with the highest performance were Case 99, Case 36, and Case 90. These models demonstrated superior results concerning MAE values of 0.0626, 0.06446, and 0.06606, MSE values of 0.00667, 0.00706, and 0.00759, RMSE values of 0.0817, 0.084, and 0.0871, and R^2 values of 0.99261, 0.99219, and 0.9916, respectively. In addition, the LSTM model, utilizing optimized hyperparameter Tuning, attains a noteworthy mean absolute error (MAE) of 0.0712, mean squared error (MSE) of 0.00861, root mean squared error (RMSE) of 0.09278, and coefficient of determination (R^2) of 0.99047. These results demonstrate the efficacy of LSTM models for ET rate estimation. The hybrid LSTM-GRU model, in particular, offers significant advantages over other models, as it is able to maintain long-term dependencies and achieve high levels of accuracy. This makes it a promising approach for ET rate estimation in a variety of Tuning

Jeffri, Nor Farzana Syaza (2023) *Enhancing The Design Of Augmented Reality Systems For Manual Assembly Using Effective Visual Cues.* Masters thesis, Universiti Teknologi PETRONAS.

Manual assembly operators are prone to high levels of mental workload, which can result in product defects costly errors. Augmented Reality (AR) technology has potential in the manual assembly industry to reduce mental workload and improve task performance. However, the effectiveness of an AR system depends on its design. This research aims to identify effective AR visual cues with the goal of enhancing the design of AR systems for manual assembly. Existing visual cues, categorized based on manual assembly frameworks, were simplified into two cues (2D images and spotlights) for picking and four cues (arrows, contours, silhouettes, and 2D images) for placing. An AR system prototype was developed with these cues. An experiment involving 22 participants assessed the effects of the cues. Task completion time and error rate measured task performance, while the NASA-Task Load Index assessed mental workload. The results showed that spotlights were effective in reducing error rates for the picking task, while silhouettes were the most effective cue for the placing task, resulting in shorter completion time, lower error rate, and less mental workload. Conversely, 2D images performed poorly compared to other cues for placing tasks. This research provides empirical evidence for designing effective AR systems in manual assembly. Suggestions for future work includes developing a comprehensive AR guidance system incorporating these cues and comparing it with traditional instructions and other AR systems.

Kamaruddin, Nur Anis Liyana (2023) *Removal of Pb(II) Ions from Aqueous Solution using Solid-Supported Ionic Liquids (SSILs).* Masters thesis, Universiti Teknologi PETRONAS.

High viscosity and cost of ionic liquids (ILs) are among the major drawbacks in the usage of ILs as an adsorbent. These drawbacks may affect the capability of ILs as potential alternatives of metal adsorbent. This study aimed to evaluate the use of novel SSILs as a cost-effective and efficient method to remove Pb(II) ions from aqueous solution. Firstly, ILs containing functional groups i.e., thiosalicylate, salicylate and dicyanamide were synthesized and characterized based on structural, purity and thermal stability before immobilizing chemically onto a solid support material. Batch adsorption experiments were carried out to investigate Pb(II) sorption parameters. Accordingly, the effects of mass ratio of activated silica gel to ionic liquids (1:0.1 to 1:0.5, g/g) in SSILs, pH (3 to 9), contact time (2 to 250 min) and initial metal ion concentration (10 to 200 mg/L) were explored. The sorption data of all SSILs obeyed pseudo-second order kinetic model and Freundlich isotherm model, suggesting heterogeneity in adsorption mechanism governed by chemisorption process. The maximum adsorption capacities obtained were 8.3970 mg/g, 7.2106 mg/g and 4.4410 mg/g for thiosalicylate, salicylate and dicyanamide-based SSILs, respectively. Further evaluation of Pb(II) sorption using thiosalicylate-based SSIL was conducted through Response Surface Methodology (RSM) to investigate the effects of four independent factors i.e., pH, initial metal ion concentration, adsorbent dosage and contact time on the removal of Pb(II) ions from aqueous solution. The experimental data were fitted to a quadratic model with R2 value of 0.9940. The accuracy of the developed model was confirmed through additional experiments where the experimental values were found to be within the 95% confidence interval. From the RSM-generated model, the optimum conditions for Pb(II) sorption in aqueous solution were at pH 8, initial metal ion concentration of 146 mg/L, 0.2 g of SSIL dosage and 120 minutes of contact time. The results obtained from this study indicate that SSILs have high potential as cost effective adsorbent for the removal of Pb(II) ions.

Mohammad Nazari, Najat (2023) *Mtgs And Methods For Assessing Lubrication Oil Parameters For Degradation Prediction.* Masters thesis, Universiti Teknologi PETRONAS.

The lubrication oil change interval recommended by original equipment manufacturers (OEM) is designed to deliver maximum engine protection when operating under a wide variety of conditions. It is estimated that more than 30.3 billion litres of used lubrication oil are produced annually. The increasing amount of used lubrication oil produced is due to unnecessary lubrication oil change. The objective of the study is to evaluate the lubrication oil test parameters that influence the effectiveness of lubrication oil for remaining useful life (RUL) prediction. Data were collected from the lubrication oil reports which comprised of lubrication oil samples from two gas turbine generators. Lubrication oil test parameters considered in this research were kinematic viscosity (40°C), total acid number (TAN) and particle count based on test standard ASTM D445, ASTM D664 and ISO 4406. Statistical trending and correlation analysis were performed as preliminary analysis. Mahalanobis-Taguchi Gram-Schmidt (MTGS) was applied to evaluate lubrication oil test parameters that influence the effectiveness of lubrication oil. Signal-to-noise ratio (SN ratio) gain for kinematic viscosity (40°C), TAN and particle count > 6 µm were positive. The degradation of these three parameters were predicted based on Gaussian process regression (GPR). Corresponding maximum oil age at critical threshold were identified for RUL evaluation. For both equipments, TAN prediction model was selected with maximum oil age of 25.7 months for Equipment 1 and 23.4 months for Equipment 2 at critical threshold. At this oil age, the predicted degradation of kinematic viscosity (40°C) and particle count > 6 µm were still within its critical threshold. The results revealed that the lubrication oil change interval can be extended. The study presents a new insight on the application of MTGS to evaluate the lubrication oil test parameters that influence the effectiveness of lubrication oil for RUL prediction. GPR was applied to predict degradation of the lubrication oil test parameters until its critical threshold. For future work, oil analysis can be specifically conducted for the study to gather detailed information such as data on running hours and operating condition. Accelerated oil ageing test can be conducted to obtain data from fresh and completely degraded lubrication oil.

Tabaaza, Grace Amabel (2023) *Application of Machine Learning To Predict The Toxicity of Ionic Liquids.* Masters thesis, Universiti Teknologi PETRONAS.

QSAR methods address data scarcity in IL toxicity, but often rely on univariate analysis, isolating cation, or anion effects without accounting for variations between ionic counterparts. Assumptions of fixed effects and lack of cation-anion interactions are common, with some studies incorporating electrostatic or topological descriptors. This approach has been improved using GRID in VolSurf+ for in silico physicochemical descriptors of anions and cations, validated by QSAR with strong correlation in aquatic toxicity. To manage extensive datasets, nine principal properties (PPs) were introduced as descriptors, enhancing representation for 38 anions (4 PPs-) and 218 cations (5 PPs+). To improve upon this advancement, this study deploys unsupervised machine learning and robust supervised machine learning framework for IL toxicity assessment. K-means clustering was used to explore the influence of the various descriptors on the IL toxicity. Supervised machine learning algorithms were used to build QSAR models for predicting cytotoxicity on leukemia rat cells (IPC-81), acetylcholinesterase inhibition (AChE) enzyme toxicity, and Vibrio fischeri ecotoxicity using PPs. Feature selection and hyperparameter tuning were also implemented to enhance model performance. In this study three (3) linear models and three (3) treebased models are used. Analysis of the effect of various descriptors on the toxicity outputs showed that molecular properties like hydrophilicity are linked to reduced toxicity, while hydrophobicity and higher partition coefficients are associated with greater toxicity. In ionic liquids (ILs), longer alkyl chain lengths heighten toxicity, outweighing the impact of cationic core type, suggesting their significant role in determining IL toxicity. Based on the initial model screening, the Ridge regression and XGBoost models were chosen among the linear and tree-based models respectively. Performance evaluation of the developed models with relevant features showed that the optimized Lasso-Ridge and optimized RF-XGBoost models were most effective for IPC-81 prediction with prediction accuracy of 0.7749 and 0.8759 respectively. The viii optimzed SkB-Ridge (R2 = 0.7476) and optimized SkB-XGBoost (R2 = 0.9292) were the most robust models for AChE prediction. The optimized RF-Ridge (R2 = 0.9731) and optimized SkB-XGBoost (R2 = 0.9337) were the most robust models for Vibrio fischeri prediction. Despite the higher prediction performance of the XGBoost model, the Ridge regression model proved more robust in external validation. Finally, the Ridge regression models were deployed to develop an Excel-based prediction tool. Therefore, this study improves QSAR studies on toxicity prediction of new ILs with the application of machine learning, feature selection techniques and hyperparameter tuning and develops a readily accessible predictive tool

W Mohd Zainudin, W Nur Safawati (2023) *Integrating Well Logs And NMR Analysis To Generate Machine Learning Prediction Model For Enhanced Reservoir Characterization For Baram Delta, Sarawak Basin.* Masters thesis, Universiti Teknologi PETRONAS.

Economic growth and rising global energy demand, known reserves being depleted, and limited new prospect discoveries were pushing drilling and production into deeper reservoirs. Challenges where the recovery factors were much lower, typically 10% to 30% lower especially in brownfields. Well Beta Deep ST1 was an exploration well, drilled into the deep reservoirs (Z reservoir) to determine the presence of hydrocarbons and evaluate their potential, while also obtaining conventional cores for Nuclear Magnetic Resonance (NMR) measurements. The deep reservoir is found to be oilbearing, but it presents challenges due to low porosity and permeability values. The conventional core analysis is conducted with limited SCAL plugs due to high cost, hence not much core data is available. For that reason, a new technology of using machine learning (ML) methodology to predict the desired reservoir properties is used to give a positive impact such as in the consistencies in performing reservoir evaluation. ML utilizes the raw logs data to predict the reservoir quality with less constant applied in the equation hence will reduce the uncertainties. The primary objective of this research is to develop an ML model that leverages on core NMR measurement results to predict the quantity of moveable fluid, porosity, and permeability of reservoir rocks in un-cored intervals and in other existing wells, using conventional log data as the input. The output will be predicted logs of moveable fluid, porosity, and permeability values, which can be employed to assess the potential and flow capacity of the deep reservoir rocks. The secondary objective is to study the diagenetic events and their impact on reservoir quality at Z reservoir by performing sedimentological analysis such as petrography thin sections analysis. The reservoir quality of the analyzed samples was assessed by estimating composition, texture, pore volume, and the authigenic phase of the rock fragments.

Pratama, Hadyan (2023) *Automated Geological Interpretation In 3d Seismic Data Using Semi-Supervised Learning.* Masters thesis, Universiti Teknologi PETRONAS.

A geological interpretation plays an important role in gaining information about the structural and stratigraphic of hydrocarbon reservoirs. However, this is a timeconsuming task due to the complexity and size of seismic data. Recently, the growth of computing power has enabled the application of Artificial Intelligence and Deep Learning models in service of studying many geoscience challenges, including the prediction of geological features in seismic data. Although, the Deep Learning model relies on two aspects, including the dataset size and the hyperparameter selection. This research proposed a semi-supervised machine learning method which combined unsupervised technique to gather and build the dataset and supervised technique named Convolutional Neural Network (CNN) to automatically and accurately delineate the geological features from 3D seismic data. A new enhanced workflow based on unsupervised learning has been designed to generate labelling data for the training model. This workflow utilized seismic attributes and Kernel-PCA to enhance the visualization of geological targets and cluster the features into binary classes using the K-means approach. By using this workflow, a more data-driven model can be developed. This research trained the CNN model using U-Net architecture by considering geological interpretation in seismic data as the segmentation image problem. By fine-tuning several hyperparameters and leveraging the transfer learning technique, the model accurately predicts the actual class by evaluating it using the F1 score and Intersection over Union (IoU) score. This workflow was applied to two seismic datasets with different geological settings to validate the result from the trained model. The synthetic data and the real seismic investigation from the Angsi Field in the Malay Basin. From this application, the CNN-based model is highly accurate and consistent with the previous manual interpretation in both cases. In addition to qualitatively evaluating the interpretations, the 3D body of the predicted geological target was extracted. With the seismic geomorphology analysis, the predicted result viii from a real seismic dataset from Angsi Field could reveal several fluvial depositional elements, including point bar and channel sands. This result could help the interpreter focus on tasks requiring human expertise and aid the model's prediction in subsequent studies.

Mohd Fauzi, Noor ‘Aliaa Amira (2023) *Development Of A New Formulation For Fines And Sand Agglomeration At Separator.* Masters thesis, Universiti Teknologi PETRONAS.

Sand production is a traditional issue in the oil and gas industry and can be challenging if the amount is unexpected. “Solids production” is a term used to refer to all solid materials that exist with produced oil and gas. Typically, solids production may include the solid particles and debris from drilling and completion activities, fines, and sand. These solids can erode and promote corrosion on the surface and downhole equipment, requiring additional costs to rectify the problems. This occurrence is often known as fines carryover further downstream of the surface equipment, contributing to additional non-productive time. This research focuses on reducing sand and fines carryover in the surface facility, specifically the separator. Of particular interest, it is accomplished by encouraging sand/fines agglomeration in the separator, which results in larger particles and shorter solids settling time. The planned accumulated particles are to be taken out through sand jetting. Since most of the previous technology focused on not allowing sand production, this limitation of producing sand makes it an essential criterion of the research. The research primarily aims to develop and evaluate a new formulation for a polymer-based sand/fines agglomeration. The research involves characterization of sand, crude, and produced water for a full analysis of the chemical performance. The passing criteria is set based on the prior sand deposition study of the actual separator configuration in both fields. Two types of polymers were identified: a cationic and an anionic polymer. The evaluation of chemical performance was done under no shear and high shear condition. Further optimization of the formulation conducted by mimicking the actual separator condition. It was concluded that combo polymer system is required for Field A and a single cationic polymer system for Field B to achieve the optimal agglomeration performance. The outcome of this research is expected to provide better Open viii understanding of the agglomeration chemical performance with reservoir formation conditions and a basic guideline on experimental procedures to be conducted.

Ishak, Effa Affiana (2023) *Development Of A Modified Solidification And Stabilisation Technique For Petroleum Sludge In A Cementitious Framework.* Masters thesis, Universiti Teknologi PETRONAS.

The surge in petroleum demand poses an environmental challenge due to PS generation and improper disposal. Current methods are costly and experimental, lacking a definitive solution. The widely used of SS technique results in low compressive strength which makes it unapplicable for industrial use. This study presents an innovative approach to address these challenges by introducing modified SS technique through FA incorporation in mortar mixture and epoxy coating for PS before encapsulation in the cement matrix. Raw PS have been tested physically and chemically to analyze its specific gravity, pH value, PAH and heavy metal content through XRF and GC-MS analysis. The effect of organic compound towards the cement matrix has been studied using various compositions of mix design which includes 10%, 20%, 30% of PS, 5%, 10%, 15% of FA, and 5% of epoxy incorporation. Through comprehensive analysis, results obtained validated the pessimistic impact of PS towards cement through morphology structure of samples. The laboratory experiments and tests carried out on these samples include compressive strength, toxicity characteristic leaching procedure, water absorption, FESEM analysis, physical detail observation, FTIR analysis, EDX mapping on elements existence, as well as ANOVA testing in study the correlation of percentage of PS with curing days, water permeability, and compressive strength of experiment products. This study identified that the addition of epoxy as an additional binder contributed towards the growth of mortar structure and bond. In addition, PS coated with epoxy with addition of pozzolanic materials as a filler successfully enhances the performance of the solidified waste to be compared with cement-sludge sample. A significant hike in the compressive strength was observed to be compared with the samples with no additional binder added. Overall, this study has been successfully encapsulated the PS in the cement matrix and advancement of SS performance was achieved through epoxy coated PS samples.

Effendi, Adam Daniel (2023) *Pectic Polysaccharides (Pectin) In Agriculture Waste As Natural Kinetic Hydrate Inhibitor At High Subcooling.* Masters thesis, Universiti Teknologi PETRONAS.

Recent industrial trends encourage administration to update and utilize better substitute to existing practices. These alternatives reduce overall production and operational cost. In Malaysia, the agriculture, and the oil and gas industries have the opportunity to develop Pectic Polysaccharides (Pectin) extracted from organic waste for various purposes. As a green alternative, it can remedy oil and gas issue specifically gas hydrate implementation cost and environmental issues while generating revenue for the agriculture companies and reduced their generated waste. Therefore, investigation and an evaluation of pectin was done based on previously developed methodology. The methodology used High Pressure Micro Differential Scanning Calorimeter (HP-µDSC) device to detect hydrate formation in two experimental conditions: constant cooling – isobaric, and isothermal – isobaric condition. Each condition has different monitored parameter, hydrate formation temperature and induction time for ramping method and isothermal method, respectively. These methods were used to examined new potential pectin source for hydrate inhibition, find the difference in performance from each type of pectin in different condition, and statistically analyse obtained results descriptively and through Full Factorial method. The investigation has discovered Tamarindus Indica L. seeds polysaccharide (TSP) to have inhibitory performance through isothermal method; managing to delay hydrate formation for 101.66 minutes and 174.41 minutes, at 0.25 wt.% and 0.50 wt.%, respectively. The assessment of each pectin types concluded low methoxylated pectin (LMP), high methoxylated pectin (HMP), and amidated pectin (AMP) have their optimal environmental condition in term of performances. HMP suited best at higher subcooling (23℃) while LMP performed best at lower subcooling (21℃). However, AMP perform the best when the temperature gradually decreases (constant cooling – isobaric condition). These comprehensives evaluation defined their inhibitory ability better and more accurately. Hence, implementation of Pectic Polysaccharides (Pectin) requires preparation to ensure correct application.

Lumen, S M Sanzad (2023) *Design And Development Of A Hybrid Dc Circuit Breaker Topology With Regenerative Current Breaking Capability.* Masters thesis, Universiti Teknologi PETRONAS.

Recently, dealing with DC power has become significantly easier due to the stunning breakthrough of semiconductor technology and the continuous development of power electronics. The DC power system is getting immense attention in application areas such as DC Microgrid, HVDC Transmission, HVDC Grid, Electric Traction, etc. Despite its numerous advantages, interruption of DC current poses significant challenges due to the lack of a natural zero crossing like AC current has. Furthermore, when current flows in a DC network, energy is stored in the network inductances, and this stored energy strongly opposes the current breaking. Therefore, for safe and efficient breaking of DC current, the stored energy of the network must be removed. A DC Circuit Breaker (DCCB) is the appropriate technology to break this current, and while doing so, it absorbs the energy and dissipates it as heat through snubber networks or nonlinear resistors. This conventional current breaking technique makes the circuit breaker operation inefficient, especially in highly inductive networks, because a significant amount of energy is wasted during every current breaking operation. In this study, a hybrid DC circuit breaker topology capable of fast current breaking along with energy regeneration is proposed. The main feature of the proposed topology is that during every current breaking operation, it conserves energy instead of wasting it and regenerates it afterwards, which none of the existing topologies can do. A detailed mathematical model for current breaking and regeneration operations was derived, and accordingly, the circuit breaker's performance evaluation criteria were established. The proposed DCCB topology was modeled and simulated in PSIM software to break the current and regenerate energy in a radial DC network. In addition to that, performance indicators such as current breaking time, energy recovery efficiency, conduction loss, voltage stress, etc., were thoroughly investigated and evaluated. The simulation results were compared with the outcome of the mathematical model as well as with those of the major conventional topologies. The mathematical modeling and simulation results of the proposed concept are supported by experimental results. A prototype of the viii proposed model with scaled down parameters was developed for experimental validation. Both the current breaking and regenerative capabilities of the prototype were validated through experimentation, and the performance indicators were thoroughly checked and evaluated. Finally, the simulation results, the experimental results, and the responses calculated by the mathematical model were all compared to each other and found to be consistent. This new capability of regeneration ensures the energy efficient operation of the DCCB and enhances the overall system performance by conserving energy.

Zulkiffli, Puteri Nor Ilya Nadia (2023) *A Subjective Data Quality Metrics To Assess Retail Inventory Dataset.* Masters thesis, Universiti Teknologi PETRONAS.

Data quality management remains a challenge in every organization where highquality data is needed to help decision-making. Poor data quality management has a negative impact resulting in financial loss, loss of privacy, business process failure, and inefficiencies, creating legal and security risks and loss of reputation. Much research has been conducted on the data quality areas, but not many studies specifically focus on the retailing area with dedicated dimensions, sub-dimensions, and measurement parameters to assess the inventory dataset from a data collector point of view. The problem in retailers' inventory has led to a loss in profit even though most retailers have implemented a system. However, without a proper assessment that consists of dimensions with their own sub-dimensions at the early stage, the data with quality would not be acquired. Besides, this study tried to fill up the research gap in the body of knowledge which is the previous data quality studies were not in the detail that consisted of dimensions, and dedicated sub-dimensions, in retailing inventory sector. Hence, the objectives of this study are (1) to investigate the data quality issues that arise throughout the business process and how it affects the quality of the dataset, (2) to investigate the appropriate dimensions used in assessing data quality in inventory dataset, (3) to develop a subjective metrics that consist of measurement parameter in supermarket retailing, specifically to assess retail inventory dataset to identify data with quality and (4) to investigate how the developed subjective quality metrics helps data collector to assess retail inventory dataset. This study adopts a single case study research method on the retail sector, which was appropriate for exploratory studies. The study highlighted outcomes from an in-depth interviewed with case study's data consumers in inventory management from the Headquarters and three branches in the northern area of Malaysia were interviewed to gain an insight into their requirements and the dimensions (criteria) of data quality to assess the inventory dataset. The case study's respondents were from a player in the retailing industry. The Total Data Quality Management (TQDM) theory viii was adapted to support the development. Three dimensions, namely Accuracy, Completeness, and Timeliness, were crucial in developing subjective data quality metrics at the end of the research. Each dimension consists of its own sub-dimension: reliability, correctness, precision, validity, and closely-match are sub-dimensions of accuracy. Contain all required information, sufficient breadth, and depth, data is not missing, and a null value is defined are sub-dimensions for completeness. Finally, timely, currency, availability, and volatility are sub-dimensions for timeliness. The findings of sub-dimensions have been grouped to support the assessment of the main dimensions are the contribution to the body of knowledge as most previous studies only focus on main dimensions but not the sub-dimensions that could support the dimension to be supported from various perspectives. Hence, a subjective metric, consisting of measurement parameters in supermarket retailing, specifically to assess the inventory dataset, is proposed, and reviewed by credible experts. The subjective metrics enable the data collectors to assess the data acquired at the early stage of inventory record collection and ensure that quality data requirements are fulfilled.

Raman, Moganes (2023) *Development Of Mechanically Reinforced Efb-Cg (Empty Fruit Bunch-Chitosan Graphene) Composite For Mercury Adsorption.* Masters thesis, Universiti Teknologi PETRONAS.

Mercury contamination is a prominent threat because it is a potent neurological poison in fish, wildlife and humans. Inorganic mercury greatly increases its toxicity and the potentiality for accumulation in aquatic organisms. Currently, composites which act as adsorbents had weak mechanical strength and had a lower adsorption capacity because they had trouble removing Hg2+ . Hence, the aim of this study is to develop empty fruit bunch-chitosan reinforced with rGO (EFB-CG) composite film via solvent casting method which leads to environmentally friendly and ecologically responsible for the removal of mercury. Firstly, 1.5 wt% of chitosan powder, 10 wt% of glycerol were mixed together in a 2%v/v acetic acid solution. Later, 0.1-0.5 wt% of rGO and 0.2 g of chopped EFB fibers were added to the solution to form composite filmogenic solution. The composite solution was casted on petri dish and was peeled off after drying process. The developed EFB-CG composite films were thoroughly analysed using scanning electron microscopy, thermogravimetric analysis, Fourier transform infrared spectroscopy, UV-vis spectroscopy and tensile test. EFB-CG 0.3% composite film recognized as mechanically strong because it has higher tensile strength of 14.58 MPa. EFB-CG 0.3 wt% composite film is stronger, mechanically stable and attained adsorption capacity of 75.23 mg/g. This composite film was further utilized to evaluate the adsorption capacities in terms of adsorbent dosage, contact time, specificity, initial concentration of HgCl2 and pH. The adsorption performances were highlighted with the optimum adsorption parameter in terms of mercury (II) contents (120 mg/L), contact time (9 th hour), solution pH (8), adsorbent dosage of composite film (0.3 g) and selectivity of mercury (Hg2+, Pb2+, Zn2+, Cu2+). These findings were firmly justified that Freundlich isotherm model and Pseudo-second order model met the requirement of the adsorption of mercury by EFB-CG 0.3% composite film. As a result, EFB-CG 0.3% composite film was proven to have high potential to eliminate heavy metal like Hg2+ from water.

Rashid, Noor Adilah (2023) *Self-Optimized Long Short-Term Memory For Predicting Remaining Useful Life Of Machines.* Masters thesis, Universiti Teknologi PETRONAS.

Remaining Useful Life (RUL) is the period from the current time to the time when a machine fails to operate. Unexpected machine failure brings critical damages to the industry, such as loss of investment in assets and high unplanned maintenance costs. Machine failure and RUL of machines can be predicted by using Recurrent Neural Network- Long Short Term Memory (RNN-LSTM) to avoid such consequences. RNN-LSTM utilises the long period of time series data recorded by machines without any memory issues due to LSTM. Long-Short Term Memory unit (LSTM) is an improvement of the Recurrent Neural Network (RNN) as RNN faces issues predicting long-term dependencies. Issues such as vanishing and exploding gradients result from backpropagating errors, taking place when the network is learning to store and relate information over extended time intervals. LSTM selective memory mechanism only reserves space for significant inputs. Thus, RNN-LSTM suits time-series predictions such as machine failure prediction. The performance of RNN-LSTM, specifically accuracy, depends heavily on the weight training algorithm and network hyperparameter topology. However, the existing RNN-LSTM suffers from the limitations of being easily trapped in local minima and slow convergence due to the backpropagation through time (BPTT) weight training algorithm. These limitations would lead to less accurate weight being used during model training. Finding the optimal network topology which promises optimal performance is also a challenge. This can be solved by resorting to hyperparameter tuning, such as changing the number of LSTM units in the hidden layer to an optimal value that maximises the performance of RNN-LSTM. Commonly, grid search methods and manual trial and error tuning are used. However, these methods are time consuming and laborious. Thus, an alternative training algorithm that optimises network weight and hyperparameter topology is highly required. This research proposes a hybrid prediction method known as Self-optimized Long Short Term Memory (SOLSTM)) to improve these gaps. It is an integration of RNN-LSTM and GA, which performs duality functions to optimise both network weights and topologies by using a hierarchical optimisation approach. This proposed prediction technique is compared to the conventional RNN-LSTM with BPTT (LSTMBP), and GA weight-optimised RNN-LSTM (LSTMGA) methods on the sensor reading datasets. The results show that the accuracy of SO-LSTM has improved significantly for all tests compared to LSTMBP and LSTMGA.

Zainuddin, Zahirah (2023) *Predictive Analytics For Equipment Failure By Using Gated Recurrent Unit – Genetic Algorithm (Gru – Ga).* Masters thesis, Universiti Teknologi PETRONAS.

Failure is described as an inability to attain a desired goal and acknowledged to be contradictory with success. It is a scenario that happens frequently across several industries and results in either minor or severe consequences such as maintenance expenses, production disruption and safety concerns. The reasons behind this issue are always related to improper predictive maintenance, prolonged equipment operating hours and many other factors. Hence, the issue can be solved by adopting a prediction activity to monitor and predict the state of equipment in advance. Prediction predicts the upcoming instance by evaluating the assertions obtained from the gears. In this case, Deep Learning (DL) is chosen to construct the prediction activity for estimating the life expectancy of an equipment. Gated Recurrent Unit (GRU) algorithm is used to cater the predicting action of equipment state based on data from an oil and gas industry. GRU is a deep neural network algorithm that computes and stores essential data while projecting the prediction output using update and reset gate mechanisms. Yet, GRU has hyperparameters that affect the method's execution performance. The hyperparameters are now assigned to random values because of no optimal network topology has been found leading in non-optimal prediction results. GRU employs a Genetic Algorithm (GA) to find the optimal hyperparameter values. In a nutshell, GA is recognized to produce the optimal solution from the survival of the fittest over the concept of natural evolution with several steps to hit the end. As GA able to provide the optimal values for the hyperparameters of GRU, the prediction accuracy of the model is improved by reducing Root Mean Squared Error (RMSE) values to roughly 0.339 on average across the dataset. Thus, GA is validated to improve the accuracy of GRUS's equipment state prediction.

Bin, Ong Kai (2023) *Enhanced Symbol Recognition Based on Data Augmentation in Engineering Drawings.* Masters thesis, Universiti Teknologi PETRONAS.

Recognizing symbols has received research interest for image analytics of engineering diagrams recently to improve identification and retrieval of specific symbols. Convolutional Neural Network (CNN) have become a more popular approach for symbol recognition compared to structural, syntactic, and statistical techniques. However, the accuracy of CNN recognition is hindered by shortage symbols in certain domains. To overcome this shortage, data augmentation can be used to generate additional artificial samples from existing datasets. CycleGAN is a promising data augmentation technique that has the potential to improve the accuracy of symbol recognition by CNN model. This study highlights the importance of data augmentation techniques for enhancing the accuracy of symbol recognition in engineering symbols in Piping & Instrument Diagrams (P&IDs) of process plants. To validate its performance, the study conducted experiments and compared the results with those from other methods. The proposed method was called CycleGAN+CNN(CCNN) and it showed promising results, with the highest 92.85% accuracy achieved when the number of synthetic samples matched the original samples in the training dataset. This improvement in accuracy can be attributed to the ability of CycleGAN to generate synthetic samples that augment the training dataset and enhance the model's ability to recognize symbols accurately. However, excessive addition of synthetic samples may lead to decreased accuracy. Further research is needed to determine the optimal number of synthetic samples to prevent decreased accuracy in the proposed CycleGAN+CNN method for digitizing P&ID diagrams.

Khalid, Hafizatul Alina Binti Mohd (2023) *A Study On Green Human Resource Management Towards Organizational Citizenship Behavior Towards Environment In Two of Petronas Downstream Petroleum Operation: A Moderating Effect of Perceived Organizational Support.* Masters thesis, Universiti Teknologi PETRONAS.

Organizational Citizenship Behavior towards Environment (OCBE) is a developing concept that is progressively utilized in describing and explaining employees' voluntary behavior in organizations that contribute to reduce negative impacts on environment by inspiring employees' active environmental citizenship behavior and eventually promoting green and low-carbon workplace. Considering the depth of OCBE literatures, this study attempted to close literature gap by exploring impact of employees' OCBE through organizational practices such as Green Human Resource Management (Green HRM). Besides, moderation effect is being examined between Perceived Organizational Support (POS) and the relationship between OCBE and Green HRM. The survey was conducted virtually, and 256 responses were collected from employees ranging from executives to senior managers in two of PETRONAS downstream petroleum operations in Malaysia. The collected data were computed into SPSS software program to analyze results of frequency analysis, reliability testing using Cronbach's Alpha coefficient, Pearson correlation coefficient and multiple regression analysis. Based on the findings, Green HRM has a direct positive impact on employees' OCBE in organization. Furthermore, these findings illustrate that POS moderates the relationship between OCBE and Green HRM. Thus, this paper contributes to the advancement of literature of OCBE by providing more information for research study in examining the impacts of employees' OCBE on organizational practices such as Green HRM with the moderating effects of POS in two of PETRONAS downstream petroleum operations in Malaysia.

Mann, Christine Ch'ng Wei (2023) *Study on the Performance of Membranes Containing Low Loadings of Zeolitic Imidazolate Framework-8 and Polysulfone for CO2 Removal from CH4.* Masters thesis, Universiti Teknologi PETRONAS.

In natural gas purification, removal of CO2 as an undesirable impurity remains challenging. This research work focuses on the development of mixed matrix membrane (MMM) for the removal of CO2 from CH4. High performance neat MMMs containing low loadings (<2wt%) of zeolitic imidazolate framework 8 (ZIF-8) and polysulfone (PSf) were prepared via simple solvent evaporation method and single solvent. Low loading of ZIF-8 particles is focused on this research work as to date, the reported ZIF-8 based MMMs is primarily subjected to high loadings of ZIF-8. The gas permeation performance of membranes was tested using neat CO2 and CH4 gases. Subsequently, the CO2 and CH4 gas sorption behavior of ZIF-8/PSf mixed matrix membranes were obtained experimentally. Dual-mode sorption was then applied to validate the experimental gas sorption values while the CO2 and CH4 diffusivity coefficients in Langmuir (DH) and Henry (DD) modes were determined by using partial immobilization model. The changes of gas transport properties of CO2 and CH4 in the polymer matrix after the incorporation of ZIF-8 particles were studied through experimental and model fitting via CO2 and CH4 gas sorption tests. Significant enhancement of CO2 permeability and CO2/CH4 ideal selectivity were obtained for the resultant MMMs as compared to the neat PSf membrane. Highest CO2 permeability of 33.57 Barrer and CO2/CH4 ideal selectivity of 39.03 were achieved for PSf membrane loaded with 1 wt% of ZIF-8, which were 514% and 161% higher than the values obtained for neat PSf membrane, respectively. Meanwhile, ZIF-8/PSf MMMs showed increment in CO2 solubility and diffusivity up to 125% and 195%, respectively, as compared to the neat PSf. Lastly, the experimental CO2 and CH4 sorption values of the MMMs is well fitted with the dual-mode sorption and partial immobilization model. Overall, MMMs fabricated in this work demonstrated significant improvement of CO2 separation from CH4 compared to PSf-based MMMs reported in the literature which usually contain high loading of fillers up to 30 wt%.

Aminuddin, Muhammad Syahir (2022) *Metal Chloride Anion-based Ionic Liquids for Hydrogen Sulfide Remova.* Masters thesis, Universiti Teknologi PETRONAS.

Hydrogen sulfide (H2S) removal and conversion into elemental sulfur is an attractive route in sweetening process of natural gas. However, current commercial technologies such as Liquid Oxidation Catalyst (LO-CAT) and Claus processes are facing catalyst degradation and deactivation, causing sulfur production output to decrease and expensive conversion cost. To overcome current deficiencies of commercial technologies and conventional ILs, Task Specific Ionic Liquids (TSILs) such as metal chloride anion-based ionic liquids (ILs) were proposed for H2S conversion into elemental sulfur. Three (3) metal chloride anion-based ILs were synthesized via metathesis reaction between cation of [P66614] and metal chloride anions of Ga, Fe and Sn with highest yield of 95.2% and characterized using FT-IR, UV-Vis, CHNS elemental analysis, TGA, DSC, viscometer, densitometer and Karl Fischer water titrator. The synthesized ILs possess desirable physical properties such as low viscosity at higher temperature (53.42 cP) and high thermal stability (459.19 ℃) which make them excellent catalyst for H2S conversion. Their performance as catalysts were excellent with over 90% efficiency for H2S conversion at pressure 1 bar, temperature 100 ℃, speed 150 rpm and time 360 min. P66614SnCl3 was the best catalyst for H2S removal with desulfurization rate of 97.54%. The kinetics studies showed that H2S conversion reaction followed the pseudo first-order kinetics model with activation energy of 12.978 kJ/mol. Overall, metal chloride anion-based ILs have a high potential as catalyst for conversion of H2S in industrial settings.

Dafaallah Mohamad, Dafuallah Esameldien (2022) *An Ensemble Model For Sentiment Analysis On Emergency Situation Using Twitter Data.* Masters thesis, Universiti Teknologi PETRONAS.

Accidents, disasters, and other types of crises require the assistance of emergency response teams. Humans may be used as sensors to monitor and measure crucial events as they happen, thanks to the potential of social media data. Positive, negative, and neutral sentiment is frequently assigned to user sentiment based on an incident. The surges in hostility associated with incident tweets could indicate that a crisis is happening in real time, giving Emergency Response Teams (ERTs) more information to better address the incident. As a result, sentiment analysis may investigate and categorize user opinions into different polarities. From the standpoint of computer linguistics, sentiment analysis is an opinion mining technique. Many existing tactics for determining users' opinions on social media have been enhanced, however most of the current techniques and algorithms are not ideal for the incident/accident sector because their models are focused on other domains. To improve text classification accuracy, a novel solution called enhanced sentiment analysis (Naive-Bayes-Extra Tree ClassifierAda Boost (NEA)) based on Gaussian Naive Bayes, Extra Tree Classifier, and Ada Boost models is proposed in this study. Even though the models have different formulas, it is thought that they complement each other. The Naive Bayes classifier technique relates to the independence of words in a text, but the Gaussian classifier is a special kind of Naive Bayes that uses different models to classify texts. The Extra Tree Classifier employs averaging to increase predictive accuracy and control overfitting, whereas Ada Boost employs boosting to transform chained week classifiers into powerful, unified classifiers. Thus, in this study, NEA is recommended to be utilized to improve the accuracy of the sentiment classification algorithm, which has two tiers: the Level-1 Model (Extra Tree Classifier & Ada Boost) and the Level-2 Model. The proposed technique achieved accuracy of 93.16 percent, precision of 93.8 percent, recall of 92.40 percent, and F Score of 93.10 percent.

Ahmad, Afnan (2022) *Sustainable Application Of Scraped Shreded Tires, Silica Fume ,And Bitumen Emulsion In The Peat Soil Improvement.* Masters thesis, Universiti Teknologi PETRONAS.

Peat is considered problematic soil due to its high-water content, low strength, and poor bearing capacity. It is also highly compressible, and its spongy nature leads to excessive settlement and makes peatland an unfavorable foundation material for a highway. On the other hand, the progressive generation of tire and silica fume wastes is alarming for the environment. For the past years, many studies have been carried out to strengthen the highway materials using these wastes. The current study examines and compares the strengthening effect of various additives including binders and waste materials i.e., OPC, silica fume (SF), bitumen emulsion-silica fume (BESF) mix, shredded tires (ST), and their combinations in various proportions in the peat soil improvement. The BESF mix was first synthesized by optimizing the SF content in bitumen emulsion using the response surface methodology (RSM) tool. Initially, the indexed properties of peat derived from Teluk Intan were investigated followed by the standard compaction, mechanical and microstructural properties. The mechanical properties were assessed through the unconfined compressive strength (UCS) and California bearing ratio (CBR) tests while the microstructural testing includes scanning electron microscope (SEM), X-ray diffraction (XRD), and Fourier transforms infrared (FTIR). The optimization of the BESF mix suggests 4.68% SF content mixed at 1924 rpm speed. Also, the experimental findings show that the hydraulic binders i.e., OPC and SF increase the strength and bearing capacity significantly. While the ST and BESF mix reduce the UCS and CBR values with their increasing percentage. However, the application of ST waste with other binders i.e., SF and BESF mix have shown strength enhancement, thus ensuring the incorporation of waste materials in peat improvement. In addition, the increasing amount of BESF mix reduced the dry density and strength of treated peat, indicating 5% BESF mix is an effective amount. Finally, the microstructural testing revealed significant morphological improvement due to the development of new minerals which causes the strength enhancement. In this way an industrial waste materials has been utilized in the peat soil strength improvement.

Anbealagan, Lanisha Devi (2022) *Amine-Modified Zeolite AlPO-18/Polysulfone Mixed Matrix Membranes for Carbon Dioxide Separation.* Masters thesis, Universiti Teknologi PETRONAS.

The global anthropogenic carbon dioxide (CO2) gas emission has risen over the last few decades and affects the environment. Besides, the presence of carbon dioxide in natural gas renders gas compression and transportation challenging. In light of this, Mixed Matrix Membranes (MMMs) has been extensively investigated for CO2 gas permeation and separation however, it still remains challenging to search for filler with a pore size small enough for effective CO2 gas separation. In addition, the differences between the filler and polymer phase in MMM also affects the gas separation performance of the membranes. In the current study, zeolite AlPO-18 and aminemodified zeolite AlPO-18 (NH2-AlPO-18) filler were incorporated into Polysulfone (PSf) polymer matrix in order to develop MMMs with enhanced CO2/CH4 gas separation performance. Due to its higher affinity for CO2 compared to CH4 and small pore size of 3.8 Å, zeolite AlPO-18 appeared to be a very promising candidate for CO2 permeation and separation. The synthesized zeolite AlPO-18, NH2-AlPO-18 and fabricated membranes were characterized using X-Ray Diffractometer (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Thermogravimetric Analyzer (TGA), Field Emission Scanning Electron Microscopy (FESEM) coupled with Energy Dispersive XRay Spectroscopy (EDX) and N2 adsorption-desorption analyzer for their properties. XRD and FTIR analysis revealed that zeolite AlPO-18 was successfully modified and incorporated into the PSf polymer matrix. According to TGA analysis, the thermal stability of the membranes was improved by introducing zeolite AlPO-18 and NH2- AlPO-18. Furthermore, FESEM images revealed the incorporation of zeolite AlPO-18 and NH2-AlPO-18 into the polymeric matrix. Based on the membrane gas performance test, remarkable improvement was observed for MMMs incorporated with 2 wt% of NH2-AlPO-18 where high ideal CO2/CH4 selectivity of 67.40 with CO2 permeability of 6.74. Barrer was attained. Incorporation of NH2-AlPO-18 into PSf improved the affinity of the membrane towards CO2 and hence resulted in the enhancement of CO2/CH4 gas permeation and separation performance of the membranes.

Baig, Mohammed Feras (2022) *Assessment of Groundwater Potential and changes in Land Use patterns using Geographic Information System.* Masters thesis, Universiti Teknologi PETRONAS.

Assessment of groundwater potential with respect to climatic and land use changes is vital to study for appropriate usage of available groundwater. However, limited research has been conducted regarding groundwater potential and the impact of land use changes on a larger scale in Malaysia. The study aimed to assess groundwater potential and the impact of changes in the land use patterns on groundwater using Geographic Information System (GIS). The identified hydrological and geological parameters are mapped and then integrated into a weighted linear combination using Analytic Hierarchy Process (AHP) and GIS. The parameters used in this study are rainfall, geology, geomorphology, slope, drainage density, soil, LULC, and lineament density. The satellite images from 1991–2021 were classified to develop LULC maps using support vector machine (SVM) classification in ArcGIS. The image classification was based on six different LULC classes, i.e., water, developed, barren, forest, agriculture, and wetlands. The cellular automata-artificial neural network (CAANN) technique was used to predict the LULC changes from 2031–to 2051. The resulting groundwater potential map illustrated that 4.32% of Selangor is low potential zone, 52.02% is moderate potential zone,40.98% is high potential zone and 2.68% is very high potential zone. The area covered by moderate and high groundwater recharge zone was 47.7% and 45.3%, respectively. The LULC maps showed that the area changes from 1991 to 2021 in different classes, where developed, barren, and water lands increased by 15.54%, 1.95%, and 0.53%, respectively. The prediction maps from 2031–2051 illustrated decreasing trends in agricultural by 3.73% and forest by 1.09%, while increasing trends in developed by 5.12%. The percentage of correctness for the simulation was 82.43%, and the overall kappa value was 0.72. The assessment of LULC changes noted that growing urbanization is linked to decreasing high groundwater potential zones.

Pereira, Eric Joseph (2022) *Characterization Of Hydrodynamic Performances For A Membrane-Type Floating Wave Attenuator System.* Masters thesis, Universiti Teknologi PETRONAS.

A floating breakwater is regarded as a sustainable coastal protection system due to its low construction cost and its ability to be deployed in various water depths with minimal environmental impacts. The typical floating breakwaters that are being researched, developed, and commercialised are hard structures in which the floating barriers are made of concrete and foam. The rigidity of the structure results in high degree of wave reflection causing a confusing sea state at the seaside of the structures. This may cause navigation hazards to the small floating vessels, including potential collision with floating breakwaters in a harsh wave environment. Air filled membranes have the capability to prolong the impact time and to reduce the impulsive loading on the structure. Hence, the objective of this study was set to investigate the hydrodynamic characteristics, motion responses and mooring loading of an air-filled flexible floating breakwater system using a physical modelling. In this study, an airfilled membrane-type floating wave attenuator system (MeFWAS) was developed to overcome the limitations of the rigid floating breakwaters. The experiment was carried out in a 20 m wave flume and the test models were subjected to random waves of various properties. The wave transmission, reflection and energy dissipation of the test models were quantified using wave probes, and the motion responses and mooring forces were measured using an optical tracking system and load cells, respectively. The MeFWAS is a highly reflective structure, yielding up to 50% wave attenuation when exposed to random seas. The heave and pitch motions of the structure were significantly governed by the wave steepness; however, the mooring loadings on the structure is more affected by the wavelength.

Sofian Tan, Iwan Tan (2022) *Hydrodynamic Interactions due to Detached Breakwaters used for Stabilisation of Tanjung Piai Shoreline.* Masters thesis, Universiti Teknologi PETRONAS.

Tanjung Piai is recognised as the southernmost tip of Asia continent. It's location at the entrance of the Straits of Johor is of strategic importance for national security and in the geo-political context. Severe erosion had been reported at Tanjung Piai since 2000. Detached breakwaters approximately parallel to the shoreline were initially designed to mitigate the erosion and protect mangroves along the shoreline. An artificial island was later proposed by a developer to be reclaimed in close proximity off the coast of Tanjung Piai. The goal of this research is to evaluate the hydrodynamic changes due to the island reclamation in Tanjung Piai. Numerical modelling using MIKE 21 hydrodynamic (HD) model, which is a module within the MIKE 21 software suite, has been used to assess the hydrodynamic impacts on the existing coastal environment of Tanjung Piai, including the neighbouring shoreline. The data collected for the modelling includes bathymetry, water levels and currents. Model validation is done using measured water levels and currents. Apart from the baseline condition, scenarios involving breakwaters only and breakwater separated 0.1 km with the reclamation with reclamation were simulated. Another two scenarios were then simulated i.e. with reclamation shifted 0.3 and 0.5 km from the breakwater. The presence of the breakwaters and the reclamation plots generally do not cause any current speed variations at the mudflat bounded by the breakwaters and the mainland. The reclamation does not affect current speed within the gaps between the breakwaters. The interactions between the nearby breakwater and the reclamation significantly increased the current speeds by 183 and 150% within the channel created by the reclamation and breakwater when compared with the baseline condition with the reclamation sited 0.1 and 0.3 km from breakwater respectively. The maximum current speed is reduced to 83% with a 0.5 km gap between both structures. Shifting the reclamation 0.5 km seaward of the breakwater would considerably lower the current speed. It is concluded that this study has demonstrated that the more the reclamation is shifted seawards, the more the impact of the interactions between the reclamation and breakwaters is significantly reduced.

Supardi, Nadilah Ayu (2022) *The Optimized Evolutionary Stream Clustering Model For Outlier Detection In Data Stream.* Masters thesis, Universiti Teknologi PETRONAS.

The massive and scattered nature of the data sets are being tied to the term "data stream," Data stream differs from the traditional and typical data due to several reasons. One of the reasons would be since data stream consists of unlimited and unstructured data. It may cause outliers from data stream nature. Data stream threatens in the clustering executions, by being time-consuming, utilizes memory usage and provides a single access data alone. Therefore, this paper demonstrates the integration of evoStream and Grey Wolf Optimizer (GWO in constructing a hybrid of The Optimized Evolutionary Stream Clustering for outlier detection in data stream. A total of three real data sets and nine representative evaluation measures have been validated on the performance of the proposed algorithm and the state-of-art evoStream and Evo Cluster. This approach aims at dealing with the performance of cluster analysis in the existence of outliers. Several major GWO elements are advanced due to the performance of clustering by exploring a search area and exploiting optimal solutions. The substantial balance of exploration and exploitation will optimize the individual (s) performance at every iteration by make use of fitness function. The results have revealed that the proposed method fosters the performance of The Optimized Evolutionary Stream Algorithm with the values of Heart data at epoch 20; 0.63 Purity, 0.2 CS, 0.16 HS, 0.13 Accuracy, 0.18 VM, 0.09 AMI, 0.13 ARI, 0.36 F-measure, and 0.63 Entropy. The data set Sonar at epoch, 10th has shown results in the evaluation measure at 0.65 Purity, 0.33 CS, 0.34 HS, 0.22. Accuracy, 0.33 VM, 0.23, 0.22 AMI, 0.65 ARI, and 0.57 Entropy has improved as compared to the original evoStream and Evo Cluster. The results showed that the final data set. Wine at epoch 30 at 0.59 Purity, 0.32 CS, 0.34 HS, 0.19 Accuracy, 0.23 VM, 0.27 AMI,0.19 ARI, 0.44 F-measure, and 0.51 Entropy exceeds better than evoStream and Evo Cluster. Since it appears that exploitation and exploration tend to converge on the same answer as well as data stream inadequate to accommodate multi-objective in high-dimensional data sets. In order to address these x concerns, it is suggested that this study use a variety of operators in the future, including aggregation and niching methods, to handle multi-objective optimization problems.

Zulkefli, Ahmad Umair (2022) *The Self-Potential Development Model Among Youth in Malaysia.* Masters thesis, Universiti Teknologi PETRONAS.

Youth self-potential development is one vital element in achieving excellent life quality and youth well-being. However, while the increase in challenges faced by today's youth, the group's well-being is declining. Despite the various studies and interventions implemented to overcome the situation, the issues faced by youth in Malaysia were still in challenge, and the debate continued on the best strategies for youth development. There is still a dire need for a model that can guide the development of youth selfpotential holistically. The aim of this study is to develop a sustainable and holistic youth self-potential development model. This study adopted the Fuzzy Delphi Method (FDM) to provide the proposed elements in the model which were systematically analysed using the Interpretive Structural Modeling (ISM) to develop the model. The FDM method is capitalised on ten (10) stakeholders from various background of expertise in developing the model. The model consists of 25 elements that were divided into five main indicators. The model findings show that the most driving indicator is the entrepreneurial mindset among the youth, followed by other indicators of youth selfpotential development. Also, the model shows that the civic-mindedness indicator is the output of youth self-potential development that will surface at the end of the development. The findings were parallel with known development theories and empowerment frameworks, including Bronfenbrenner's Ecological Systems Theory, Human Development, Context and Community Influence and Community Change, thus supporting the effectiveness of these approaches in facilitating youth development in Malaysia. The model will serve as a guide to the authorised body to work on the priority elements that can improve the youth self-potential systematically and strategically to meet the future challenges in line with the youth aspirations.

Saleh, Abdullahi (2022) *A Deep Learning-Based Mixed Method For Detecting Cyber Security Attacks In Cyber Physical System.* Masters thesis, Universiti Teknologi PETRONAS.

In recent years, there has been an increasing demand for computing devices in CyberPhysical Systems (CPSs) which include smart manufacturing, air intelligent transportation, critical infrastructure, robots services as well as Internet of Things (IoT) infrastructure. The CPS is vulnerable to cyber security attacks because field devices generate a lot of data through their network and communication layers, such as sensor data and actuators. In this research study, a deep learning-based mixed method has been proposed which consists of XGBoost (eXtreme Gradient Boosting) and Long ShortTerm Memory (LSTM). Firstly, the proposed LSTM model analyzes the performance of sophisticated cybersecurity attacks through time series by analyzing any abnormal changes in trends of data over some period of time to extract meaningful statistics about cybersecurity attacks. Secondly, the proposed XGBoost model was developed based on binary classification for prediction of cybersecurity attack behavior. The model parameter is based on supervised learning where data are been trained using multiple features xi to predict target variable yi (result). The boosting technique has the ability to model weak classifiers more efficiently, accurately, and feasible by making subsequent attempts to correct errors from the previous model. Feature selection techniques have been used to reduce the number of input variables in predictive model development to improve the performance of XGBoost results. The proposed model has been evaluated using Accuracy (ACC) to generally describe how the model performs across all classes. The results of the experiment showed that the proposed models are more accurate than several current methods. LSTM achieved an ACC of 98.80% and XGBoost achieved an ACC of 98.69%. The proposed methods have been tested and validated using real-world Industrial Control System (ICS) from gas pipeline datasets consisting of seven types of cybersecurity attacks. The models show good performance in terms of accuracy and computational complexity.

Ahmad, Mohd. Afnan (2022) *Purification Of Biodiesel Via Ultrasonic Assisted Solvent Aided Crystallization.* Masters thesis, Universiti Teknologi PETRONAS.

Biodiesel offers environmental and commercial benefits since biodiesel does not contain Sulphur, aromatic hydrocarbons, metals, or crude oil residues. Purification of crude biodiesel is mandatory to remove all the contaminants present This study focuses on the purification of biodiesel via solvent-aided crystallization process (SAC) with solution movement assisted, which is radiation. The idea of this technique is based on the addition of assisting agent (i.e.,1-butanol solution) inside the biodiesel to ease the purification via crystallization. 1-butanol was used due to good and rapid crystallization compared to another solvent and reduced the sample viscosity (ie., biodiesel/glycerol). The unpurified biodiesel goes through the SAC method to remove its contaminants including glycerol and left pure biodiesel behind. Likely, two phases were formed during the process where the contaminants crystallize (solid phase) and left behind pure biodiesel (liquid phase). The radiation device consisted of an ultrasonic processor and probe used to agitate the biodiesel continuously during the purification process by SAC. It replaces the method of using the propeller for stirring purposes. Technically, the implementation of the radiation can optimize the laboratory activity in terms of time saving where no cleaning or washing is needed for the propeller as it takes a longer time. The purity of the biodiesel was analyzed using Gas ChromatographyMass Spectrometry (GC-MS. High yield of FAME percentage was achieved at around 98% by implementing a radiation device as an assistance part in SAC and manipulating the concentration of the 1-butanol solvent, coolant temperature and the crystallization time which were 1 wt%, 9oC and 40 minutes, respectively. In addition, water content analysis and total acid number (TAN) achieved a range of 0.2% and 13 to14 mg KOH/g oil, respectively. The comparison between the two-solution movement methods shows that the radiation method is the best method paired in the SAC system.

Altaf, Muhammad (2022) *Integrating Building Information Modelling (BIM) to Automate Life Cycle Cost Analysis (LCCA) for Building Projects.* Masters thesis, Universiti Teknologi PETRONAS.

Construction industry projects play a significant role in the sustainable economic growth of all other industries. To achieve a sustainable economy, the future associated costs act as a barrier that must be addressed in the initial stages of a construction project. To evaluate the future costs, Life Cycle Cost Analysis (LCCA) is found to be an effective technique that determines the present worth of future costs. However, despite its significance, the LCCA technique is found limited in construction projects due to limited knowledge and understanding of its execution procedure. The current study focuses on developing an Automated Building Information Modelling (BIM) approach for LCCA. An extensive literature review was conducted highlighting the LCCA barriers and different techniques adopted. Before developing the automated LCCA approach, a questionnaire survey was conducted among the construction industry professionals to evaluate the level of LCCA implementation and barriers in the construction industry, followed by statistical analysis and Structural Equation Modelling (SEM). Based on the outcome of the survey, about 21 % of the professionals did not know about the term LCCA, 29 % had weak knowledge and only 4 % were well aware of the LCCA. Besides this, only 13.4 % of construction firms adopt Automated approaches and BIM for LCCA, but the implementation is less due to a lack of LCCA knowledge and proper practices. Moreover, the lack of LCCA knowledge and data availability and integration were the most significant barriers influencing LCCA implementation. Finally, an automated strategy was developed by introducing the LCCA tool into the BIM platform, i.e., Revit using a programming language (C#). The tool integrates the cost data of a project with LCCA parameters to determine Life Cycle Cost (LCC). This study presents a comprehensive insight into LCCA knowledge, awareness, implementation, and barrier factors that will help to enhance LCCA implementation in Malaysia and other developing countries. Moreover, the automated strategy of LCCA using BIM promotes an easy and time-saving LCC method.

Mustapha, Siti Nor Adibah (2022) *Performance and Optimization of Progressive Fractional Freezing for Oil Separation from Bilge Water.* Masters thesis, Universiti Teknologi PETRONAS.

Periodically discharging bilge water to the sea is essential to maintain the vessel's stability and safety. However, improper bilge water treatment might have negative impacts on the environment, especially on marine populations. Specific conventional oil-water separator (OWS) such as gravitational and electrocoagulation had been reported to have difficulty complying with the discharge limit and consume high energy consumption. Hence, this study introduces a new method, namely progressive fractional freezing (PFF), that has the potential for oil-water separation in bilge water. PFF works based on the freezing temperature difference between two fluids. The separation took place in a stirred freeze crystallizer. This study collected 45 litres of bilge water sample from Lumut Maritime Terminal, Perak, Malaysia. The efficiency of PFF in separating the oil from the bilge water was evaluated using percentage removal of oil and grease, chemical oxygen demand (COD) and turbidity. The effect of three operating parameters: coolant temperature, cooling time, and stirring rate, was then analyzed towards the listed efficiency determinant parameters. Response surface methodology (RSM) with central composite design (CCD) was employed in an optimization study to investigate the interaction effect of independent variables on percentage oil and grease removal and obtain ideal conditions for optimum oil and grease removal. Energy consumption was calculated and compared with energy consumed electrocoagulation method. Results showed that the PFF process managed to freeze the water, forming a single ice crystal on the crystallizer wall, subsequently separating it from the oily bilge water sample. The findings proved the ability of PFF as the new possible oil-water separation method. Based on the optimization study, a reliable mathematical model was developed with 93.44% of R2 value. The optimum conditions suggested through RSM was at −8.7℃ for 40.2 minutes with a stirring rate of 194 rpm. A validation experiment was performed, resulting in an average of 81.49% percentage removal, with an error of 3.36% compared to the predicted value. However, the average final value of oil and grease obtained, 48.11 mg/L, higher than the 15 mg/L discharge limit set by MARPOL viii and DOE. From the COD and turbidity analysis, the highest percentage of COD and turbidity removal obtained was 68.27% and 92.85% with average final values of 142.67 mg/L and 41.33 NTU, respectively. The final COD value was a bit higher than the limit, which is 100 mg/L. 5.815×10-6 to 3.305×10-5 kWh of energy was consumed to produce 60 to 340mL of ice in energy analysis. To conclude, this method is feasible to be introduced based on findings from the study conducted, especially in terms of optimization. It is recommended to do further research to improve the oil and grease and COD removal efficiency.

Qi, Siah (2022) *Modeling And Optimization Of Water-Food-Energy Nexus For Malaysia's Agricultural Sector.* Masters thesis, Universiti Teknologi PETRONAS.

The water-food-energy (WFE) nexus integrates different separated sectors, using their interconnectedness to reduce trade-offs and allow sustainable development. This strategic system helps prevent future resource insecurity. Thusfar, there are only reports from cities in countries outside of Malaysia on the implementation of WFE nexus in the agricultural sector that may not meet the conditions to be applied locally. There is also yet to have a model formulated revolving on optimizing the agricultural sector's resources distribution. Also, local existing research only involves two-way waterenergy nexus done on water resources management, and a multi-centric concept threeway nexus approach is needed to address all resources in the local agricultural sector holistically. Hence, the main objective of this research is to construct a superstructure representation to portray the complex interaction in the agricultural sector in Malaysia, to perform a quantitative analysis by proposing a decision-making optimization framework that captures the WFE nexus, and to perform sensitivity analysis on model solution that provides a guideline for decision-makers. A case study is performed on the Perak's agricultural sector, where a superstructure is developed for model formulation. A single and multi-objective linear programming (LP) is used for the optimization, which was performed in Microsoft EXCEL and MATLAB respectively. Sensitivity Analysis is then performed on the model solution to study effect of variables and constraints on the trade-offs between resources. The single-objective optimization result shows that the profit of the Perak's agricultural sector is estimated to be RM5.5B/yr while the multi-objective optimization multiple solutions could provide a guideline for decision-makers while allocating resources in the agricultural sector.

Rahim, Nurul Izati (2022) *Evaluation of Physical and Mechanical Performance of Self-Consolidating Concrete (SCC) containing Crumb Rubber and Nano-silica.* Masters thesis, Universiti Teknologi PETRONAS.

Self-Consolidating Concrete (SCC) is a type of advance concrete that is non-segregating and extremely flowable, allowing it to spread into place and fill formwork even the most congested reinforcement with no vibration. It provides these appealing benefits while retaining or improving the mechanical and durability properties of concrete. Despite of that, SCC is brittle due to the low water and cement ratio. Crumb rubber (CR) has been shown to reduce the brittleness of SCC when it is used as aggregate replacement but adding CR into the mixture decreased the mechanical strength of the concrete. To address the issue, Nano-silica (NS) was added to the rubberized SCC (R-SCC) mixture to improve its physical and mechanical performance. Three variables were selected, each with three levels of replacement and addition. Fly ash (FA) was used to replace cement by volume at 10%, 25% and 40% whereas CR was used to replace fine aggregate by volume at 0%, 7.5% and 15%. Aside from that, NS was added to the mixture by weight of cementitious materials at 0%, 2% and 4%. 20 runs of design mixes were developed using Response Surface Methodology (RSM). These mixes were casted, cured and tested for the physical and mechanical properties. The optimal mix design proportion was then generated through RSM using multi-objective optimization for the desired compressive strengths of 30MPa, 40MPa, and 50MPa. Further testing on the physical and mechanical properties were conducted to validate the optimized mix proportion. Slump flow test, L-Box test and V-Funnel test revealed that the workability and viscosity of the concrete increased with the incorporation of fly ash. However, they were negatively impacted when CR was added to the mixture. As NS was introduced, the physical properties improved. In terms of mechanical properties, adding up to 25% FA increased the strength of the concrete for 17%. Yet, incorporating CR resulted in a loss of strength up to 44% when the maximum amount of CR, 15% was added. This loss of strength was reduced to a minimum and improved by adding NS to the mixture.

Shahhiran, Aina Farwizah (2022) *Cu-Fe doped Titanium dioxide supported on Activated carbon for degradation of imidazolium ionic liquids.* Masters thesis, Universiti Teknologi PETRONAS.

Ionic liquids (ILs) have gained interest industrially as they possess a wide spectrum of physical and chemical properties which makes them suitable as a replace of conventional solvent and reaction media. However, a release of ILs from industrial processes into aquatic environments may lead to a serious water pollution due to their high solubilities in water. Due to that reason, this work was conducted to evaluate an optimized TiO2/AC codoped with Cu and Fe as photocatalysts in ILs wastewater treatment. Then, different combination of cation and anion from imidazolium and pyrrolidinium ILs were tested to investigate the efficiency of the system. This research work started with the synthesis of TiO2 using microemulsion method followed by the modification with Fe and Cu via impregnation method. Next, oxidized activated carbon (AC) was impregnated onto the composite bimetallic titania. From the study that been conducted, the most optimized photocatalyst produced was 0.2wt% metal loading with ratio 1Cu:2Fe and 10wt% of AC as support. The presence of AC, Cu and Fe onto the TiO2 lattice produces a smaller crystallite size particle in which contribute to a larger surface area as proved from FE-SEM analysis. The shifting of absorption spectra to a lower band gap energy for the composite photocatalysts as compared to pristine TiO2 from UV to visible light region can be proved through UV-Vis analysis. These properties of composite photocatalyst improve the efficiency of the system in degrading pollutants as more particles can be absorb. The photocatalytic degradation was conducted based on fixed parameter optimized which includes pH = 6, [photocatalyst] = 1g/L, [IL0] = 0.11 mM and [H2O2] = 0.75 ml/L. The optimized composite photocatalysts and the effectiveness of the degradation system was evaluated through High Performance Liquid Chromatography (HPLC). From the investigation conducted based on alkyl chain length, different anion group and different cation based ionic liquids, it can be concluded that the efficiency of the degradation was structure-related. The removal efficiency of the ILs decreased in the order of [bmim][Cl] > [bmim][BF4] ix > [emim][Cl] > [bmPy][Cl] with 76%, 50%, 27% and 18% respectively. The reaction for all three [bmim][Cl], [bmim][BF4] and [emim][Cl] follow the first-order reaction while [bmPy][Cl] fits zeroth-order the best.

Ali, Husnain (2022) *Multiscale Process Monitoring In A CSTR System Using Principal Component Analysis And Signed Directed Graph.* Masters thesis, Universiti Teknologi PETRONAS.

The chemical process industry has become the backbone of the global economy. The complexities of chemical process systems have increased in the last two decades due to online sensor technology, plant-wide automation. Principal component analysis (PCA) and signed directed graph (SDG) are some of the quantitative and qualitative monitoring techniques that have been widely applied for chemical process fault detection and diagnosis (FDD). The conventional PCA-SDG algorithm is a single-scale FDD representation origin, which cannot effectively solve multiple FDD representation origins due to low FDD resolution. The hybrid single-scale nature of the PCA-SDG produces misleading and inaccurate representations. The PCA based-contribution plots are known approaches for diagnosing faults. The contribution plots indicate the effect of each variable on the statistical index T2 or Squared Prediction Error (SPE) from the PCA. The contributions of the faulty root variables are spread to other variables, which may not represent the actual roots cause of the failure due to the quick interaction between process variables. The multiscale based wavelet transforms (WT) methodology is an extensively vital technique in various approaches such as process monitoring (fault detection and identification) and fault diagnosis. This study proposes a new and effective multiscale PCA-SDG based process monitoring and fault diagnosis framework that improves fault search efficiency and diagnosis accuracy. The multiscale PCA-SDG monitoring framework has become effective because it easily distinguishes deterministic and stochastic features. This work implements, tests, and compares the process monitoring and fault diagnosis algorithm based on conventional single-scale PCA-SDG and multiscale PCA-SDG in the continuous stirred tank reactor (CSTR) system and their intricate causal representation between process variables. The results show that the proposed multiscale PCA-SDG technique for the CSTR system case study demonstrates a satisfactory performance for detection, identification, and diagnosis compared to the conventional PCA-SDG method. The graphical propagation route of process failures in all five types of faults is efficiently monitored, which specifies the actual representation of faults.

Fatima, Syeda Saba (2022) *Development Of Surface Functionalized Carbonaceous Adsorbent Dervied From Rubber-Seed Shell For Carbon Dioxide Capture.* Masters thesis, Universiti Teknologi PETRONAS.

The severe environmental and economic impacts of greenhouse gas emissions have triggered a search towards CO2 capture. The huge release of the gas has caused issues of acid rain and urban smog that are affecting human life. Among many separation techniques, adsorption is preferred due to its capability to abate the targeted pollutant at very low concentrations. Although there are many adsorbents available for this application, researchers are focused on carbonaceous adsorbents especially those synthesized from biomass precursors. The utilization of agricultural and industrial biomass yields low-cost adsorbents and helps in minimizing the landfill for solid waste management. Rubber seed shell (RSS) is a suitable precursor for activated carbon (AC) production due to its high carbon content and low cost. RSS AC was prepared by twostep and improved three-step chemical activation methods using K2CO3. AC prepared by three-step activation was found to be superior due to larger surface area and total pore volume. It also presented slightly higher nitrogen content and additional π-π interactions introduced by the hydrothermal treatment and is expected to enhance the CO2 adsorption capacity. pristine AC usually shows low adsorption efficiency compared to zeolites and silica. To improve its adsorption capacity certain chemicals (amines and ionic liquids) are added for surface functionalization. Ionic liquids (ILs) are preferred due to degradation of amines during regeneration. Such hybrid sorbents combine a small layer of IL deposited on the surface of AC to provide additional active sites thus resulting in higher uptakes of CO2. In the present research, an attempt has been made to functionalize the surface of RSS AC using different concentrations of [bmpy][Tf2N] IL. The maximum CO2 adsorption capacity obtained was 2.165 mmol/g and 1.124 mmol/g at 25 °C for pristine and functionalized AC, respectively. A reduction in surface area and total pore volume was observed with increasing IL loading. The performance of IL was obstructed mainly by pore blockage. CO2 adsorption equilibrium was best fitted by Freundlich isotherm with R2 > 0.98. The kinetic analysis viii revealed that the CO2 adsorption on pristine AC follows physisorption whereas it is a combination of physisorption and chemisorption for functionalized AC.

Sultan, Tahir (2022) *Control Studies Of Absorption/Stripping Co2 Capture Process Using State-Space Based Fast Model Predictive Controller Framework.* Masters thesis, Universiti Teknologi PETRONAS.

The high CO2 contents of contaminated natural gas reduce the heating value of the gas mixture, endangers human health, and contribute to global warming. In this regard, effective control strategies are critical for ensuring that CO2 compositions are always maintained within the desired ranges. The drawbacks of PID-based conventional control strategies such as greater response time, overshoot, and offsets can be overcome by the Model Predictive Control (MPC)-based control systems. However, the MPC controller's performance may still have room for improvement to maintain the CO2 capture rate at set points without offsets and smaller response time. In this thesis, the Fast MPC (FMPC) scheme, which is based on the fragmental solution of a complex quadratic program (QP) and results in a fast controller response, is investigated as a possible alternative to control the CO2 capture process. The performance of the FMPC controller depends highly on the accuracy of the identified state-space model. Therefore, two state-space models (based on different focuses: prediction and simulation) are identified in the System Identification Toolbox of MATLAB® using the data generated from the Aspen Dynamics® simulation model of the CO2 capture process. The FMPC controller is then implemented in the MATLAB® on the identified state-space models to control the CO2 composition in the sweet gas and stripper bottom temperature under setpoint tracking mode with ±5% and ±15% step changes. The results showed that the FMPC controller based on the state-space prediction focus model has an average of 9.9- and 7.9-times lower offset and Integral Absolute Error (IAE) values than the simulation focus model, respectively. Furthermore, the comparison results concluded that the FMPC controller has an average settling time of 51.42 seconds, which is 74.8% faster than the Classical MPC (CMPC) controller. Additionally, the IAE, ISE, and ITSE values demonstrated much improved outcomes for the FMPC controller. The offsets for both controllers are maintained at negligible levels through suitable tunning for the comparison analysis. However, the performance viii of the FMPC controller could be broadly evaluated with high dynamic complexity models under complex ramp changes or diurnal oscillations scenarios to eliminate the offsets completely

Daha, Muhammad Yunis (2022) *Community Detection Based Link Failure Recovery In Software Defined Networks.* Masters thesis, Universiti Teknologi PETRONAS.

The complexity and uncontrollability of traditional IP networks lead to low utilization of network resources. This complexity and increasing demand for the Internet has led to the introduction of Software Defined Networks (SDN). SDN is a new networking paradigm that breaks the limitations of traditional IP networks and upgrades the current network infrastructures. Though SDN is comprehensible and easy to handle, but on the other hand, it has its own set of restrictions. Like traditional IP networks, network failures may also occur in SDN. Multiple research studies have been conducted to discuss this problem by using a variety of techniques. Among them, the community detection method in the failure recovery process of SDN is one of the technique. However, they have not considered the specific problem of multiple link multi-community failure and inter- community link failure scenarios. This research study presents a community detection-based routing algorithm (CDRA) which is efficient to deal with both the single link intra-community failure scenarios and multiple link multi-community failure scenarios and is also able to handle the inter-community link failure scenarios in SDN. Extensive simulations have been performed to evaluate the performance of the proposed CDRA scheme by using Mininet and POX controllers. The simulation results depict that the proposed CDRA scheme is more efficient and performs better in terms of average delay and average data packet loss ratio. The average data packet delay of the proposed CDRA scheme is 20.27% and 23.65% lower than the average data packet delay of the Dijkstra-based general recovery algorithm in both single and multiple link failure scenarios respectively. The average data packet loss of the proposed CDRA scheme is 2.8% and 7% lower than the average data packet delay of the Dijkstra-based general recovery algorithm in both single and multiple link failure scenarios respectively.

Mazli, Wan Nur Athirah (2022) *Volume Reduction Of Synthetic Produced Water Through Progressive Freezing Via A Circular Moving Cylindrical Crystallizer.* Masters thesis, Universiti Teknologi PETRONAS.

Treatment and disposal are the two main water cycle management approaches in the oil and gas industry. The application of freezing is when the solution is crystallized, ice crystals will eventually form and leaving the solutes in the remaining concentrated liquid phase. Freeze concentration has been identified as one of the methods to separate water from wastewater. The conventional method used for solution movement in the progressive freezing technique is stirring by a stirrer. However, the stirrer requires frequent maintenance as it needs to be cleaned and requires a longer cleaning time due to the complex structure. Thus, the new solution movement for progressive freezing is proposed, which is the circular motion of the crystallizer. This study aimed to remove water from the wastewater sample, which was synthetic produced water, and the water will be reused for other uses. Therefore, problems on disposing produced water are reduced as it reduced the volume of produced water. Further analysis and optimization process were carried out after finishing the experiment. Synthetic produced water was poured into a cylindrical crystallizer and then was immersed in the refrigerated bath at the desired temperature. For solution movement, the cylindrical crystallizer was moved in a circular motion. During freezing process, water formed into the ice while contaminants remained in concentrated solution. To optimize and investigate the effect of coolant temperature, freezing time, and rotation speed, response surface methodology (RSM) was applied to determine the efficiency of the process, and central composite design (CCD) was used to design the experiment. The optimum parameters were determined at the freezing time of 22.79 min, coolant temperature of -14.89 °C, and rotation speed of 59 rpm. A validation experiment was performed, and 89.67% of water removal was achieved. Additional analyses were done to support the validation experiment where the value reduction of COD, oil and grease and turbidity of ice is higher than 80%. The highest energy consumption of the process reached up to 10107.49 kWh/m3, and for optimum parameters, 3275.886 kWh/m3 was achieved.

Arefin, Ahmed Amirul (2022) *An Improved Island Detection Algorithm Using Phasor Measurement Unit Voltage Angle in a Distribution Network.* Masters thesis, Universiti Teknologi PETRONAS.

Since the penetration of distributed generators in the utility power system is constantly increasing, islanding detection is becoming a critical component of the power system. Accurate tripping is an integral part of the island detection scheme since an inappropriate operation might cause a hazardous situation. The problem presently is that, if the distributed generation (DG) capacity matches the connected feeder load and during that time if island occurs in the system, the islanding detection takes longer due to the minimal power exchanges between the DG and the utilities. For instance, if the settled threshold is higher than the parameter value, then it will require a longer detection time, or it won't be able to detect the island properly. This research work proposes an improved PMU technique using slip angle and acceleration angle- of the phasor measurement unit (PMU) voltage angle data. Specifically, this research work is utilizing bus voltage angle in the form of the slip angle and acceleration angle parameters. This research work presents the performance results of the proposed islanding detection algorithm for the under frequency, over frequency, and match frequency islanding conditions. A modified IEEE 30 bus system has been used to get the PMU data, and the algorithm is designed in the MATLAB/Simulink and OriginLab simulator. For the verification of the algorithm Utility Kerteh system has been designed in the PowerWorld simulator. Notably, the proposed algorithm shows that it can detect all islanding conditions of the Utility Kerteh system at 20ms, which means it requires only a single time-step after island incepts in the network. Therefore, the proposed algorithm is able to improve the detection time of the match frequency islanding condition from 500ms, as mentioned in the recent literature survey to 20ms. Furthermore, the proposed algorithm can distinguish between actual islanding events and non-islanding events.

Abdulraheem, Amgad Muneer Othman (2022) *Prognostic Prediction Of Remaining Useful Life In High Dimensional Gas Turbine Using Enhanced Deep Convolutional Neural Network.* Masters thesis, Universiti Teknologi PETRONAS.

Accurately predicting the remaining useful life (RUL) of the rotary machines is of great significance for improving the reliability and safety of the industrial mechanical system. Such predictions can improve the maximum operating availability and reduce maintenance costs. Due to the high dimensionality and nonlinearity of mechanical systems data, conventional methods are unable to satisfy the needs of medium- and long-term prediction problems with the curse of high dimensionality. To address this issue, this study presents an enhanced deep convolutional neural network (DCNN) architecture to predict the RUL of turbofan engines with prognosability method for dimensionality reduction. The prognosability metric was used for feature ranking and selection, whereas a time window method was employed for sample preparation to take advantage of multivariate temporal information for better feature extraction by means of an enhanced DCNN model. The validation of the proposed model was conducted using a well-known benchmark dataset called Commercial Modular Aero Propulsion System Simulation datasets (C-MAPSS). As most of the literature did, two evaluation measures namely root mean square error (RMSE) and asymmetric scoring function (score) were used to validate the proposed model. The experimental results show the superiority of the proposed approach to predict the RUL of a turbofan engine. Therefore, the proposed RUL prediction model was tested and verified using four subsets of data in which each subset has different operating conditions and failure modes. The enhanced DCNN model achieved the best scores on the FD001 independent testing dataset, with an RMSE of 11.81 and a score of 223. Besides, the proposed DCNN model has an RMSE of 18.34, 13.08 and 19.88 for FD002, FD003, FD004, respectively. Additionally, the model achieved a score of 2550, 280.5, 2982.3 for FD002, FD003, FD004, respectively. Finally, the overall model accuracy has been obtained in term of percentage using mean absolute percentage error (MAPE) measure with an accuracy of 8.42%, 13.67%, 9.18% and 15.83% for the subset of data FD001, FD002, FD003 and FD004, respectively.

Ahmed, Rasel (2022) *An Improved Grey Wolf Optimizer Algorithm for Propane Pre-cooled Mixed Refrigerant LNG Process Optimization.* Masters thesis, Universiti Teknologi PETRONAS.

Liquefied natural gas (LNG) is playing a major role in the transition to clean energy. To liquefy and decrease the volume of natural gas, energy-intensive low-temperature cooling over a wide temperature range is necessary, which also requires a huge capital investment. Hence, there has been growing attention to improving the efficiency of the existing LNG processing technologies which could further ensure economic feasibility. This study aims for economic (capital expenditure (CAPEX), operational expenditure (OPEX)), and operational (power consumption) optimization of the propane pre-cooled mixed refrigerant (C3MR) process. In the area of process optimization, the metaheuristic algorithms showed superiority in terms of not requiring gradient information, initial solution guesses, or comprehensive physical modeling of the system, and therefore are already the preferred method to solve various complex engineering problems including LNG plant optimization. The grey wolf optimizer (GWO) is a recently developed metaheuristic algorithm that does not need parameter tuning like other optimization algorithms and has strong exploitation ability. It already revealed superior performance than the traditional deterministic optimization methods that require trial and error parameter tuning and are often trapped in local solutions when applied to LNG plant optimization. However, the GWO may also suffer from tight problem solutions especially in the case of solving non-linear, multi-modal LNG process optimization. To handle the complexity of LNG plant optimization, a robust algorithm with strong exploitation and exploration abilities was developed in this study to get the optimum results. To address these issues, the main contribution of this research work involved the development of memory, mutation, and local search-based improved GWO (MMLGWO) to get the optimal cost and operating conditions of the propane pre-cooled mixed refrigerant LNG process. The base case of the C3MR was developed in commercial process simulator Aspen Hysys version 10 with a production capacity of 4.5 MTPA, and the process flowsheet was interfaced with MATLAB viii R2019b for modeling and optimization. Moreover, the performance of the proposed algorithm was compared with the other four state-of-the-art algorithms such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO), GWO, and Selective Opposition based GWO (SOGWO). The MMLGWO method developed in this study has outperformed all the four algorithms. The CAPEX, OPEX, and power consumption of the C3MR process were optimized by 12.76%, 10%, and 20%, respectively, from the base case. The optimum results obtained by the MMLGWO were further compared with the previous studies from the literature to validate the current findings, where the optimal conditions of the key design variables of propane cycle, mixed refrigerant (MR) cycle, MR composition and main cryogenic hear exchangers (MCHE) are in good agreement with literature. Furthermore, the performance of the proposed algorithm was also tested for 20 numerical benchmark functions, where it outperformed the other four compared algorithms.

Ishak, Mohamad Adil Iman (2022) *Insight into Hybridization of Metal-Organic Frameworks and Ionic Liquids for Gas Capture through Molecular Dynamics Simulation.* Masters thesis, Universiti Teknologi PETRONAS.

Metal-organic frameworks (MOF) have garnered much attention as the newcomer to the family of porous materials and have shown applicability in physicochemical separation in oil & gas fields. However, the use of pure or pristine MOFs for gas adsorption in the oil and gas industry is limited, as the poor resistance of MOFs to water causes the network to easily fracture and distort upon gas adsorption. One possible way to circumvent this issue is to reinforce the MOFs with ionic liquids (ILs), to form a more water-resistant hybrid MOFs. While the stability of MOF and ILs as a hybrid material are arguably not new, the understanding of the actual mechanisms of stabilization within the hybrid MOF network is limited, especially in terms of interaction and stability. Herein, the compatibility, stability, and performance of an Isoreticular Metal-Organic Framework (IRMOF-1) impregnated with choline-based ionic liquids (ILs) for selective adsorption of H2S/CO2 were studied by molecular dynamics (MD) simulation. This is the first ever in silico detailing the effect of varying ratio of choline-based ILs in MOF, to influence stability and efficacy of the IL@IRMOF-1 composite to capture H2S and CO2. Cholinium alanate ([Chl][Aln]) was nominated as the best IL for impregnation into IRMOF-1, consistent with the low RMSD values (0.546 nm, 0.670 nm, 0.776 nm) at three IL@IRMOF-1 w/w ratios (WIL/IRMOF-1 = 0.4, 0.8, and 1.2). The [Chl]+ and [Aln]- ion pair preferentially located around the carboxylate group within the IRMOF-1 framework, with the latter interacting strongly with the host. The cation was more mobile with self-diffusion coefficients (Ds) of 0.0088 nm2 , 0.0560 nm2 , and 0.0790 nm2 , with increasing mobility alongside higher ratio of ILs (WIL/IRMOF-1 = 0.4, 0.8, and 1.2) respectively against the Ds value. This was verified by the radius of gyration (Rg) and RMSD data which revealed that a ratio of 0.4 w/w of IL@IRMOF-1 (Rg = 1.405 nm; RMSD = 0.546 nm) gave the best conformation to produce an exceptionally stable IL@IRMOF-1 composite. The new IL@IRMOF-1 showed improved resistance towards water compared with pristine IRMOF-1, even at a lower IL@IRMOF-1 w/w ratio. By taking viii [Chl][Aln] as the best IL, the IL@IRMOF-1 composite was more effective in capturing H2S and CO2 than IRMOF-1. The gases were adsorbed more by the IL@IRMOF-1 composite phase compared to the bulk phase, with a preferential adsorption for H2S, as shown by the uppermost values of adsorptibility (17.954 mol L-1 bar-1) and selectivity (SSH2S/CO2 = 43.159) at 35 IL loading (WIL:IRMOF-1 of 1.2). Overall, structural stability of IRMOF-1 is improved by the impregnation of IL where the stability is significant at the lower IL ratio. The findings from this study can be used to design specific hybrid composites for the application of gas adsorption especially in oil and gas industries.

Qasim, Muhammad (2022) *Chemical-Looping Combustion Investigation Of Copper Metal Oxide With Praseodymium Modified Gamma-Alumina Support Oxygen Carrier.* Masters thesis, Universiti Teknologi PETRONAS.

The amount of CO_2 in the atmosphere is rising due to the combustion of fossil fuels to fulfill the energy demand. This study aims to synthesize a potential oxygen (OC) using wet impregnation method for chemical looping combustion (CLC) process. Two types of OCs (monometallic and bimetallic) were prepared. All the synthesized OCs were calcined at 450 oC using muffle furnace. For monometallic OCs, the oxygen transport capacities (OTCs) of 0.018 mg of O2/mg of OC, 0.026 mg of O2/mg of OC, and 0.026 mg of O2/mg of OC were determined for 10FeA, 10CuA and 10CoA based OCs, respectively. The 10CuA OC was the fastest to be reduced in 1 min out of all monometallic OCs tested in CLC process. Some agglomeration was observed for all prepared OCs when characterized using FESEM analysis. EDX results confirmed that the copper (Cu) contents for both 10CuA and 10CuPA OCs after 10 redox cycles were increased from 7.5 wt% to 21.3 wt% and 7.9 wt% to 16.4 wt%, respectively. The peaks corresponding to Cu-contents for 10CuPA-based OC were retained compared to 10CuA-based OC when scanned from 10o to 90o in XRD analysis. The cyclical oxidation-reduction cycles for CLC performed using thermogravimetric analysis (TGA). The reduction reaction of OC was caried out using 5% CH4/N2 while oxidation reaction using air in TGA. The main criteria for the selection of the OCs for CLC include oxygen transport capacities, agglomeration, and spinel formation. TGA results confirmed that 10CuPA-based OC has high OTC (0.0267 mg of O2/ mg of OC) as compared to 10CuA-based OC (0.0240 mg of O2/ mg of OC) and maintained OTC of about 0.0267 mg of O2/ mg of OC after 10 redox cycles. 20CuPA-based OC was used to optimize the process parameters such as time and temperature using RSM. The highest OTC of 0.0546 mg of O2/ mg of OC at optimum operating conditions (3 min and 800 oC) was achieved. The prepared Cu-based Pr-modified alumina support oxygen carriers exhibited excellent results for OTC along with its phase viii stability. These effective properties making them attractive choices for use in the CLC process especially applicable for energy production from power generation plants.

Roslan, Hariz (2022) *Optimum Extraction of Flavonoid From Guava Leaves for Inhibiting Urea Breakdown in the Soil.* Masters thesis, Universiti Teknologi PETRONAS.

Recent environmental impacts have emanated from unconsumed nitrogen-based fertilizers primarily urea which leads to high emissions of greenhouse gases (GHG). Commercially available enhanced efficiency fertilizers (EEF) are synthetic compounds which have adverse effects on the environment. A greener alternative points towards the flavonoid group which is abundant in guava leaves and have strong antiurease property which indicates the potential to be a soil urea hydrolysis inhibitor. However, the type of extraction solvent used in the extraction process in guava leaves is still unestablished. The objectives of this study are to identify effective extraction solvent to obtain the highest total flavonoid content based on solid-to-solvent ratio via ultrasonic extraction, to optimize the flavonoid extraction parameters, and to determine the concentration of guava leave extract (GLE) which displays effective inhibition of soil-applied urea hydrolysis. Based on the literature reviewed, five (5) main factors have been considered for the flavonoid extraction optimization studies, which are solid-to-solvent ratios, solvent-to-solvent ratios, the temperature of the extraction medium, exposure time, and equipment power intensity. Response Surface Methodology (RSM) is used to determine the best conditions for flavonoid extraction from guava leaves via ultrasonic bath. The performance of flavonoid to reduce urea hydrolysis in soil is studied by incorporating GLE in soil. This study observed the highest extraction to be at 50.44 mg of Quercetin-equivalent per gram of Dried Guava Leaves (mg QE / g DGL) using a 1:1:1 ratio of Water-Ethanol-Methanol (WEM). The optimized extraction requires 6.65 g DGL / 100 mL of solvent, using 1.14:1.38:1.00 WEM solution, submerged in a 424.54 W ultrasonic bath at 34.80°C for 42.79 minutes to yield a Total Flavonoid Content (TFC) of 50.78 mg QE / g DGL. The urea loss recorded for the Controlled sample, best performing GLE (8% concentration) and commercial inhibitor NBPT were 65%, 50% and 20% respectively, well within 7 days and in 21.74 mg urea / 10 g of soil. Despite the performance gap between NBPT and GLE, GLE treated soil shows potential by outperforming the Controlled sample.

Zeshan, Muhammad Talha (2022) *Impact of Climate Change and Development of Modified Palm Geotextile for Mitigation of Soil Erosion in Perak.* Masters thesis, Universiti Teknologi PETRONAS.

Soil erosion is considered as a serious environmental concern which is a devastating land degradation process. Therefore, this study aimed to highlight the areas prone to extreme soil erosion risks in Perak by assessment of LULC changes using Geographic Information System (GIS) and its prediction analysis was performed using cellular automata (CA) simulation in Quantum Geographic Information System (QGIS). The study also investigated causative factors such as rainfall intensity, soil type, and slope angles which trigger soil erosion. Rainfall data were obtained from the Department of Meteorological Malaysia, soil sample for making bed slopes was taken from the local field area, slope angles were designed based on the steepness analysis of the region. Based on the analysis of triggering factors an innovative palm geotextile was developed as an efficient solution to reduce soil erosion in a catchment. The modified geotextile was developed by chemical treatment of the raw palm fibers and further processes were performed to remove surface impurities and enhance physical properties. The modified palm geotextile was applied on a laboratory set-up which was formed based on investigated geological and climatological parameters. The simulation results of GIS and QGIS modeling showed that barren and urban lands observed an increase of 547.06 km2 and decrease of 4587.26 km2 in dense forest areas was observed between the years 2000 to 2020. Similar trends were predominant in future LULC predictions up to the year 2050. The results of the experimental set-up showed that modified geotextile was successfully able to reduce about 97% soil erosion. The modified palm geotextile also demonstrated its effectiveness in decreasing rates of turbidity (5%) and total suspended solids (14%) compared to other surface coverings (7%-100%). The outcomes also showed that modified palm geotextile drastically reduced surface runoff rate (~6%) as compared to other surface coverings (2%-4%). It can be estimated that more than 90% reduction in soil erosion and sedimentation can be achieved with the application of modified palm geotextile on these barren and erosion-prone areas.

Abd Razak, Nurul Nadhirah (2022) *One-Dimensional Convolutional Neural Network with Variable Weights Grey Wolf Optimizer for Modeling of Sand Retention Test.* Masters thesis, Universiti Teknologi PETRONAS.

One-dimensional Convolutional Neural Network (1D-CNN) is a deep learning algorithm that can perform feature extraction, regression, and classification. However, it has many hyperparameters that need to be configured to define the network structure and training criteria before it can be used for modeling. Manually tuning the hyperparameters until it meets the optimal values is tedious, time-consuming, and unfeasible. Likewise, some of the automated searches used to address the limitation of manual search methods suffer from dimensionality curse, search stagnation at local optima and slow convergence rate. Therefore, a hybrid hyperparameter optimization model is developed for 1D-CNN using the Variable Weights Grey Wolf Optimizer (VW-GWO) algorithm, which can tackle the problem with automated searches. The hybrid model is implemented on sand retention test (SRT) to classify plugging sign (screen plug, screen does not plug) as well as to predict sand production and retained permeability using various sand distribution, stand-alone screen (SAS), screen slot size and sand concentration as inputs. SRTs have been modelled in the laboratory using computer simulation to replicate experimental conditions and ensure that the selected screens are suitable for selected reservoirs. However, the SRT experimental setups and result analyses are not standardized. Since the application of 1D-CNN in the petroleum industry attained promising results for both classification and regression problems, this method is proposed on SRT to reduce the time, cost, and effort to run the laboratory test. The hybridization of 1D-CNN with VW-GWO has yet to be imposed. Thus, the performance of the optimized 1D-CNN networks identified by the proposed hybrid model is compared with the standard GWO and the conventional 1D-CNN with a trialand-error approach. The optimized 1D-CNN networks devised by VW-GWO outperformed the baseline models and the networks identified by the standard GWO with the average accuracy of 96% for plugging sign and the average R2 of 35% for sand produced in gram, 98% for retained permeability, 64% for sand produced per unit area of slurry test and 63% for sand produced per unit area of sand pack test.

Mohamad Sofian, Nadiah (2022) *Usability Framework in Designing User Interface of Mobile Application for Children with Autism.* Masters thesis, Universiti Teknologi PETRONAS.

The number of apps available for children with autism has increased dramatically in recent years. Unfortunately, many mobile apps for autistic children are challenging to use and learn, primarily due to a lack of the implementation of usability guidelines in designing the mobile applications, particularly for children with autism. Moreover, many designers do not consider using appropriate usability guidelines when designing apps for people with special needs. This research aims to develop usability guidelines for designing mobile application user interfaces specifically designed for children with autism. The systematic literature review was used to determine the existing usability factors for children with autism. Appearance and understandable have been determined as the usability factors that will be used in devising the usability guideline from the usability framework in designing the mobile application UI for children with autism. An expert review was conducted with five participants to validate the proposed usability guideline on the relevancy of the appropriateness of the criteria for each of the usability factors. The survey was conducted to analyse the feedback on the multimedia elements criteria involved 38 proxy users in evaluating a low-fidelity prototype of a mobile application user interface. The Analytic Hierarchy Process (AHP) was utilised to analyse the multimedia elements criteria from the standpoint of a proxy user. The results from the AHP analysis elaborate the multimedia element criteria that should be implemented in the designing of the mobile application user interface. A comparative study was then performed on 37 autistic children ranging in age from six to fourteen years, to evaluate the usability of the mobile application developed, called AutismApp. The Statistical Package for the Social Sciences (SPSS) tools were used to evaluate the responses to the survey questions. Based on the usability evaluation conducted, it was found that AutismApp achieved a better means score as compared to the controlled app. The hypothesis test also proved a significant difference between the mean score of the multimedia element criteria of each application. These findings indicate that the usability guideline devised from the ix usability framework is suitable for designing the user interface of AutismApp based on the criteria for multimedia elements

Mohamed@Mohd Ghazali, Nur Adibah (2022) *The Modification of Ni-supported Gamma Alumina with Yttrium as an Oxygen Carrier for Chemical Looping Combustion.* Masters thesis, Universiti Teknologi PETRONAS.

With the recent advancement of the chemical looping combustion (CLC) industry, the development of materials with high stability and high oxygen transport capacity (OTC) has become a research hotspot. In this work, the behavior of nickel oxide (NiO) as an oxygen carrier (OC) has been analyzed using thermogravimetric analysis (TGA). The influences of the preparation methods and Ni composition have been evaluated in order to develop OC with high performance and high OTC without chemical and structural properties changes. With the most potential Ni loading and preparation method, the effect of adding second metal, yttrium (Y) has been investigated further on the redox behavior. All the prepared OCs were characterized using BET, TPR, FESEM/EDX, XRD, and TGA for 10 cycles of reduction and oxidation processes. It has been observed that the 15 wt.% of Ni loadingprepared via impregnation method (15NA-IMP) possessed a high value of OTC approximately 3.67 % while the OCs prepared by ultrasound irradiation (15NA-ULT) possessed an OTC value of 3.17 %. XRD results showed that the addition of yttrium, as a promoter to 15 wt.% of Ni loading (15N5YA) impregnated sample, has altered the interaction between Ni and gamma alumina and modulated the properties of the OC towards an excellent reactivity. Y significantly enhanced the BET surface area up to 95 m2 /g, reduced formation of stable compound, NiAl2O4 and improved the OTC value to 3.8%. The OCs were also tested at different reduction reaction time (1 to 7 minutes) and reaction temperature (800 to 950 ℃) to study the effect of reaction conditions. The best reaction conditions were obtained at a reduction reaction time of 5 minutes and a reaction temperature of 900 ℃, in which OTC of 4.1 % was achieved. The Ni-Y/γ-Al2O3 was found to follow a first order kinetic reduction reaction with a low activation energy of 23.3 kJ/mol. As a conclusion, combination of Ni and Y with 15 wt.% loading of Ni and 5 wt.% of Y, respectively as an OC is a good candidate for CLC reactions.

Mohd Hanafiah, Ahmad Syukri Na'im (2022) *Inferential Sensing for Chemical Species Determination in CO2-MEA-H2O System Using Raman Spectroscopy and Chemometrics Method.* Masters thesis, Universiti Teknologi PETRONAS.

The improvement in energy efficiency is recognized as one of the significant parameters for achieving our net-zero emissions target by 2050. One exciting area for development is conventional carbon capture technologies. Current amine absorptionbased systems for carbon capture operate at suboptimal conditions resulting in an efficiency loss, causing a high operational expenditure. Knowledge of qualitative and quantitative speciation of CO_2 loaded alkanolamine systems and their interactions can improve the equipment design and define optimal operating conditions. Raman spectroscopy offers hands-on information about the species distribution within such solutions. This work investigates the potential of Raman spectroscopy as an in situ monitoring tool for determining chemical species concentration in the CO_2-loaded aqueous monoethanolamine (MEA) solutions. Experimental information on chemical speciation and vapour-liquid equilibrium was collected at a range of process parameters. Then, Partial Least Square (PLS) regression and Artificial Neural Network (ANN) were applied separately to develop two Raman species calibration models where the Kent-Eisenberg model correlated the species concentrations. The data were paired and randomly distributed into calibration and test datasets. A quantitative analysis based on the coefficient of determination (R^2) and Root Mean Square Error (RMSE) was performed to select the optimum model parameters for PLS and ANN approach. The R^2 values of above 0.90 are observed for both cases indicating that both regression techniques can satisfactorily predict species concentration. ANN models are more accurate with R^2 higher by 4.92% and RMSE lower by 43.63% compared to PLS. However, PLS (being a white box model) allows the analysis of spectral variables using a weight plot. Selected models were then subjected to robustness test using Raman spectra from varying MEA concentrations. Based on visual analysis, PLS models are more robust and able to give compared to ANN models against variation in total MEA concentrations.

Qadeer, Muhammad Umer (2022) *Synthesis Of Glycerol Free Biodiesel From Waste Cooking Oil Via Conventional And Microwave Heating Techniques.* Masters thesis, Universiti Teknologi PETRONAS.

Production of biodiesel from waste cooking oil is a sustainable solution to overcome the problem of available high cost of biodiesel due to the usage of waste frying oil as a feedstock that provides potential vast future economic opportunities. The production of glycerol in the process of conventional transesterification is a natural process that is low in cost, and it makes the product recovery strenuous. In a conventional process, the production of glycerol is 10% of the product. In this research, methyl acetate is used as a solvent instead of methanol for the interesterification of waste cooking oil. As a result, interesterification, biodiesel, and triacetin are produced. Triacetin has the potential to be used as a fuel additive. The characterizations of waste cooking oil are determined such as water content (0.06%), free fatty acid (0.78%), density 899 (kg. m-3), viscosity (35.28 m2 s -1), and flash point 287 (°C) respectively. A study of biodiesel production was carried out from waste cooking oils using conventional and microwave-assisted interesterification. In particular, the interesterification reaction carried out at temperatures ranging from (30-60 °C), reaction time (1-4 hrs and 8-32 mins) for conventional and microwave methods respectively, catalyst loading (0.3-1.2 wt.%), and oil to methyl acetate molar ration (1:8- 1:32) was particularly investigated. Under optimal reaction conditions: methyl acetate to oil molar ratio (24:1), catalyst concentration (0.9 wt.), temperature (50 °C), the yield of biodiesel in conventional interesterification process was 82.5% at 180 mins reaction time; while in microwave-assisted interesterification maximum yield of 92.45% was achieved at 24 mins reaction time. The response surface methodology (RSM) was used to investigate the validation of experimental data and the relationship between the yield of biodiesel and four process factors, specifically, reaction time, the molar ratio of methyl acetate/oil, reaction temperature, and the amount of catalyst. To investigate, kinetic and thermodynamic studies were conducted. The conventional technique yielded 82.5% biodiesel after 180 mins of reaction time, whereas microwave- ix assisted yielded 92.45% biodiesel after 24 mins of reaction time. The relationship between biodiesel production and four process variables was validated using response surface methods (RSM).

Shakir Sumit, Md Shahriar (2022) *Restinet: A Lightweight CNN For Designing An Efficient Human Detection System.* Masters thesis, Universiti Teknologi PETRONAS.

Among several challenges in computer vision is the human detection, which is one of the applications in object detection. In general, it is the initial phase in a number of applications, including the public security and safety monitoring. Human detecting technologies have been brought up with significant advancements in recent years, owing to the fast growth of deep learning. Despite recent advances, majority of the lightweight CNN models are not algorithmically less compute-intensive to be able to seamlessly integrate with low-power portable devices. However, few models exist which do work with portable devices, but they focus only on general object detection. Therefore, the degree of such issues motivated us to propose a novel method, ReSTiNet, a compressed CNN design that not only addresses the problem of size, detection speed and accuracy but also lays an emphasis on human detection. Inspired by SqueezeNet, ReSTiNet adopts the fire modules by examining their numbers and locations within the model to reduce both the model parameter numbers and model size. The residual connection inside fire modules in ReSTiNet is interpolated and finely constructed to enhance feature propagation and make sure the utmost information flow in the model, with the goal of further enhancing the detection speed and accuracy using the proposed network. The proposed algorithm shrinks the previously popular Tiny-YOLO model and enhances the following features: (1) faster detection speed, (2) compact model size, (3) solves the overfitting problems and (4) outperforms other lightweight models such as MobileNet and SqueezeNet in terms of mAP on MS COCO and Pascal VOC datasets. The resultant ReSTiNet model is 10.7 MB in size (nearly five times less than Tiny-YOLO) but achieves a mAP of 63.74% on PASCAL VOC and 27.3% on MS COCO on Tesla k80.

Thinakaran, Varunesh (2022) *[Factors Of Safety Misconduct Affecting Safety Performance At Tall Building Construction Site.]* Masters thesis, Universiti Teknologi PETRONAS.

The construction industry is mainly involved in building projects all over the world. Most of the country has their own unique tall building or skyscraper which is constructed to elevate the country pride. On the other hand, tall building save space and accommodate more residents as compared to low rise buildings. However, vast problems encountered by construction team to ensure the safety performance of the construction site is well maintained. It has been observed globally that there are many accidents involve during building construction especially due to misconduct of safety procedure. Those accidents affect directly on the project performance of works delay and financial constraint due to safety procedure that necessities to pursue, for example, project stop-work orders and installment for damage treatment cost for the laborers. Previous studies have shown that the major causes of the accidents are due to carry out work in unsafe condition, unsafe design for the safety elements and poor safety awareness. There is something lacking in safety procedure or lack of output from the safety management side especially for constructions of tall buildings. In this study, the top 10 factor of safety misconduct that affecting safety performance of tall building construction site have been assessed through 3 case studies, literature review, questionnaire survey and interviewing project team. The statistical analysis including Relative Importance Index (RII) and Average Index (AVI) have been used to break down the information accumulated, while the Statistical Package for Social Science (SPSS) version 23.0 has been used to gauge the Spearman's rank correlation between different gatherings of respondents, the Cronbach's alpha (reliability test) and legitimacy of the study. Correlation between the factors and variable has been performed to show the significance level between the factors which affects the safety performance. At the end this study, result revealed that based on the ranked top ten factors, five out of ten sub factors are from management related factor, two out of ten sub factors are from material and equipment related factor, two out of ten sub factors are from workplace related factor and one out of ten sub factors comes under worker involvement factor. This shows that management related factors give major impact on the safety management at construction site. A safety framework has been proposed and validated to enhance the safety performance in order to ensure that the activities progressing smoothly to accomplish the project objectives.

Syahrul Aman, Syafiqah (2022) *Mechanical Properties of Crumb Rubber Mortar Containing Nano-Silica Using Response Surface Methodology.* Masters thesis, Universiti Teknologi PETRONAS.

In order to minimize the number of discarded tires, which cause serious environmental impact, crumb rubber (CR) from scrap tires is reused in the construction industries as a partial replacement of fine aggregates in cement paste. This promotes the sustainable development of nature, economy, and society as waste tires are nonbiodegradable and flammable material. They are very bulky that they occupy large space in landfill. Inclusion of CR in mortar leads to several improvements on cement paste mixture properties such as ductility, fatigue performance, and impact resistance. However, it exhibits lower strengths and Modulus of Elasticity (ME) of the cement paste mixture. Therefore, to encourage the usage of mortar containing CR in the construction industries, it is vital to improve its mechanical strengths. By incorporating nano-silica (NS) into CRM, it able to mitigate the drawbacks of incorporating CR. This research aims to study the various percentages of NS on the mechanical properties, drying shrinkage, interfacial transition zone (ITZ), and microstructure of NS-CRM, to determine the optimum percentage of NS in CRM, and also to develop models to predict the mechanical strengths of the NS-CRM using Response Surface Methodology (RSM) technique. Compressive, flexural tensile, direct tensile, drying shrinkage, ME, Poisson's Ratio (PR), Scanning Electron Microscope (SEM), Mercury Intrusion Porosimetry (MIP), RSM, and Analysis of Variance (ANOVA) were considered in this thesis. Two variables were considered, the range of CR partial replacement to sand by volume at 0%, 7.5%, and 15%, and NS as partial replacement to cement by weight at 0%, 2.5%, and 5%. The water to cementitious materials (w/c) ratio and sand to cementitious materials (s/c) ratio used were 0.35 and 1.5, respectively. Results revealed that the mechanical properties, ITZ, and microstructure of CRM were improved by incorporating 2.5% of NS, and as well as models developed using RSM were acceptable as the percentage of error calculated between the experimental and theoretical strengths were in the range of 2% to 3%. However, the properties of NS-CRM acted contrariwise when 5% of NS was incorporated.

Ali, Fouad Ismail Ismail (2022) *Enhancing The Structural Performance Of RC Beams Made Of High-Performance Concrete Containing Graphene Nanoplatelets.* Masters thesis, Universiti Teknologi PETRONAS.

Concrete, the world's most widely used construction material, is undergoing intensive research and development in order to improve its performance and usefulness. Despite the fact that concrete is used to build many structures, it still has severe shortcomings. Furthermore, because chemical and mechanical imperfections in the cementitious composites generate the majority of concrete damage, a truly game-changing strategy to boost mechanical performance and give new capabilities needs nanoscale engagement. Accordingly, the use of high-performance concrete (HPC) incorporating nano additives would be a viable alternative for minimising and delaying structural fractures and preserving the necessary structural capacity during the life of the structure. Therefore, the current study aimed to explore the possibility of improving the structural performance of RC beams made of HPC by integrating graphene nanoplatelets (GnP) as a nano additive. To investigate the optimum content of GnP, different dosages of GnP were added, which were 0.00, 0.02, 0.05, 0.10, 0.30, and 0.50% by the weight of cement. The research objectives were divided into three objectives. The first objective was concerned with investigating the impact of GnP on the mechanical properties of HPC. Secondly, the impact of different GnP content on the bond strength of HPC was analysed and discussed. Thirdly, the influence of varied content of GnP on the flexural performance of RC beams was presented and analyzed. Test results showed that the lower content of GnP was able to enhance the mechanical properties, while excessive doses showed a negative effect. For example, GnP of 0.02 wt.% enhanced the compressive strength by 20.82%, direct tensile strength by 30.05%, and flexural strength by 13.16%. Additionally, GnP improved the bond stress of HPC. For example, GnP of 0.02 wt.% enhanced the bond stress by more than 41.28% and 53.90% for steel bars with 10 and 16 mm in diameter, respectively. Finally, the impact of GnP on the structural performance of RC beams was considerable. With the inclusion of GnP of 0.02 wt.%, there is an enhancement in the first cracking load by 36%, the yielding load by 23%, the ultimate load capacity by 15%, and the compressive strain capacity of RC-HPC beams by 10%.

Ali, Safwan Sadeq Mahmood (2022) *Modeling And Simulation Of Pmsg Wind Energy Conversion System Using Active Disturbance Rejection Control.* Masters thesis, Universiti Teknologi PETRONAS.

Electrical power generated from wind turbines inherently fluctuates due to changing wind speeds. Without proper control, disturbances such as changing wind speeds can degrade the power quality factor and robustness of the electrical grid. To ensure good power quality factor, high performance and robustness of the grid against internal and external disturbances, the use of Active Disturbance Rejection Control with an extended state observer ESO for Permanent Magnet Synchronous Generator(PMSG) Wind Energy Conversion System is investigated. The Analysis performances of our system, a conventional PI and the active disturbance rejection control (ADRC) were compared, and the results environment shows that the proposed ADRC methods gives very satisfactory characteristics with good efficiency. It has been established that the Active Disturbance Rejection Control (ADRC) controller not only regulates the wind turbine power, but it also regulates the output voltage at its terminals. The system has been simulated in MATLAB/Simulink at various wind speeds. The obtained simulation results indicate that the controller maintains constant DC voltage at the interface of the generator-side converter and grid-side converters and achieves maximum power. The results also show that the system performance has good stability, precision and rejection of internal disturbances, with an overall system efficiency of 98.65%.

Fakourdabbaghi, Milad (2022) *Numerical Investigation And Optimization Of The Crank-Rocker Engine Ignition Timing Based On Performance And Combustion Characteristics.* Masters thesis, Universiti Teknologi PETRONAS.

Crank-rocker (CR) engine is a newly developed combustion engine based on a combination of the conventional and toroidal engine with a curved-cylinder combustion chamber. The fundamental of the CR engine has been obtained from a four-bar mechanism. The engine is significantly required to be optimized in terms of ignition timing. Meanwhile, the detailed characteristics of the performance with respect to the optimum ignition timing for the CR engine are still undetermined. Thus, this research aimed to investigate the effect of varying the spark timing on the performance characteristics of the CR engine while predicting the ignition timing for the best performance using mathematical modeling. For these purposes, a four-stage methodology was designed to perform the investigations. These include modification of the CR engine combustion model, heat transfer correlations evaluation, and optimization process of CR engine in terms of performance characteristics under various operating parameters and predicting the optimum condition. Then, the results were analyzed and compared with experimental data at each stage. The accuracy of the modified combustion model increased once a sub-model of the specific heat ratio was included. Comparing various heat transfer correlations and their influence on the accuracy of the prediction led to concluding that Annand's model is the best choice for heat transfer modeling. The developed models in the optimization process shed light on the effects of various parameters that led to the modification of the optimization model. The results were compared with the benchmarked engine (Modenas ACE115) and showed a good match in terms of performance. In conclusion, the optimum timing for the CR engine was determined to be at 24° CA BTDC, which resulted in the best performance characteristics with the maximum values for the brake torque, brake power, and brake thermal efficiency of 8.9 Nm, 8 kW, and 32% respectively.

Hassan, Tengku Nur Adibah Tengku (2022) *Synthesis Of Pebax 1657/Hierarchical Linde Type-T (H-LTT) Zeolite Mixed Matrix Membrane For CO2/CH4 Separation.* Masters thesis, Universiti Teknologi PETRONAS.

Zeolite-based mixed matrix membrane (MMM) has been introduced as a prominent approach to overcome the performance and commercial constraints of polymeric and inorganic membranes. However, zeolite-based MMM is usually prone to diffusion limitation due to the narrow size of pore channels. Alternatively, hierarchical zeolites-based MMM have been identified as promising potential to overcome the diffusion limitation via the presence of bimodal porous structure. Therefore, the present work aims to fabricate MMM by incorporating hierarchical Linde Type-T (h-LTT) zeolite into Pebax 1657 for CO2/CH4 separation. The MMMs were fabricated at different loading ranging between 5 wt% – 30 wt% and characterized using FESEM, EDX, FTIR, XRD, TGA and DSC. Then, the performance of the MMM was investigated through the single gas permeation test using pure CO2 and CH4. Subsequently, the optimized MMM was tested for CO2-induced plasticization and investigated for CO2/CH4 binary gas separation at a pressure of 3.5 bar - 10 bar and a temperature of 30°C - 60°C. The results showed that the h-LTT zeolites were homogeneously dispersed in the MMMs and improved crystallinity, thermal stability and glass transition temperature in comparison with pristine membrane. Furthermore, MMM loaded with 25 wt% of h-LTT zeolites displayed the highest increment of CO2 permeability up to 164.83 Barrer and CO2/CH4 selectivity up to 19.37. Besides, the membrane demonstrated enhanced CO2-induced plasticization pressure from 7.5 bar to 12.5 bar relative to the pristine membrane. For the binary gas separation, CO2 permeability reduced while CO2/CH4 selectivity increases at elevated pressure. On contrary, the membrane shows a significant increment in CO2 permeability and decrement in CO2/CH4 selectivity as the temperature increased. Overall, the combination between h-LTT zeolites and Pebax 1657 for the formulation of MMM enhances the CO2/CH4 separation, which signifies their potential in biogas upgrading and natural gas purification application.

Kamil, Ernie Amira (2022) *Determination of Mangrove Adequacy in Dissipating Waves along Kedah Coastline.* Masters thesis, Universiti Teknologi PETRONAS.

Mangroves are widely acknowledged for their ability in attenuating wave. The protection function that mangroves provide is evident where the mangrove-shielded areas encountered minimal damages compared to the unprotected coastlines. However, studies on the adequacy of mangroves in providing optimum coastal buffer especially along the Kedah coastline remain scarce. This study hereby aims (1) to analyze the distribution and characteristics of mangrove along the Kedah coastline, (2) to determine the wave height reduction across the mangrove forests along the Kedah coastline, and eventually (3) to determine the adequacy of mangrove band width for optimal protection along the Kedah coastline using Bao's formula. Kedah, which was previously affected during the 2004 Indian Ocean Tsunami has been undertaken as the study site. Mangrove characteristics were assessed during field assessment and Landsat-8 OLI images were utilized for mangrove mapping. Later, incident and transmitted wave heights were analyzed to study the reduction by mangroves. Bao's formula was further incorporated to assist in determining mangrove adequacy upon respective wave conditions and mangrove structures. A total area of 5,568.12 ha of mangroves was discovered with dense coverage growing along Merbok River, Kuala Muda and Ayer Hangat, Langkawi. Clearance of mangrove in Kuala Kedah, mangrove defoliation in Jerlun, scarp formation in Merbok, bamboo as replantation technique in Kuala Teriang and sand topping the muddy area in Sungai Melaka have been spotted. The highest shoaling and refracted wave heights of 1.05 m and 0.92 m respectively were analyzed in both Jerlun and Sungai Daun. While less transmission occurred in Kangkong with wave height of 0.68 m, Jerlun, however, recorded the greatest transmission with 0 m wave height. Jerlun, which possesses high density, canopy closure, and maximum band width showed the best performance with a 100% reduction rate. Meanwhile, the lowest dissipation performance of 33.5% was marked by Kangkong. A comparison between the required and current band width of mangroves viii was made. The findings revealed that most of the locations had insufficient protection over the minimum band width. Therefore, replantation is needed where the coverage is low to ensure optimum protection towards the coastline.

Mohammed, Musa (2022) *[Development of Conceptual Framework for Achieving Sustainable Construction Waste Management Through Application of 3R Principles.]()* Masters thesis, Universiti Teknologi PETRONAS.

Resistance Spot Welding (RSW) is a well-known joining technique in the automobile industry. In producing stainless steel RSW joints, one of the problems encountered is poor weld quality indicated by a reduction in weld nugget resulting from inappropriate RSW parameters. Furthermore, the hardness of the Fusion Zone (FZ) influences the mechanical performance of the weld joints as it affects the failure mode. The optimization of the RSW parameters and the application of post-weld treatment has the potential of improving the quality of RSW joints. The incorporation of design of experiment, such as the central composite design of the response surface methodology, facilitates the optimization process. In this research work, the welding current, welding time and electrode pressure, which optimizes the nugget diameter and FZ hardness of RSW 2 mm SUS 316L austenitic stainless steel, were determined. Subsequently, the effect of preheating and post-weld tempering on the FZ hardness was also investigated. A total of twenty experimental runs each were generated for RSW parameters and post-weld treatment parameters using CCD. The domains for the RSW parameters are 6 – 11 KA welding current, 10 – 30 cycles welding time and 4 – 6 bar electrode pressure, while the domains for the post-weld treatment parameters are 100 – 200 oC preheating temperature, 400 – 600 oC tempering temperature and 2 – 4 hours holding time. Mechanical characterization of weld joints was achieved using Vickers microhardness tester, while microstructural characterization was conducted using optical microscopy, energy dispersive x-ray analysis and field emission scanning electron microscopy. The optimum RSW parameters that maximized the nugget diameter and minimized FZ hardness were 10.884 KA welding current, 30 cycles welding time, and 5.822 bar electrode pressure, producing a nugget diameter of 9.837 mm and FZ hardness of 196.07 HV. A lower FZ hardness of 149.2 HV was obtained after the application of postweld treatment at 150 oC preheating temperature, 500 oC tempering temperature and 4.7 hours holding time. The reduction in hardness was due to deferritization, growth of austenite and delta ferrite grains and release of residual stresses. RSW parameters optimization and application of appropriate post-weld treatment has a significant potential of improving weld quality.

Nuruzzaman, Md (2022) *Numerical Evaluation of Thermal Mixing Efficiency of Natural Gas in Two Different Converging Mixing T-Junctions.* Masters thesis, Universiti Teknologi PETRONAS.

Rapid temperature fluctuations and thermal fatigue occur at the weld area of Tjunction due to incomplete thermal mixing of hot and cold fluids in the mixing region. Crack or leakage in pipelines or sudden accident can happen in cooling system of nuclear reactor due to this high cycle thermal fatigue. Higher thermal mixing performance can help prevent this phenomenon. So, it is essential to find out and compare thermal mixing performance for different flow configurations and flow parameters. The present study aims to compare thermal mixing characteristics and efficiency of two different converging mixing tees, namely colliding, and intersecting T-junction with intention to produce working correlation(s) for thermal mixing efficiency, inlet temperature ratio and mass flow rate ratio. Numerical simulations were conducted by utilizing k-ε turbulence model and natural gas as working fluids. Thermal mixing efficiency for both intersecting and colliding tees at different planes along the mixing outlet and at different time steps were recorded. Experimental design methodology was used with inlet temperature and mass flow rate ratios as two variable factors. Results indicated that for same boundary conditions, thermal mixing efficiency of colliding mixing tee is 9 to 13% higher than intersecting tee. In the intersecting tee, there is an irreducible thermal stratification layer, but such layer was not observed in the colliding mixing tee. It is discovered that thermal mixing for both mixing tees increased with the increase of distance and time. Thermal mixing efficiency is found to be higher when the cold and hot inlet temperature ratio is higher which shows a direct proportionality relation. Moreover, higher thermal mixing was found to be achieved for much lower or much higher flow rate ratio than unity as the higher flow rate difference produce more turbulent mixing. This study provides clear guidelines to reduce thermal fatigue and temperature fluctuation in thermal mixing T-junction used in pipeline of different industries.

Rahman, Musfika (2022) *Pore-scale Investigation of Wettability and Spreading Coefficient Effects in Low Salinity Waterflood-WAG EOR.* Masters thesis, Universiti Teknologi PETRONAS.

Low-salinity water (LSW) flooding is an emerging EOR technique due to its oil recovery performance and lower environmental impact compared to the conventional EOR approach. LSW combined with water alternating CO2 gas (WAG) is a recent addition to the EOR process which has not yet been properly explored. From the recent literature, the effect of wettability and spreading coefficient (SC), in a three-phase flow system such as the combination of LSW flood with CO2 WAG requires further investigation as it play important role in the recovery of residual oil by controlling the fluids distribution and mobilization at the pore scale. The main aim of the study is to investigate the effect of wettability and SC on the low salinity water alternating CO2 (LSWACO2) process on a pore scale. In this study, Dulang, Decane, and Decane+Dulang mixture has been used as the oil phase whereas seven different salinity brine and CO2 have been used as the water phase and gas phase. Reservoir temperature (96℃) and pressure (200 - 2000 psi) have been maintained in the interfacial tension and contact angle experiments. For the wettability study, the contact angle of Berea sandstone has been measured under different wettability conditions (water-wet, oilwet), whereas for the SC study, IFT700 has been used to measure the interfacial tension of oil-water, gas-oil, and gas-water, all using different salinity brine with and without CO2 gas. Furthermore, for pore-scale visualization of the interactions of wettability and SC, glass micromodel experiments have been conducted in different wettability conditions. A significant outcome has been observed from interfacial tension and contact angle experiments which indicate the presence of CO2 gas has shifted the SC from negative to positive values and wettability alteration more like wetting to the system. From the micromodel experiments, it has been found that regardless of the value of the SC and wettability conditions of the rock, LSW resulted in more recovery compared to moderately high salinity water (HSW) and high salinity sea water viii (HSSW). Moreover, with a positive SC and water-wet condition, the recovery is 8% more than the negative SC and oil-wet condition. During the pore-scale investigation of LSW, the wettability condition and brine salinity influenced the oil bank formation regardless of the value of the SC. The results of this study have significant implications for the understanding of pore level interactions during LSWACO2 flooding.

Rasid, Shahrul Aida Ab (2022) *Foam Modelling with Nanoparticles Effects.* Masters thesis, Universiti Teknologi PETRONAS.

The potential use of nanoparticles as a foam stabilizer has been extensively assessed in recent studies. The nanoparticle effect in stabilizing foam has been proven in laboratory analysis but has yet to be piloted in the field. Although the conventional foam flooding process simulation is relatively established in the industry, one that incorporates nanoparticles' effect has yet to be realized. Simulating nanoparticlesstabilized foam behaviour is crucial to reduce risks and uncertainties associated with this process; nano-foam flooding can only be modelled with low accuracy as a "stabilized foam" with the current state-of-the-art. The purpose of this study was to assess the applicability of modelling nano-foam using an implicit texture model solely on the foam stability improvement in the presence of silica nanoparticles at the first level of understanding with respect to the nanoparticle stabilisation mechanism, while excluding the limiting factors that degrade foam performance (oil free and at standard conditions). Both experimental and modelling analysis were conducted to meet the research objectives. Based on established literature, silica nanoparticles were chosen in combination with MFOMAX surfactant. The nanofluid mixture compatibility were revalidated at standard condition. Then, the rheological behaviour of nano-foam regarding nanoparticle concentration, shear rate, and foam quality was assessed using a flow loop rheometer. After that, the mobility reduction factors (MRF) in surfactant foam and nano-foam flooding under the influence of nanoparticle concentration, salinity, foam quality, and total injection rate were experimentally obtained and compared. Lastly, the applicability of the existing implicit texture foam model was analysed for nano-foam. According to the compatibility results, the optimal nanoparticle-surfactant concentration ratio varies under standard conditions. Based on laboratory analysis, the nano-foam exhibits shear-thinning behaviour as the apparent viscosity decreases with increasing shear rate up to 750 s^{-1} at varying nanoparticle concentration and foam viii quality between 50% to 80%. Therefore, the current implicit texture foam model's assumption that foam is shear thinning is still valid within the studied nano-foam system. Based on the foam flooding experiments, nano-foam exhibits a significantly higher MRF at foam quality of 80% to 95% compared to surfactant foam. In addition to that, two foam decay rates were observed from the foam quality scan of the nanofoam. The established foam quality scan was used as an input to determine the critical foam model parameters (fmmob, F_3, and Fdry-out) to simulate foam flow behaviour. The existing foam model is unable to properly fit the nano-foam collapse behaviour established through the foam quality scan. Better nano-foam model parameter fit can be achieved by force-tuning the epdry parameter to precisely fit one of the two decay rates separately and validated in a commercial simulator with good differential pressure matching. A modified Dry-Out function was proposed and it can represent foam collapse behaviour in the presence of nanoparticles within the current scope of the study. This research's revised Dry-Out function model provides a novel method for finding the nano-foam process's fitting parameters.

Raya, Sofiah Atirah Binti (2022) *Analysis of Synergistic Effect of Silica Nanoparticles and Surfactants on Oil-In-Water Emulsion Resolution.* Masters thesis, Universiti Teknologi PETRONAS.

The potential use of nanoparticles as a foam stabilizer has been extensively assessed in recent studies. The nanoparticle effect in stabilizing foam has been proven in laboratory analysis but has yet to be piloted in the field. Although the conventional foam flooding process simulation is relatively established in the industry, one that incorporates nanoparticles' effect has yet to be realized. Simulating nanoparticlesstabilized foam behaviour is crucial to reduce risks and uncertainties associated with this process; nano-foam flooding can only be modelled with low accuracy as a "stabilized foam" with the current state-of-the-art. The purpose of this study was to assess the applicability of modelling nano-foam using an implicit texture model solely on the foam stability improvement in the presence of silica nanoparticles at the first level of understanding with respect to the nanoparticle stabilisation mechanism, while excluding the limiting factors that degrade foam performance (oil free and at standard conditions). Both experimental and modelling analysis were conducted to meet the research objectives. Based on established literature, silica nanoparticles were chosen in combination with MFOMAX surfactant. The nanofluid mixture compatibility were revalidated at standard condition. Then, the rheological behaviour of nano-foam regarding nanoparticle concentration, shear rate, and foam quality was assessed using a flow loop rheometer. After that, the mobility reduction factors (MRF) in surfactant foam and nano-foam flooding under the influence of nanoparticle concentration, salinity, foam quality, and total injection rate were experimentally obtained and compared. Lastly, the applicability of the existing implicit texture foam model was analysed for nano-foam. According to the compatibility results, the optimal nanoparticle-surfactant concentration ratio varies under standard conditions. Based on laboratory analysis, the nano-foam exhibits shear-thinning behaviour as the apparent viscosity decreases with increasing shear rate up to 750 s^{-1} at varying nanoparticle concentration and foam viii quality between 50% to 80%. Therefore, the current implicit texture foam model's assumption that foam is shear thinning is still valid within the studied nano-foam system. Based on the foam flooding experiments, nano-foam exhibits a significantly higher MRF at foam quality of 80% to 95% compared to surfactant foam. In addition to that, two foam decay rates were observed from the foam quality scan of the nanofoam. The established foam quality scan was used as an input to determine the critical foam model parameters (fmmob, F_3, and Fdry-out) to simulate foam flow behaviour. The existing foam model is unable to properly fit the nano-foam collapse behaviour established through the foam quality scan. Better nano-foam model parameter fit can be achieved by force-tuning the epdry parameter to precisely fit one of the two decay rates separately and validated in a commercial simulator with good differential pressure matching. A modified Dry-Out function was proposed and it can represent foam collapse behaviour in the presence of nanoparticles within the current scope of the study. This research's revised Dry-Out function model provides a novel method for finding the nano-foam process's fitting parameters.

Riyadi, Zaky Ahmad (2022) *A new approach to permeability prediction of reservoir from rock elastic properties using machine learning.* Masters thesis, Universiti Teknologi PETRONAS.

The potential use of nanoparticles as a foam stabilizer has been extensively assessed in recent studies. The nanoparticle effect in stabilizing foam has been proven in laboratory analysis but has yet to be piloted in the field. Although the conventional foam flooding process simulation is relatively established in the industry, one that incorporates nanoparticles' effect has yet to be realized. Simulating nanoparticlesstabilized foam behaviour is crucial to reduce risks and uncertainties associated with this process; nano-foam flooding can only be modelled with low accuracy as a “stabilized foam” with the current state-of-the-art. The purpose of this study was to assess the applicability of modelling nano-foam using an implicit texture model solely on the foam stability improvement in the presence of silica nanoparticles at the first level of understanding with respect to the nanoparticle stabilisation mechanism, while excluding the limiting factors that degrade foam performance (oil free and at standard conditions). Both experimental and modelling analysis were conducted to meet the research objectives. Based on established literature, silica nanoparticles were chosen in combination with MFOMAX surfactant. The nanofluid mixture compatibility were revalidated at standard condition. Then, the rheological behaviour of nano-foam regarding nanoparticle concentration, shear rate, and foam quality was assessed using a flow loop rheometer. After that, the mobility reduction factors (MRF) in surfactant foam and nano-foam flooding under the influence of nanoparticle concentration, salinity, foam quality, and total injection rate were experimentally obtained and compared. Lastly, the applicability of the existing implicit texture foam model was analysed for nano-foam. According to the compatibility results, the optimal nanoparticle-surfactant concentration ratio varies under standard conditions. Based on laboratory analysis, the nano-foam exhibits shear-thinning behaviour as the apparent viscosity decreases with increasing shear rate up to 750 s^{-1} at varying nanoparticle concentration and foam viii quality between 50% to 80%. Therefore, the current implicit texture foam model’s assumption that foam is shear thinning is still valid within the studied nano-foam system. Based on the foam flooding experiments, nano-foam exhibits a significantly higher MRF at foam quality of 80% to 95% compared to surfactant foam. In addition to that, two foam decay rates were observed from the foam quality scan of the nanofoam. The established foam quality scan was used as an input to determine the critical foam model parameters (fmmob, F_3, and Fdry-out) to simulate foam flow behaviour. The existing foam model is unable to properly fit the nano-foam collapse behaviour established through the foam quality scan. Better nano-foam model parameter fit can be achieved by force-tuning the epdry parameter to precisely fit one of the two decay rates separately and validated in a commercial simulator with good differential pressure matching. A modified Dry-Out function was proposed and it can represent foam collapse behaviour in the presence of nanoparticles within the current scope of the study. This research’s revised Dry-Out function model provides a novel method for finding the nano-foam process’s fitting parameters.

Samsudin, Nur Marina (2022) *Sedimentological and Micropaleontological Characteristics of the Pedawan Formation Sediments in Siburan, Kuching.* Masters thesis, Universiti Teknologi PETRONAS.

A comprehensive study on the Pedawan Formation (Jurassic – Cretaceous age) was conducted on fourteen (14) outcrops in Siburan area, Kuching. These outcrops were exposed along the Borneo Heights road and Jambusan-Semadang road. Detailed facies analysis has identified ten (10) lithofacies, in which six (6) are sand lithofacies and four (4) are mud lithofacies. They are mainly mud dominated, interbeds of sandstone and mudstone with some deformational features that are prominent in outcrop JS13. The soft-sediment deformation structures in this research are analysed to be the results of both, large scale mechanism, like earthquake, and smaller scale mechanism, such as overloading and rapid deposition. The main processes that develop these structures are fluidisation and liquefaction. Previous reports by Ting (1992) and Hutchison (2005), explained that the facies of Pedawan Formation is deep marine, argillaceous rocks of black shales with some sandstone beds and carbonaceous materials, but no particular sub-environment of the deep marine was mentioned. Using the results from facies analysis, micropaleontology, petrography and soft sediment analysis, the depositional model of the Pedawan Formation for this study is able to be more specified. It is the interpreted to be the complex, deep marine fan lobe setting, with deformed external distal-levee facies. Based on the micropaleontological study, new assemblages of foraminifera and nannofossils are identified for the Pedawan Formation. The bathymetric zone is middle to outer neritic and partly bathyal setting. The possible age are recognized to be from Upper Paleocene to Lower Eocene. Even though this new age range is older than the reported age range (Jurassic to Cretaceous), it may probably propose that the Pedawan Formation has a much longer and extensive range of age.

Yusoff, Muhamad Shakir Bin (2022) *Effect Of Epoxidation Level On The Physicochemical And Field-Dependent Rheological Properties Of Epoxidized Natural Rubber-Based Magnetorheological Elastomers.* Masters thesis, Universiti Teknologi PETRONAS.

Two commercialized variants of epoxidized natural rubber (ENR), namely, ENR 25 and ENR 50, have been explored. ENR-based MREs has several advantages such as good mechanical properties, particularly damping property, which can be applied to vibration and control noise devices. ENR 25 and 50 is chosen as it is easy to fabricate and already commercialized. However, there is a dearth of concrete information on physicochemical characteristics and rheological properties in terms of different levels of epoxidation. Therefore, the main contribution of this study is to investigate the effect of epoxidation level of ENR 25- and ENR 50-based MREs on physicochemical characteristics and rheological properties. Both ENR-based MREs were fabricated by mixing with carbonyl iron particles (CIPs) and other additives. The mixture then was cured at 150°C for 30 minutes. Ten different samples with different weight percentages (wt%) of CIPs were produced. The t90 increased upon increasing weight of CIPs, while ts2 decreased for both ENRs. Randomly distributed CIPs particles within the matrix were observed, and isotropic type is identified. MRE/ENR 25 had the highest saturated magnetization with 42.54 emu/g compared to MRE/ENR 50 with 40.80 emu/g using 70 wt% CIPs. At 1245cm−1 (C–O group), MRE/ENR 50 showed the highest peak compared to MRE/ENR 25. The glass transition temperature (Tg) of MRE/ENR 50 was slightly similar with range −24.5°C to −26.1°C compared with MRE/ENR 25 samples with temperature ranging from −53.2°C to −55.1°C. The addition of CIPs in both ENR samples delayed the thermal degradation process, where Tonset shifted toward higher temperature. MR effect for MRE/ENR 25 increased from 1.88% to 22.6%, while for MRE/ENR 50, it increased from 2.47% to 18.18%. Results and their analysis confirm that different levels of epoxidation of ENR slightly affect the physicochemical and rheological properties of ENR-based MRE. Overall, this research can be used by the researchers since both ENR-based MRE in this study resulted in different values in any aspect of analysis that had be done in this study when it is implemented in any MRE device such as potential vibration control devices.

Zubir, Wan Mohammad Aflah Bin Mohammad (2022) *Adaptive Selection of Inference Method for Latent Dirichlet Allocation (ASIM-LDA).* Masters thesis, Universiti Teknologi PETRONAS.

A lot of textual data is generated daily due to the advent of technologies, such as social media networks. Characteristics of textual data introduces challenges in analysing the data such as selecting a suitable text representation method for varying complexity of dataset. Topic Modelling is a research area that focuses in addressing this issue, by establishing the assumption that textual data are clustered in topics, rather than simply independent words. Latent Dirichlet Allocation (LDA) is one of the method in Topic Modelling. LDA is a generative probabilistic method, which allows LDA to adapt to new and unseen data, without having to retrain the model on the entire dataset. To extract topic representations, LDA uses approximate inference algorithms, such as Variational Bayesian Inference (VB) and Gibbs Sampling (GS). These two inference algorithms are selected due to their high performance in extracting quality topic distributions. Each of the inference algorithm adapts differently to different complexity dataset. The inference algorithms also have hyperparameters which need to be tuned to increase fitness to a dataset. To address these two challenges, Adaptive Selection of Inference Method for Latent Dirichlet Allocation (ASIM-LDA) is proposed. The objective of this research is to overcome the challenge of adapting to varying complexity of dataset by introducing two stages of refinement, namely hyperparameter optimization of individual inference algorithm and establish selection filter of best inference algorithm based on topic coherence score. The proposed algorithm is tested on three textual datasets. It is then evaluated based on performance of classification task. In this evaluation, three parameters of classification performance which are, accuracy, precision, and recall, are analysed. Based on the results, it shows that the proposed method accomplishes improvement of average of 9% in comparison to other topic modelling algorithms, despite being tested on different levels of dataset complexity. ASIM-LDA adapts through the two stages of refinement, which effectively selects the best approximate inference algorithms and best set of hyperparameters for given dataset.

Rosli, Mohd Arif Fahmi (2021) *Experimental Investigation Of Droplet Evaporation And Micro Explosion Behaviour Of Gas-To-Liquid (Gtl) Fuel.* Masters thesis, Universiti Teknologi PETRONAS.

Gas-to-Liquid (GTL) fuel is considered as clean fuel alternatives and has been given much attention as a replacement for conventional fuel. Unfortunately, there exist a minimal number of studies discussing the behaviour of the droplet evaporation and micro-explosion of GTL fuel blends. Therefore, this study aimed to study the effect of different blending ratio in GTL-diesel fuel blends on droplet evaporation and microexplosion behaviour through appropriate methods. A group of GTL-diesel fuel blends (G20, G50, G80, and G100, where the number reflects the proportion of GTL fuel inside the fuel blend) was prepared. The effect of different blending ratio of GTLdiesel fuel blends on the droplet evaporation behaviour was investigated using single droplet drop test on a hot plate under the Leidenfrost effect. On the other hand, the impact of different blending ratio of GTL-diesel fuel blends on the droplet microexplosion behaviours was tested using single suspended droplet test in high temperature control volume chamber. The hot plate and constant volume chamber were set up to have 500°C of temperature and 101 kPa of ambient pressure. The shadowgraph and high-speed camera were incorporated for droplet visualisation. An image processing system and Statistics and Machine Learning in MATLAB were used to analyse the droplet evaporation behaviour. In contrast, an additional of Image Processing Toolbox in MATLAB was incorporated to study the droplet microexplosion behaviour. The single droplet drop test showed increasing GTL fuel ratio decreased the heating phase duration and evaporation rate while increased their steady evaporation phase duration and droplet lifetime. The suspended droplet test found that puffing was not perceptible for G100, while micro-explosion was not perceptible for G20. In contrast, both events were experienced by the remaining fuel blends and importantly, G50 portrayed the best micro-explosion intensity amongst others. The result found the GTL fuel would enter the superheated state and encourage microexplosions at the tested temperature. This opens up the prospect of introducing a GTLdiesel fuel blend as a fuel blend that will induce micro-explosion and puffing phenomena, among others.

Mansoor Nasser, Ahmed Mohammed (2021) *Condition Assessment Model For Offshore Gas Pipelines Using Deep Learning Approach.* Masters thesis, Universiti Teknologi PETRONAS.

Condition assessment is necessary to select the appropriate maintenance or replacement plans for oil and gas pipelines. Artificial intelligence such as artificial neural network (ANN) and fuzzy-based models are recently used for offshore pipelines condition assessment. However, ANN models do not process large data due to the limited number of layers. Also, feature extraction is done manually, which makes it subjected to human error. Fuzzy-based models need an extensive model testing, highly dependent on expert knowledge and need specific criteria for determining fuzzy rules and membership functions. To overcome these limitations, a deep neural network (DNN) model was developed based on deep learning technique. Python associated with several libraries such as Keras was used to develop the DNN model to predict offshore gas pipelines condition. The inspection data for two offshore gas pipelines were collected from an oil and gas company. The actual numerical scale (Y) determined by an ANN model was also obtained. The dataset which consists of seven parameters were normalised into a scale of 0 to 1. The DNN model consists of four hidden layers which activated with Relu and Sigmoid activation functions. The model was trained using the feedforward process and backpropagation algorithm associated with Adam optimisation. The trained DNN model was evaluated using mean absolute error to prove its accuracy. A sensitivity analysis was conducted to evaluate the effect of each parameter on the pipeline condition. Finally, the deterioration curve with respect to age was developed to show the combined effect of all parameters on the pipeline condition. The developed DNN model was used to determine the predicted numerical scale (Y^) of 818 pipeline data points, which was validated against Y. The results showed a good agreement between Y^ and Y with a maximum error of 2%. The performance comparison conducted in terms of mathematical validation diagnostics showed that DNN model outperforms the fuzzy-based model. Furthermore, the average validity percentages of the DNN and the ANN models are 99.9% and 97.8% respectively. This indicates that the DNN model performance is better compared to the ANN model. It viii was observed from the sensitivity analysis that the metal loss, cathodic protection, and coating condition are the most influential parameters on Y^. Finally, the developed deterioration curve indicates that the pipeline fitness for service decreases with increasing age.

Abd Ghani, Nur Azeanni (2020) *Dry Reforming Of Methane For Syngas Production Over Ni-Co Supported Al2o3-Mgodoped Zr-Nb Catalysts.* Masters thesis, Universiti Teknologi PETRONAS.

DRM is one of the alternatives to produce syngas by utilizing the main greenhouse gases which are CO_2 and CH_4 to reduce environmental emissions. However, the use of Ni-based catalysts. i.e. Ni/Al_2O_3 catalyst for DRM reaction brought a drawback impact to the reaction as it contributes to the formation of coke and sintering of catalyst at high temperature which led to low reactants conversion and syngas production. Thus, this research focused on the development studies on the catalyst which has the potential to increase the reactants conversion and syngas production in the DRM reaction. In this work, five catalysts were developed for the production of syngas by synthesizing NiCo catalyst with Al_2O_3, and MgO supports and doped with Zr-Nb promoters. The characteristics of the catalysts were analyzed using various characterization techniques. FESEM results showed that the $Ni\text{-}Co/Al_2O_3\text{-}MgO/Zr\text{-}Nb$ catalyst has more uniform and the metal dispersed well compared to other catalysts. The incorporation of Zr-Nb proved that it helps to increase the BET surface area of the catalyst which was 11.2 $m^2\ g^{-1}$ is owing to the high surface area of promoters. Also, XRD and CO_2-TPD analysis revealed that there is a formation of $MgAl_2O_4$ spinel-type due to the interaction between alumina lattice and magnesium metal. This formation helps to increase the resistance to carbon which could minimize the carbon formation and enhance the catalytic performance as proved by the TPO analysis. The DRM reaction was done in the tubular furnace reactor at a temperature of 1073 K, the pressure of 1 atm and a CH_4/CO_2 ratio of unity. The $Ni\text{-}Co/Al_2O_3\text{-}MgO/Zr\text{-}Nb$ catalyst was found to be the best synthesized catalyst with the CH_4 and CO_2 conversion of 86.96% and 87.84%, respectively, because of the strong metal-support interaction, high carbon resistance as well as higher stability in the DRM reaction. The process optimization using RSM was performed using the best studied catalyst. The process variables which were studied in the process optimization are reaction temperature, CO_2/CH_4 ratio, and GHSV. The optimal CH_4 conversion analyzed from the RSM was 97.15% with the reaction temperature of 1112.3 K, $CO_2:CH_4$ ratio of 3.4, and GHSV of 30675.5 mL $g^{-1}\ h^{-1}$.

Muhammad Fuad, Iqmal Irsyad (2020) *Enumeration Approach for Simulating Condensate Banking in Gas Condensate Reservoir.* Masters thesis, Universiti Teknologi PETRONAS.

Condensate banking problem is notorious in managing gas condensate reservoirs. Failure to correctly model the physical processes expected in a reservoir could lead to wrong prediction on the impact of condensate banking. Initially, coarse scale grid is commonly used for gas condensate reservoir simulation study. Nevertheless, the coarse scale simulation disregards the condensate bank, or it is not able to demonstrate the precise distribution and effects. By introducing Local Grid Refinement (LGR) in simulation model arguably brings a better representation of the condensate bank effect near wellbore but significantly increases the computation time. This becomes severe especially in full field modelling with comingled production. Therefore, the objectives of this research are to develop new workflow to model efficiently condensate banking in gas condensate reservoir, to demonstrate effectiveness of the new model by using a real field data from Malay Basin, and to compare performance of the new model with existing conventional methods. A single well model was designed, and enumeration initialization approach was developed to divide the simulation explicitly in coarse scale simulation. During the simulation stop, a region near wellbore was designed where condensate bank parameters were modified based on the history matching. Hence, the drastic change of well performance due to condensate banking could be captured. This drastic change could not physically describe in conventional coarse scale simulation model, thus affect prediction accuracy. Comparison between enumeration ways with conventional approach were then investigated. It was found that enumeration method shows a better prediction in investigating the pressure behaviour of gas condensate system with less than 6% error. This is due to its ability to predict mobility changes due to condensate banking, consequently, improve the condensate bank characterization with improved computation time. As conclusion, the new workflow of Enumeration Method able to simulate gas condensate system effectively and efficiently.

Zainal Malek, Muhammad Syafiq (2019) *Reservoir Characterization And Modelling Of Koala Field In Termit Basin, Niger.* Masters thesis, Universiti Teknologi PETRONAS.

During the initial development of Koala Field, the evaluation of radioactive sands and low resistivity low contrast (LRLC) layers were ignored. Research from other fields of Termit Basin has proven the existence of LRLC anomaly. Moreover, radioactive sands have been reported in Bornu Basin, Nigeria which is a basin connected directly to Termit Basin itself. It is reported that almost half of its producing wells comprises this abnormality. Investigation of the stated anomaly should be conducted as part of characterization phase in Koala Field in efforts to re-evaluate its potential. Main objectives of the research are to analyse and integrate geophysical and petrophysical data of the field by exploring the presence of radioactive sands and LRLC anomalies. Findings are applied in the static model built from 3D seismic data and comparison of volume before and after the characterization application was done. Methods used were dependent on evaluation of conventional wireline logs, field development report and seismic data. Four approaches in evaluating radioactive sands were established. In defining the anomaly, evaluation of gamma ray readings, mud cake existence, resistivity readings, and neutron-density crossover was used alongside neutron-density cross plots for identification of hydrocarbon bearing radioactive sand lithology. Source determination was evaluated via spectral gamma ray analysis together with thorium vs potassium (Th/K) cross plots. LRLC determination were conducted via evaluation of neutron-density logs and deep resistivity logs. Types of sources that were established focussed on laminated intervals, conductive clay minerals and fresh water formations. Findings were mostly focussed on low contrast effects from laminated intervals.

Muhammad Sajid (2019) *Microwave Assisted Catalyzed Glycerol Etherification into Polyglycerol in the Presence of Alkaline Modified Aluminum Pillared Clay.* Masters thesis, Universiti Teknologi PETRONAS.

The potential of glycerol conversion into a valuable product such as polyglycerol was examined through the microwave assisted catalytic etherification process. This study revealed the achievement of a nonconventional heating method for glycerol etherification via modified aluminum pillared clay (AlPC). The series of metals such as lithium (Li), sodium (Na), potassium (K), and cesium (Cs) were impregnated with AlPC for the selective glycerol etherification to polyglycerol to improve the yield by the solvent-free process. The prepared catalysts were characterized to investigate their structural and chemical properties by Thermogravimetric analysis (TGA), X-Rays Diffraction (XRD), Attenuated Total Reflection Fourier Transform Infrared Spectroscopy (ATR-FTIR), Scanning Electron Microscopy (SEM), Temperature Programmed Desorption Ammonia (TPD-NH3), and Temperature Programmed Desorption Carbon Dioxide (TPD-CO2). The catalyst exhibited remarkably enhanced activity for the glycerol conversion in the following order AlPC < Cs/AlPC < K/AlPC < Na/AlPC < Li/AlPC. Among the synthesized catalyst, the performance of the best catalyst (lithium modified AlPC catalyst) was evaluated for glycerol etherification reaction under microwave irradiation as a heating source. The glycerol conversion of 95% was achieved with 76 wt% yield of polyglycerol over 20%Li/AlPC catalyst after 4 h. Glycerol conversion was investigated at different reaction conditions such as metal loading, catalyst concentration, time, and different reaction temperatures. In addition, the optimum condition was found to give 45 wt% diglycerol (dimer) and 20 wt% triglycerol (trimer) at 260 oC in the presence of 2 wt% catalyst (20%Li/AlPC) concentration under microwave irradiations. The kinetic study was conducted on the best-selected catalyst to find out the order of the reaction as well as activation energy. The Arrhenius equation model was used to calculate the activation energy of 128 kJ/mol for glycerol etherification reaction. In short, microwave-assisted glycerol etherification showed excellent performance concerning reaction time and yield. This technology has been very efficient for glycerol conversion into polyglycerol that can viii save reaction time about two folds. The Li/AlPC catalyst was found to be the most effective catalyst for selective glycerol conversion into short oligomers in order to promote the biodiesel industry through utilization of glycerol.

Babikir, Ismailalwali Alobaid Magzoub (2019) *Attribute-Assisted Seismic Sedimentology for Investigating the Litho-Geomorphological Facies and Depositional Architecture of the Coal-Bearing Fluvio-Deltaic Reservoirs, Northern Malay Basin.* Masters thesis, Universiti Teknologi PETRONAS.

The Northern Malay Basin is a long-life natural gas asset for Malaysia. Most of the non-associated gas accumulations are occurred in the basin centre and trapped in Groups E, D, and B reservoirs. The Middle-Upper Miocene Group E is holding a considerable amount of this resource. It is characterized by thin sandstone reservoirs, thick shale, and abundant occurrence of coal. Imaging and identifying the stratigraphic architecture of Group E have proven to be challenging due to a number of geophysical reasons. The sandstone reservoirs are commonly very thin and bellow seismic detectability. Coal has a masking effect on seismic data. It exhibits very strong negative acoustic impedance similar to the gas sandstone. The occurrence of coal introduces uncertainty to the seismic attributes interpretation for lithology and fluid prediction. The thick occurrence of shale tends to decrease the overall impedance contrast and diminish the amplitude versus offset (AVO) response. The aim of this work is to establish an integrated seismic sedimentology workflow that can efficiently characterize the litho-geomorphological facies of coal-bearing reservoirs. The undertaken methodology integrates many attributes such as spectral decomposition and colour blending, seismic waveform classification, and pre-stack seismic inversion. The interpretation and analysis of the generated attributes have mainly been carried out on maps obtained via stratal slicing. The high seismic frequencies produced by coal were removed by spectral decomposition. The produced band-limited frequency and the red, green, and blue (RGB) colour composite maps were able to image the reservoir geomorphology and depositional architecture in good detail. The elastic properties of acoustic impedance, shear impedance, compressional to shear wave velocity ratio (Vp/Vs), and density that were obtained from pre-stack inversion were used to identify coal from gas sandstone and shale. Coal is characterized by a low acoustic impedance and a high Vp/Vs. The interpretation revealed that the interval was deposited in a lower delta and subaqueous delta plain setting. Depositional elements such as distributary channels, distributary mouth bar, viii subaqueous levee, and interdistributary fill were interpreted. The varying trends of the distributary channels flow direction in the area support the hypothesis that describes the Malay Basin during Miocene time as a narrow gulf, connected to an open sea to the south and flanked by deltas and fan deltas.

Sivanathan, Prema (2019) *Effect of Chloride Concentrations and Temperature On Pre-Stressed Austenitic Stainless Steel 304 Based on Pressure Vessel in Oil and Gas Industry.* Masters thesis, Universiti Teknologi PETRONAS.

Chloride-induced stress corrosion cracking (CISCC) of austenitic stainless steel type 304 (SS 304) under thermal insulation is a classical pressure vessel failure case, but recurrent failures require further analysis of possible mechanisms which lead to the damage particularly on the effect of leachable chloride from the thermal insulation. The objective of the research was to investigate the effect of chloride leached from thermal insulation material on CISCC of SS 304. The study was based on actual failure vessel case sample whereby proposed parameters such as temperature and chloride concentrations were derived. SS 304 samples were immersed in sodium chloride solution to identify the pitting corrosion mechanism which leads to CISCC failure of a pressure vessel. CISCC test was carried out by using ASTM G30 standard for the Ubend sample preparations to simulate CISCC of SS 304 under chloride environment. The test parameters used were various chloride concentrations of 200 to 30,000 ppm as per ASTM C692 at 40, 60, and 85°C temperature as per ASME B31.3 standard. Visual and stereomicroscope results revealed no external surface macro-crack appearance found on the U-bend SS 304 samples tested at 40, 60 and 85°C in chloride concentrations of 200 to 30,000 ppm. FESEM and EDX analysis revealed the surface morphology micro-void cracks on the corrosion products at 40 and 60°C and revealed CISCC initiation at 85°C of the SS 304 U-bend samples. The metallographic examination in cross-section revealed transgranular cracking across the grain boundaries by film dissolution mechanism occurred only in the U-bend SS 304 tested at 85°C (3000, 8000 and 30,000 ppm chloride concentrations of 9 months duration). In conclusion, general corrosion has occurred at 40°C, localized pitting corrosion has occurred in a failed vessel at 60°C and the CISCC was initiated by the leachable chloride from the insulation material perlite at temperature above 85°C in the presence of moisture. Corrosion consideration in materials selection for vessel operating above 85°C is crucial and suggested to install a hydrophobic waterproofing thermal insulation material to minimize the accumulated chloride ions over years in-service.

Wong, Jia Mang (2019) *Engineering Geological Characterisation of Sedimentary Rocks in Kuala Kangsar to Parit, Perak.* Masters thesis, Universiti Teknologi PETRONAS.

This study was conducted in Kati Formation which located along the road from Parit to Kuala Kangsar, Perak, A164. Kati Formation consists of alternating layers of sandstone, siltstone and mudstone that results in non-uniform weathering that causes the rocks to lost their original strength and the increment in slakability. Furthermore, weathering of heterogeneous sedimentary rock mass produces a non-systematic weathering profile that is dependent on the characteristics of the unweathered, interbedded sedimentary sequence. The presence of surficial features due to weathering such as iron bands, iron oxide recementation, iron oxide staining and lithobionts coating in an uneven distribution on the outcrop causing more complexity to the heterogeneous sedimentary rocks which are also tectonically deformed. The complexity in engineering behaviours of the rock mass affects its slope stability. Thus, this study is conducted to determine the engineering geological characterisation of interbedded sedimentary rocks material in different weathering condition and lithology, suitability of testing methodology and quantify the sedimentary rock mass. The research work consists of field study, weathering classification, thin section and several laboratory tests were conducted to characterise the physical and geomechanical properties of weathered rocks. Geological Strength Index (GSI) was used to quantify the rock mass. This study was conducted at a roadcut that consists of Kati Formation which had undergone slight to complete weathering. Results show that the durability and rock strength decreases with increases of weathering grades. However, presence of iron oxide staining and iron oxide recementation improve the rock durability. Among the laboratory tests conducted in this study, slake durability test is the ideal test to characterise the rock samples of different weathering grades as it gives a large range of laboratory test results. The values obtained are not affected by the uneven distribution of iron oxide present in the rock samples. GSI also shows that Outcrop 1 is classified as fair rock mass which is partially stable, Outcrop 2 is poor rock mass which is unstable and Outcrop 3 is fair rock mass which is partially stable by using the classification description of Slope Mass Rating.

Ku Ariffin, Ku Muhammad Faez (2018) *Performance Analysis Of Grooved Hydrodynamic Journal Bearing With Texture And Slip Surface.* Masters thesis, Universiti Teknologi PETRONAS.

Hydrodynamic journal bearings are one of the important components in hydrodynamic lubrication, ranging from small applications such as motors, up to large applications, such as engines and turbines. The problem is that the hydrodynamic journal bearing shows poor performance under low eccentricity ratio conditions. This study has been carried out to investigate the effect of partial texture with a slip surface towards the performance of hydrodynamic journal bearings; namely, pressure distribution, load carrying capacity, shear stress, and friction coefficient. The study has been carried out by formulating the partial texture with single and two-slip surfaces onto a bearing surface in a fluid film region, which was then solved by using long bearing and short bearing approximations, respectively. The approximations which were applied that, the long journal bearing was considered in the circumferential direction, whilst the axial direction was applied on short journal bearing. The applied partial texture with slip surface showed different performance outcomes on both the long and short journal bearings. The long journal bearing showed significant improvement on the pressure distribution and load capacity for both single-slip and two-slip configurations. The performance improvement at the 0.1 eccentricity ratio achieved for the single-slip was from 0.1% and up to 125%, whilst the partial two-slip textured surface managed to achieve the performance increase of up to 166% compared to the plain journal bearing. In addition, the partial texture, single-slip surface also reduced the friction coefficient up to 22% at the 0.1 eccentricity ratio. However, the results also showed that applying the proposed surface configuration, especially twoslip texture, greatly increased the shear stress and friction coefficient to some extent. On the other hand, applying the partial texture with both single and two slip configurations on the short journal bearing showed the decrease of performance of the short journal bearing compared to the plain journal bearing, reflected poor performance under numerical analysis of this research.

Chun, Ung Wei (2018) *Functional Near-Infrared Spectroscopy Based Dynamic Difficulty Adjustment System For Cognitive Training And Rehabilitation.* Masters thesis, Universiti Teknologi PETRONAS.

Mental overload and underload are equally serious conditions that can impinge the gains of cognitive training and rehabilitation. Therefore, it is always better to train at appropriate pace but the challenge to impose the right amount of cognitive workload remains. This thesis reports the designing and development of a functional near-infrared spectroscopy (fNIRS) – dynamic difficulty adjustment (DDA), a closedloop feedback system, that allows users to train at their appropriate difficulty level and workload, and also aids them in preventing mental overload. Oxygenated hemoglobin signals measured in the dorsolateral prefrontal cortex (DLPFC) are first processed in real time before extracting relevant parameters, which are then compared to assess the mental workload and adjust the task difficulty accordingly. It is based on the theory that there is a linear relationship between workload and hemodynamics where the task difficulty does not exceed the cognitive capacity, however, once there is cognitive overload or mental overload hemodynamics starts to decrease. The first study was a pilot test involving a mild Alzheimer's disease patient and a healthy older individual, which validated the theory and region of interest – DLPFC. In the second study, the functionality of the fNIRS-DDA system was fully explored using 25 healthy university students. They underwent two separate training sessions: adaptive (incorporating the fNIRS-DDA system), and nonadaptive (where the task difficulty was fixed at optimum). The workload in each condition was assessed using the NASA Task Load Index (NASA-TLX). The significant drop in DLPFC activation and negative quadratic regression model observed only in nonadaptive condition coupled with sustained performance and higher NASA-TLX scores, especially in both mental demand and frustration subscales, might indicate mental overload. Absence of such drop in activation and negative quadratic regression model alongside lower NASATLX overall and all subscale scores in adaptive condition suggest that the incorporation of the fNIRS-DDA system indeed optimised the participants' engagement and aided the participants in avoiding mental overload.

Mazlan, Mohammad Amir Firdaus (2017) *Batch And Continuous Pyrolysis Of Rubber Wood Sawdust For Production Of Bio-Energy And Bio-Chemicals.* Masters thesis, Universiti Teknologi PETRONAS.

The prospect of energy generation and chemical derivation based on biomass utilization is drawing great attention. One of the promising technologies to generate valuable fuels and chemical products from biomass is through a pyrolysis process. It is a heating process of organic materials at a medium temperature between 400 to800 °C under the absence of oxygen and in a short retention time. It converts biomass into liquid (bio-oil), solid (bio-char), and gas (pyrolysis gas) products. In this research, rubber wood sawdust (RWS) residue with a size range of 0.15 to 0.50 mmwas pyrolyzed by two methods of batch and continuous pyrolysis. The first part of the study is to determine the influence of pyrolysis temperature (450, 500, 550, and600 °C) by using a drop-type fixed bed pyrolyzer. When pyrolysis temperature increased, the yield of bio-char reduced from 38.7 to 25.7 wt%, while bio-oil and non- condensable gas (NCG) yields increased. However, at a certain high temperature (550 °C), the bio-oil yield started to decrease because secondary reaction happenedand more gas was produced. To evaluate the effect of fluidization gas velocity, Ug (3.64, 4.55, and 5.46 cm/s), the second part involved continuous pyrolysis of RWSvia a bubbling fluidized bed pyrolyzer. As the Ug was increased, the bio-oil yieldincreased from 26.2 to 29.3 wt%, but the yield of pyrolysis gas declined from47.6 to42.8 wt%. Physicochemical characteristics of RWS biomass and pyrolysis products were determined using various analyses. Bio-oils produced in this study had highpercentage of oxygen (52 to 73 wt%) and hydrogen (6 to 11 wt%) than the RWSfeedstock and char, indicating high water content (33 to 76 wt%) which considerablydecreased the calorific value (CV). By applying fractional condensation setup, water content of bio-oil fractions was reduced. Acetic acid, phenol, cyclopentanone, andtetrahydrofuran (THF) were the main bio-oil compounds. The bio-char product hadsignificantly higher carbon composition (70 to 78 wt%) and CV (26 to 30 MJ/kg) when compared to the biomass feedstock and bio-oil product. The major components of pyrolysis gas were CO_2 (43 to 53 wt%) and CO (33 to 37 wt%)

Sarwar, Muhammad Bilal (2017) *Design And Development Of Wireless Stakeout System Based On Zigbee Transceiver Modules.* Masters thesis, Universiti Teknologi PETRONAS.

Wireless technology has become a new emerging technology in stakeout and security concerned industries. Study of robot communication with energy efficiency is also one of the important research area. Therefore this research work presents an efficient computerized wireless vehicle (CWV) for stakeout and recognition purposes with the use of energy efficient ZigBee based transceiver. The vehicle is capable of positioning the stakeout system at tedious and hazardous work space as instructed through command to get the actual visual feedback in all types of environments where human eye cannot make a view. In general conventional surveillance and security based industries have setbacks in terms of reliability, movability, cost and continuous monitoring of any desired place. So this system is able to work in hazardous environments where human would injure or die because literature shows in previous studies wireless camera with ZigBee transponder have not been implemented in the system. The research entails a combination of programmable microcontrollers, relay circuitry, NTC temperature sensor, DC motors and sharp camera eye to control the vehicle through another wireless transceiver module which is connected with personal computer. In the operation of each sensor node in wireless and movable stakeout system, battery is also an important limiting factor for the whole system performance and lifetime, so it is obtained that ZigBee transponders are capable in providing wider transmission range up to 41 m to 50 m and efficient compare to RF. The comparative analysis and experimental results also show the NTC sensor is capable of detecting stable and reliable readings at different environments.

Rajabi, Mansoure Sadat (2017) *Ionic Liquids For Extraction Of B Carotene: Modeling And Experimental Approaches.* Masters thesis, Universiti Teknologi PETRONAS.

B-carotene, an important bio-molecule with highly unsaturated heavy structure (C4oHs6) is available in plenty of natural products. This hydrocarbon with noticeable antioxidant is a valuable compound in food and pharmaceutical industries. ~-carotene has been extracted from different sources using several techniques including super critical fluid extraction, ultrasound assisted extraction and traditional solvent extraction. However, these methods have several limitations. For instance, adverse operating conditions, extensively usage of VOCs and required special equipment. To overcome abovementioned issues, development of a novel method for ~-carotene extraction was considered. Recently, ionic liquids (ILs) - green and tailor made solvents - have been involved in bio-molecules extraction and shown to be efficient replacement for conventional solvents. The main objective of this study was to find potential ILs to extract ~-carotene from organic solvent at mild conditions. To identify selective ILs for ~-carotene extraction ILs were screened by COSMO-RS on the basis of activity coefficients at infinite dilution. Different structures of cations including imidazolium, pyrrolidinium and ammonium based and many common anions were investigated. Moreover n-hexane, acetone and benzene were presumed as model solvent for ~-carotene. Modeling data were verified experimentally. Parametric studies and optimized conditions were also determined via response surface methodology, using the central composite design of the Design Expert 8.0 software. ILs water content, biphasic volumetric ratio and extraction time were chosen as input variables. As result, ILs selectivity to ~-carotene was reversely proportional to alkyl chain length. Selective ILs had stronger H -bonding enthalpy which caused more interaction. Among studied ILs, tetramethylammonium acetate ([Nuu][OAc]), trimethylethylammonium acetate ([N 1112][OAc]), 1, 1-dimethylpyrrolidinium acetate ([C1Pyrr][OAc]) and 1-ethyl-1-methylpyrrolidinium acetate ([C2Pyrr][OAc]) were identified potential for ~-carotene extraction from three organic solvents. However Vll 1,2,3-trimethylimidazolium acetate ([CI-2Me-MIM][OAc]) and tetraethylammonium acetate ([N2222][0Ac]), were found able to extract this bio-molecule only from nhexane. [N1111][0Ac], [N1112][0Ac] and [C2Pyrr][OAc] were synthesized, characterized and employed to experimental extraction. Predicted data were successfully validated and supported by experimental results. Maximum extraction efficiency of 63.09%, 37.89% and 29.45% respectively for [Nun][OAc], [Nn12][0Ac], and [C2Pyrr][OAc] was achieved at optimized conditions. Based on this study we can confidently believe that ILs studied here can be used for ~-carotene extraction from different sources.

Joseph, Easter (2017) *Synthesis And Characterization Of N-Doped Graphene Film And Ti02-Ng Photo Anode For Dye Sensitized Solar Cell.* Masters thesis, Universiti Teknologi PETRONAS.

Dye sensitized solar cell (DSSC) is the emerging third generation solar cell that is cost effective and has simple fabrication process. Additionally, the optical properties in DSSC such as transparency and color are suitable for windows and sunroof application in the building. However, at this point in time, their efficiency is much lower than that of silicon solar cell. The charge recombination at the semiconductor/dye (back transfer) and semiconductor/electrolyte interfaces (dark current) have been the main obstacles in achieving higher efficiency in DSSC, which decelerate the electron transfer process at Ti02 photoanode. The main objective of this research work is to study the properties of N-doped graphene (NG) incorporated Ti02 based DSSC. Graphene is a single layer of graphite that has a high surface area, transparency and excellent electron mobility that are beneficial for Ti02 photoanode. In this research, the NG was synthesized by using chemical vapor deposition (CVD) in the presence of methane (CH4) and ammonia (NH3) gasses. TheN atoms were successfully introduced in the graphene lattice which was verified by various characterization and techniques. The NG film which was used as a blocking layer in DSSC was transferred on fluorine-doped tin oxide (FTO) and coated with Ti02 paste on top of the film. The DSSC with Ti02-NG photoanode exhibits an optimum efficiency at 2.871% with 7.33% and 45.74% higher than the DSSC with Ti02-G (2.675%) and conventional Ti02 (1.970%) photoanodes. The effect of blocking layer prevents the direct contact of the photogenerated electrons with the h- ions at the FTO surface and Ti02/electrolyte interface which consequently minimized the charge recombination and improved the open circuit voltage (Voc). The DSSC with optimum NG exhibits high resistance of electron recombination (165.5 0) and provided extra 'bridges' in the Ti02 nanoparticles which expedite the electron transfer to the FTO electrode that resulted in the enhancement of the short circuit current (Isc) and conversion efficiency of DSSC. The optimization of the quality of graphene can further improve the performance ofDSSC.

Pardiansyah, Indratno (2016) *A Combined Histogram Of Oriented Gradients And Completed Local Binary Pattern Methods For People Counting In A Dense Crowd Scenario.* Masters thesis, Universiti Teknologi PETRONAS.

Estimating the number of people in a dense crowd scenario is one of the most interesting subjects in visual surveillance system application. It is extremely important in controlling and monitoring the crowd for safety control and urban planning. However, estimating the number of people in any dense crowd situation is not an easy task. This problem mostly arises due to some false positive and false negative and it affects the performance of system on detection rate. Therefore in this thesis, an innovative method for people counting in dense crowd scenario is proposed. This method used a collaborative Histogram of Oriented Gradients (HOG) and Completed Local Binary Pattern (CLBP) based on people detection algorithm to detect headshoulder region. Head-shoulder region is used as features to detect people against the false positive and false negative issue. HOG and CLBP descriptors are utilized to extract the edge contour and texture features of head-shoulder region, respectively. The two features are then fused together to generate a cumulative feature vectors. Support Vector Machine (SVM) is used to perform classification of the fusion features to people from a mixture of objects. The results show that the detection rate of the proposed method HOG-CLBP, on Recall value and Accuracy, achieves better performance compared to the current method for dense crowd scenario.

Ahmad Afif, Hafizah (2016) *Microwave Induced Pyrolysis For Bio-Oil Production From Lignocellulosic Biomass.* Masters thesis, Universiti Teknologi PETRONAS.

Pyrolysis is a process where the decomposition of material occurs at elevated temperature (typically at around 300 to 650 °C) in the absence of an oxidizing agent. The pyrolysis of biomass by means of conventional heating is found to be slow due to the biomass has relatively high moisture and low heating value that would slow down the heating process. In order to overcome this issue, microwave induced pyrolysis was introduced in this study to decompose biomass into chemical compound. The microwave, heats effectively by delivering energy to material through molecular interaction with electromagnetic field and transfers energy throughout the volume of material. Volumetric heating is the key to reduce the processing time. Ten types of biomass that are available in Malaysia were used in the study such as oil palm kernel shell, oil palm leaves, empty fruit bunches, oil palm frond, rubber seed inner shell, rubber seed outer shell, corn cob, sugarcane bagasse, rice husk and coconut shell. The main objective of this study is to investigate the feasibility of producing bio-oil by microwave induced pyrolysis, the practicality ofmicrowave technology in the pyrolysis system. The second objective is to produce bio-oils from different types of biomass feedstock. The third objective is to characterize the chemical and physical properties of the bio-oil, char and gas produced. The fourth objective is to study the effect ofreaction time and particle size on product yields and their properties. In order to achieve the first and second objectives, biomass screening experiment was conducted at temperature of 350 °C and microwave power of 1 kW. From this experiment, it was observed that all biomass reacted with microwave and was successfully heated to form hot vapours after a few minutes exposed to the microwave irradiation. Hot vapour was later condensed and formed liquid known as bio-oil and the uncondensed gas was recognized as pyrolysis gas. The remaining biomass left in reaction area was labelled as char. The bio-oil yield was in the range of 24 to 61 %. The char and gas yield were in the range of 18 to 55 % and 7 to 52 % respectively. The third objective was achieved by studying the composition (focusing on bio-oil) and analysing the water content, elemental composition and calorific value of pyrolysis products. From bio-oil analysis via gas chromatography, the major compounds in bio-oil were carboxylic acids, phenolic groups, ketone, carboxylate ester, halo alkanes, etc. The bio-oil contained of 64 wt.% to 84 wt.% of water. The highest element in the bio-oil was Oxygen (65 wt.% to 94 vii wt.%). The calorific values of bio-oil were low at 1 MJ/kg to 12 MJ/kg. The fourth objective was achieved by conducting a parameter study where several setsofpyrolysis experiment were performed on OPKS. The parameter studied were the reaction time (30 min, 70 min and 100 min) and particle size of biomass (0.15 to 0.5 mm, 0.5 to 1 mm and >10mm (unground biomass)).

Rahman, Shaikh Atikur (2016) *Structural Response Of Offshore Blast Walls Under Accidental Explosion.* Masters thesis, Universiti Teknologi PETRONAS.

In order to provide adequate blast protection for on-board personnel and critical equipment against any accidental explosion, stainless-steel profile panels commonly known as blast walls are widely installed on offshore platforms. Offshore blast walls are usually non-load bearing members and are connected with primary steelwork for support. These walls are likely to display significant plastic deformation, hazardous failure or even blowout when exposed to high magnitude blast loading. Most ofthe operational blast walls were designed by simplified analysis techniques like single degree of freedom (SDOF) as recommended in common blast design guidelines, where damage criterion is usually defined in terms of global deformation or displacement response. Metal walls or thin plate structures like blast wall when subjected to blast impact, may damage severely in a particular region without experiencing a significant global deformation. The equivalent spring mass system SDOF models with simplified material properties are not suitable for such blast damage analysis. Moreover, those oversimplified assumption of material behaviour and structural response in SDOF system can cause design inadequacy or economic loss. The aim ofthe present studyis to study the realistic response and corresponding damage of offshore blast walls under various accidental hydrocarbon explosions by using extensive nonlinear finite element analysis (NFEA). Relationships between local and global damage with the structural response of blast walls were also established. The NFEA models were verified against the experimental results ofHSE blast panel tests. Simplified analytical method of nonlinear elastic-plastic single degree of freedom (SDOF) system was also performed as an alternative approach to identify structural behaviour of blast wall. Detailed parametric study for blast wall was conducted to establish sensitivity of different structural parameters. Finally pressure-impulse diagrams also known as iso-damage curves were developed based on the results obtained from the parametric study. The damage criteria and overall procedure for evolving P-I curve were adopted from available blast resistant design vn guidelines. These developed curves can be employed for designing or damage assessment of offshore blastwallsunder different explosions.

Habib, Iffat (2016) *Congestion Control And Load Balanced Routing In Wireless Ad Hoc Networks Using Optimization Techniques.* Masters thesis, Universiti Teknologi PETRONAS.

Ad hoc networks consist of mobile devices such as mobile phones, tablets, laptops, that are connected over a wireless medium Most of the existing routing protocols for wireless ad hoc networks follow the shortest path or minimum distance as the route selection criteria. This type of routing is called shortest path routing (SPR). However, the shortest path does not balance the traffic load on all nodes in a network. When multiple users use the shortest path for data transfer, some nodes may be overloaded with data forwarding and the wireless links get more data traffic than they can handle. The congestion can be decreased by careful distribution of data traffic on all available links. This technique is called load-balancing. Existing literature on load-balancing considers certain parameters for congestion measurement. These include the length of the queue, MAC utilization, queuing delay, transmission delay, packet drop rate, etc. The congestion is usually measured at a node or at the link. However, the combination of nodal and link congestion is necessary for accurate congestion estimation This research work presents two load-balancing routing algorithms for congestion control in wireless ad hoc networks. These are load-distributive path routing (LDR) and delay-based load-balancing routing (DLBR) algorithm LDR is similar to SPR because it uses distance as routing metric, but it distributes the network traffic on all available links according to the capacity of links. DLBR uses end-to-end delay (EED) and avoids the use of congested links. Moreover, a dynamic programming (DP) based Dijkstra's algorithm is presented that is used by proposed routing algorithms for route finding. The simulations are performed in MATLAB to compare the performance of LDR and DLBR with SPR. Through simulations, it is shown that LDR and DLBR perform better than the SPR in terms of different quality ofservice parameters.

Al Batati, Nabil (2016) *Simulation Of Drill String Vibration Due To Riser's Oscillation.* Masters thesis, Universiti Teknologi PETRONAS.

In deep sea drilling, there are two major components of drilling tools that are subjected to vibration, namely the marine riser and the drilling pipe. Analysis of vibration in the marine riser and drill pipes are two topical areas that have individually received considerable attention by researchers in the past. For the marine riser, the focus was on the vortex-induced vibration (VTV) in different shear and flow regime. On the other hand, the focus on the drill pipes was on different vibratory modes and resonance. While these two subjects are interrelated, borne by the fact that the marine riser encapsulates and protects the drill pipe, they have been little attempt to investigate them together as an assembly. This research intends to couple the marine riser VTV to the drill pipe vibration using a staggered approach. Due to the complexities of the models, simplifying assumptions were made in order to undertake the model. The computational fluid dynamic simulation and mechanical finite element analysis were used in this research to study the behaviour of drillstring lateral and torsional vibration due to riser oscillation. The computational fluid dynamic approach used to obtain the working drag forces at the riser. The obtaineddrag forces then used as mechanical input for mechanical finite element analysis. It was used to model the physique body of riser coupled with drillstring using spring-damper element which represent as transfer media of drag forces from riser to drill string. The outcome result of model was compared with experimental and simulated results obtained from several previous researches, Interesting results were recorded that the maximum displacement and sticking phenomena were occur when the drillstring operates at lowRPM. With thisresult making the clear critical speed that has to be avoided when drilling in progress

Ekaputra, Andhy Arya (2016) *Investigation On The Effects Of Solvents In Mitigating Wax Precipitation During C02 Flooding.* Masters thesis, Universiti Teknologi PETRONAS.

When the wax precipitation reaches the most severe level, it may result in the plugging of well bores, production facilities, and transportation pipelines during oil/gas production. Based on literature study, there are several techniques conducted to mitigate wax precipitation, including chemical, electrical, thermal, mechanical, and microbial treatment. In view of their availability and affordability, chemical methods were chosen to the method applied in this study. The study aims to investigate the effects of solvents in maintaining the wax crystallization growth during C02 flooding process. Physical properties such as viscosity, density, and pour point were measured by using Viscometer, Digital Density Meter, and Pour Point Tester. In addition, the additional study on C02 effects on wax precipitation was conducted. The information about wax content and reservoir temperature of oil was required to support other physical properties measurement.Based on observation, the Tetrahydrofuran performance was found better compared to Cyclohexane and Tetrahydrofuran in reducing pour point, viscosity, and density. Additionally, it demonstrated that the amount of C02 injected to oil reservoir contributed to accelerate a wax crystallization process and stimulate the wax to precipitate rapidly. The additions of solvent with volume in the range of 5% to 25% were intended to inhibit the acceleration of wax crystal growth during C02 flooding.

Ali, Syed Muzammil (2016) *Parametric Analysis On Reflector Designs Of Single Element Cylindrical Dielectric Resonator Antenna (Cdra) For Wlan Applications.* Masters thesis, Universiti Teknologi PETRONAS.

In microwave communication field, reflector antennas are widely used in high gain wireless communication systems. The main constrain in reflector antenna design is the design of an efficient feed. Moreover, various techniques developed to enhance the gain ofsingle element DRA have limitations such as high cost, design complexity and fabrication impediments. Therefore, in this research work, the gain of single element DRA is enhanced by using DRA as a feed for three reflectors. The types of reflector explored are; flat, box shaped and parabolic reflector. The reflectors are implemented at the back ofthe CDRA design to reflect the backward radiation and consequently improving the forward gain of the antenna. The effect of reflectors on the resonant frequency, impedance bandwidth, directivity gain and backlobe leveliof CDRA are analyzed by using CST 3D Microwave Studio software. An equivalent circuit model for single element CDRA is proposed to validate the structure with lumped elements values using Agilent ADS software. A comprehensive parametric study has also been conducted to examine the effect of different parameters of reflector on the directivity and backlobe level of the CDRA. It is found that the aperture coupled of single element CDRA produces a gain of 5.5 dBi with an impedance bandwidth of 200 MHz and antenna efficiency of 83.24% at the centre frequency of 5.41 GHz. With an addition of flat, box and parabolic reflectors to aperture coupled CDRA; the design achieved directivity gains of 7.7 dBi, 10.49 dBi and 13.7 dBi respectively. Improvement in directivity gain of 2.2 dBi, 4.99 dBi and 8.2 dBi has been observed for flat, box and parabolic reflectors respectively. The impedance bandwidths achieved for flat, box shaped and parabolic reflector are 190 MHz, 180 MHz and 199 MHz at resonant frequencies of 5.44 GHz, 5.46 GHz and 5.48 GHz with antenna efficiencies of 88.13%, 92.48% and 94.30% respectively. From the results, it is found that the designed antenna prototypes are able to operate within 5 GHz band, therefore, they are suitable for WLAN IEEE 802.1 la application.

Imran Gulcharan, Nurul Fauzana (2015) *Development Of Continuous Remote Patients Monitoring System Using Zigbee Technology.* Masters thesis, Universiti Teknologi PETRONAS.

Monitoring and observation applications have been deployed throughout the years using wired and wireless technologies in healthcare industries. The procedure implemented by health professionals in Malaysia on measuring vital signs is conducted manually. Efforts have been made by many researchers to use Wireless Sensor Network (WSN) as a solution in measuring vital signs of patients from remote location in hospitals. Amongst the wireless technology chosen were Radio Frequency Identification (RFID) and Zigbee technologies where they fit the purpose of healthcare application in terms of two ways communication, high patient's safety, higher number of nodes and etc. However, the current RFID tag is seen to have setbacks in terms of efficiency and accuracy of data transfer. Zigbee Network on the other hand is able to fulfil the stated criteria with an addition of larger number of nodes and stability during data transmission which is an added advantage to the application. This research is discussing on the development of two individual real - time continuous wireless vital sign devices which are heart rate and temperature monitoring. These devices will be used as a medium of patient data transfer and data gathering. Each device consists of a sensor, microcontroller and a transceiver module (Zigbee) is placed on a patient while data is transmitted and monitored at nurse workstation. Readings obtained are benchmarked with the conventional handheld heart beat reader and a thermometer respectively to fulfil the accuracy and stability criteria. Multiple tests on stability, transmission range capability and reliability of device for various age groups and gender were also conducted. Furthermore, to ease and attract the end user in monitoring the vital readings of a patient, a Graphical User Interface (GUI) system has been developed which displays and stores the patient's data in the database. Results obtained are very impressive and comparable to the miniaturization ofthe device for further testing in the hospital.

Alex, Amal Sebastian (2015) *Nonlinear Regression Analysis For Estimation Of Hydrodynamic Coefficients For Offshore Jacket Platforms.* Masters thesis, Universiti Teknologi PETRONAS. Adaptations in the design and reliability analysis of jacket platforms are gaining importance in the economical perspective, due to the discovery of new shallow water oil fields and aging of existing oil and gas assets. This research is focused on improving the design of offshore jacket platforms by the conclusions and recommendations made from an experimental study on the hydrodynamic force coefficients. Majority of the members on a jacket platform are slender cylinders with circular cross-section. Critical part in the estimation of wave forces on small diameter cylindrical structures employing Morison equation, is the determination of precise hydrodynamic force coefficients. Wave tank tests were conducted in the offshore laboratory facility of Universiti Teknologi PETRONAS. Model cylinders were tested in both regular and random, unidirectional waves. Total wave forces acting on the model cylinders were measured by a wave force sensor named Wave Force Totaller, which was developed exclusively for use in the experimental works reported. The wave elevation and force data from the wave runs were used in the estimation of force coefficients by employing an error minimization fit between the experimental and predicted wave forces. The force coefficients thus estimated were used in the formulation of non-linear regression equations for the prediction of the same, considering relevant wave and model parameters. The regression equation predicted drag coefficient values range from 0.36 to 0.64 and the inertia coefficients range from 1.2 to 1.56. Accordingly, this research is aimed to bring forth a novel change in the conventionally adopted values for these coefficients as specified by PETRONAS Technical Standards. The influence of relevant wave and model parameters on the hydrodynamic force coefficient values were also examined in the present study. Single cylinders along with cylinders in linear arrays as well as a multi-dimensional array were investigated. The effect of cylinder proximity is explored by increasing the number of cylinders in the linear array and varying the spacing between cylinders in the multi-dimensional vii array. Considerations to be made in the design of cylindrical members existing as linear arrays are discussed. Relevance of using the new force coefficients in the design of jacket platforms in Malaysian waters is presented by comparing an existing jacket platform design with the design incorporating the revised values of the coefficients. The adoption of revised coefficients showed a decrease in the estimated member forces of the platform, thus suggesting the use of smaller member sections in resisting the lower forces. Use of lower member thicknesses resulted in a material savings of 7% for the jacket platform considered. Owing to demand from the industry, a part of this study was focused on the effect of sacrificial anode mounting on the cylindrical members. The total force on the anode mounted cylinders was always higher, in comparison to that acting on a single cylinder and was observed that this hike has been contributed mainly by the inertia force. The areas of potential application of findings from the present project are, the design of new jacket platforms, reliability analysis of existing or age-over platforms and the design of offshore-monopod structures.

Shirazi, Muhammad Irfan (2015) *Fiber Orientation In Metal Injection Molded Short Carbon Fiber Reinforced Copper Matrix Composite.* Masters thesis, Universiti Teknologi PETRONAS.

Short carbon fiber (CF) reinforced metal matrix composites (MMCs) are a favorable candidate for aerospace and electronics industries. Improving short fiber orientation can significantly enhance physical and mechanical properties of these MMCs. Powder Injection molding (PIM) has the potential to control orientation of short fibers in MMCs. This research was focused to develop carbon fiber reinforced copper composite feedstocks with three component binder system using a z-blade mixer. Fluw properties of copper and composite feedstocks were determined using a capillary rheometer. A specially designed mold was used to enhance fiber orientation in molded samples. Binder was removed by solvent and thermal techniques at 60°C and 500°C respectively. Debound test samples of copper and copper/CF composites were sintered at 1050°C for 3 hours for densification. Rheological data showed pseudo-plastic nature of feedstocks and viscosity of feedstocks was less than 1000 Pa.s andwithin desired range of PIM. Sintered density was determined using Archimedes principle and found to be 92-94% for copper and copper/CF composites. Fiber orientation was examined qualitatively and measured quantitatively using field emission scanning electron microscopy (FESEM). Fiber orientation angle was measured in skin and core using FESEM micrographs. Results showed fiber alignment within the theoretical range of ±22.5° for both composites developed. Fiber orientation results indicated that the specially designed mold has effectivelyenhanced fiber orientation in copper/ carbon fiber composites.

Tomi, Azfar (2015) *A Framework For Markerless Full Body Human 3d Monocular Pose Estimation.* Masters thesis, Universiti Teknologi PETRONAS.

Pose estimation IS an important pre-processing step m computer vision-based automatic capture and analysis human motion. Despite its high efficiency in handling the ambiguities situation, multiple view approach of pose estimation is costly incurs high computational cost due to more complex system. Recently, most of the work focusing in a low cost and practical monocular view approach due to its suitability for a common user and low complex system. However, several monocular view issues arise with regard to self-occlusion which leads into problem in body part extraction, and the undetermined value in human pose reconstruction focusing on upper and lower limbs reconstruction that caused the reconstruction problem especially in high noise movement. Thus, this thesis project presents a framework for a real time markerless motion capture to track human full-body movement for monocular 3D pose estimation. The proposed framework comprises of a combination of top-dov.'!1 and bottom-up approach toward 3D pose estimation in monocular view based on endeffector driven. The proposed framework is built as a three-stage framework. Based on overall proposed framework, this thesis work has come out with two main contributions which are vector-based pose estimation and a proposed method for upper and lower limb reconstruction based Sequential Inverse Kinematic (SIK). The framework was evaluated by conducting several experiments which are 2D pose detector evaluation, vector-based pose estimation evaluation and human pose reconstruction evaluation. 2D pose detector evaluation shows that 14-part model is suitable for the proposed framework in comparison with 26-part model. Vector-based pose estimation evaluation shows an average of 24% improvement over recent 2D pose detector. Human pose reconstruction evaluation shows that the extra known position used in SIK improves the human pose reconstruction based SIK and TGBSIK by 4% and 12% respectively. OveralL the framework offers enhanced approach for marker less full body human monocular 3D pose estimation.

Noor Hussain (2015) *Frequency Dependence On Water Tree Degradation In Xlpe Medium Voltage Power Cable.* Masters thesis, Universiti Teknologi PETRONAS.

Cross-linked polyethylene (XLPE) medium voltage (MV) power cables are being utilized worldwide due to their suitable electrical and physical characteristics. Water tree degradation is categorized as a pre-breakdown aging phenomena, it is associated with XLPE MV power cable insulation failure. Water treeing in cable insulation behaves with a nonlinear dielectric response. The purpose of this research is to diagnose water tree induced degradation in XLPE MV power cable insulation. The effects ofsupply frequency on detection ofwater treeing are investigated in this work. We found that the degradation caused by water treeing could be diagnosed at higher frequencies by utilizing 3rd harmonic current based methods. Furthermore, a novel method, based on series resonant has been proposed. The implementation ofthe new method not only detects the degradation in cables at early stages, but also gives information about the distribution of degradation caused by water treeing in the cable insulation. MATLAB/Simulink program is used to model and simulate water tree degradation. Two different methods are implemented in order to model and simulate the water tree degradation. Inthe first method, a nonlinear equation is used to model and simulate the nonlinear characteristics of water tree degradation. In the second method, semiconductor diodes are utilized to model and simulate the water treeing characteristics. The 3rd harmonic current based tests are performed at various supply frequencies (50 Hz, 75 Hz, 100 Hz, 125 Hz and 150 Hz). The series resonant based tests are performed at variable sweep frequencies (0 Hz - 1000 Hz). Moreover, lab level experiments are performed to implement both the techniques for diode based cable insulation model. The simulation and lab level experiment results have shown that these two methods could be able to detect and quantify the water tree degradation levels, and its distribution in MV power cable insulation.

Hamzah, Hazmatul Farha (2014) *Nonlinear Static Analysis For Seismic Evaluation Of Reinforced Concrete (Rc) Structures Using Seismostruct.* Masters thesis, Universiti Teknologi PETRONAS.

Earthquake is known as the unpredictable disaster that occurs from beneath the earth as a result of a sudden release of energy in the Earth's crust. The impact ofthis massive disaster is visualized as the shaking ofthe area and caused extensive damages to humankind and environment. Buildings and other structures face extensive damages and collapse due to high earthquake intensity. The response ofthis structure is becoming the main interest to the structural engineers and researchers to study the structure's behavior under seismic action. Over the past fifty years, there is remarkable progress in this area where the studies concern in understanding the response of structures under seismic loading. Since reinforced concrete (RC) structures are unlike steel materials and heterogeneous, there is still lacking information ofresponse ofRC structures. To study the RC structure's behaviour under earthquake loading such analyses are important. Most of the researchers performed nonlinear static analysis and time history analysis to evaluate the RC structures performances. Nonlinear static analysis is mostly preferable due to less computation time consumed, but time history analysis provides accurate result of the structure's behaviour under the earthquake loading. Nonetheless, nonlinear static analysis still provides adequate information on many response characteristics that can be obtained from an elastic or dynamic analysis. The objective ofthis study is to assess the seismic performance of RC structures using nonlinear static analysis. The nonlinear program, SeismoStruct is used throughout the analysis and the accuracy of this analysis is verified by time history analysis using 1940 El Centra earthquake data. The observation of deformations, maximum capacity and other responses are discusses with the results obtained from the experimental results conducted by previous researchers.

Khan, Arif Ali (2014) *A Communication Risk Framework For Requirements Change In Global Software Development.* Masters thesis, Universiti Teknologi PETRONAS.

Global Software Development (GSD) has gained great attention during the past decade or so; and it is also being implemented throughout the world. Due to the economic and strategic effects of GSD, it is treated as a substitute to a single site. The geographically dispersed environment makes software development a complicated task and brings out several challenges such as geographical, socio-cultural and temporal distances. The process ofRequirements Change Management (RCM) in the GSD is thought to be puzzling even in the finest situations. Due to effect of geographical, socio-cultural and temporal distances, various communication risks arise among the distributed team members during the process of RCM. In this thesis communication risks have been discussed along with their causes and effects that hinder the effectiveness of GSD projects. Moreover mitigation practices to resolve communication risks have also been discussed. Several relevant factors that are defined as geographical distance, socio-cultural distance and temporal distance, have been merged together to form a framework. The data were gathered from several GSD industries in Pakistan, by the use of quantitative method. The total of 163 responses was received. The observed results showed that hypotheses developed for weak communication, lack of face to face meeting, lack of trust, mitigation practices for risks occur due to geographical distance, lack ofmutual understanding, poor business language skills, lack of cultural awareness, less time overlapping, delay in response and mitigation practices for risks occur due temporal distance are supported and have significant relationship with communication issues. Based on results, this study will also help the theorists and practitioners in GSD industries to better understand the communication risks, which occur during the process of RCM.

Hing, Ratana (2014) *Computer Algorithms For A Fundamental Problem In Bioinformatics: The "Protein Loop Closure" Problem.* Masters thesis, Universiti Teknologi PETRONAS.

The "protein loop closure" problem is a fundamental problem in bioinformatics. Thebackbone of a protein is a kinematic chain. When using current techniques to try to get a "picture" of a protein, there are limitations. Whilst we can "see" most ofthe backbone, there are parts that current techniques do not show. We need to fill in any gaps in the "picture", as thebackbone defines thetype of protein. From computational perspective, the "protein loop closure" problem can be viewed as an inverse kinematics problem. Inverse kinematics can be bestthought of in terms of a robotic arm comprising of several links connected byjoints. Given theposition and "pose" of the hand ("end effector") then we have to work outthejoint angles. There have been attempts to apply inverse kinematics solutions for the protein loop closure problem. Existing work, as with working deploying methods otherthan inverse kinematics, do manage to solve the loop closure problem to some extent. However, they have difficulty incorporating the space constraints, i.e. the rest of the protein atoms, in the algorithm. To put it crudely, some results have thebackbone crossing itself, which is a poor model of reality. In this research, we present an extensive literature study of existing "self-organizing" and"self-organizing superimposition" algorithms, andthen we implemented a new form of solution known as "modified self-organizing algorithms withsuperimposition methods" for modeling protein loops. This newwork was then evaluated to assess its effectiveness.

Naqvi, Syed Ali Arsalan (2014) *Evaluation Of Visually Induced Motion Sickness Caused By Viewing Of 3d Stereoscopy Using Electroencephalography Technique.* Masters thesis, Universiti Teknologi PETRONAS.

The 3D movies are attracting the viewers as they see objects flying out of the screen. However, many viewers reportof problems that they face after watching 3D movies. Visual fatigue, eye strain, headaches, dizziness, blurred vision or in other words, Visually Induced Motion Sickness (VIMS) are reported by viewers of 3D movies. In this thesis, we aim to compare a 3D passive technology with a conventional 2D technology to find whether 3D is causing trouble in the viewers or not. For this purpose we designed an experiment in which participants were randomly assigned to watch 2D or a 3D movie. The movie was specially designed to induce VIMS. The movie was shown for 10 minutes to every participant. The movie presents a scene resembling a camera moving onthe road while it isrotated continuously along the pitch and roll axes on alternate minutes. The electroencephalogram (EEG) and electrocardiogram (ECG) datawas recorded throughout the session. At the endof the session participants rated their feelings using the Simulator Sickness Questionnaire (SSQ). First we analyzed the SSQ data and compared the ratings of 2D and 3D participants using a two tailed t-test. From the SSQ results, it was found that participants watching 3D movies reported significantly higher symptoms ofVIMS (pvalue < 0.05). From the analysis of the ECG data, we have found no significant results. EEG data was analyzed in time-frequency domain and topographic plots are created from the data. A significant difference has been found in the frontal theta power which increased with time in 2D condition while decreased with time in 3D condition. We found decreased beta power in the temporal region of the brain of the participants in the 3D group. There was no significant change found in the temporal region ofthe brain inthe participants of the 2D group. Finally, features were reduced to fewhighly significant features that can classify the symptoms of VIMS.

Shaaran, Siti Nurul Asikhin (2012) *Prediction Of Flammability Characteristic Of Multicomponent Mixture Of Refinery Waste Water Laden Using Enhanced Qsar Model.* Masters thesis, Universiti Teknologi PETRONAS.

Study offire and explosion is very important mainly in refineries and industries due to several accidents, which have been reported in the past and present. This study investigates the possibility of the occurrence of fire accident occasioned by the vaporization of hydrocarbon components derived from refinery wastewater drainage systems. In this study, liquid sample containing mixtures ofhydrocarbon products and water were collected from a refinery's drainage system that is located near to the naphtha unit. The liquid sample in thp initial stafrp wqg <?nhjprtpd in n dktillntinn process to separate the oil and water contents. Then, the oil-liquid phase was analysed using Gas Chromatography Mass Spectrometry (GC-MS) to examine the compositions of the sample. The results obtained indicate that there are 77 hydrocarbon components ranging from C9 to C22- Mole fractions of components in the liquid phase were obtained from the GC results. Meanwhile, modified Roult's law equation is used to calculate the mole fractions ofthe components in the gas phase as the mixture in this study is considered as a real solution. The activity coefficients were calculated using UNIversal Functional Activity Coefficient (UNIFAC) method; while the fugacity coefficients were obtained by using Peng Robinson method. Lower Flammability Limits (LFLS) and Upper Flammability Limits (UFLS) for individual components were calculated using stoichiometric concentration method. The results were compared with others obtained from DIPPR 801, experimental and developed models. The results show good agreement between the experimenM and calculated values. The LFLmjx and UFLmjx for the mixture were calculated in accordance with Le Chatelier equationJn this study, the LFLmix for the mixture is calculated at 0.74vol% and 4.71vol% for UFLmjx. Meanwhile, the Limiting Oxygen Concentration (LOC) for the mixture is 11.48vol%. Based on these results, a flammability diagram method was used to show the flammability region ofthe vapour mixture and then to examine ifthe vapour mixture is considered a flammable mixture or not.

Annotated Bibliography

PhD Theses

Azeem, Abdul (2024) *Dynamic Forecasting Under Concept Drift In Different Generation Modalities Within Smart Grid: A Transfer Learning Approach.* Doctoral thesis, Universiti Teknologi PETRONAS.

In the dynamic landscape of energy generation, where different modalities (DGM); a fundamental part of smart grid (SG) coexist, electrical load forecasting (ELF) plays a pivotal role in maintaining a balance between energy demand and supply. These environments with multiple energy sources experience data variations that increase complexity in energy data. This complexity influences concept drift (CD). Traditional forecasting methods stand obsolete in such non-stationarity, rendering them ineffective in modern energy landscape. Therefore, this research proposes a vigorous "Evolving Prognosis" framework termed as "EPF". EPF leverages transfer learning and long short-term memory (LSTM) to dynamically adapt to changing data conditions i.e. concept expansion (CEXP), concept evolution (CEVO), and Novel Instance arrival (NIA), ensuring the reliability and robustness of ELF. EPF's performance is evaluated against various ELF approaches across CEXP, CEVO, NIA(1), and NIA(>1) scenarios using four datasets. The results demonstrate EPF's superior performance across all benchmarks due to its knowledge transfer capability utilizing transfer learning and enhanced LSTM architecture. In the absence of CD conditions, EPF achieves a MAPE of 0.011, outperforming SVM (1.862), RF (0.099), CNN (0.120), and LSTM (0.152). In the presence of CEXP and CEVO, EPF maintains its superior performance due to knowledge retention, transfer, and selective yet effective capability and has MAPE values of 0.013 and 0.192, respectively, compared to SVM (1.791 and 1.782), RF (0.109 and 0.197), CNN (0.169 and 0.195), and LSTM (0.0.718 and 0.909). Notably, EPF successfully adapts to NIA(1) and NIA(>1), unlike other approaches that fail under these conditions since the data is completely unknown to them. However, EPF, due to its transfer learning approach effectively retrains itself without being offloaded from the system. EPF's adaptability and robustness make it a valuable tool for ELF in DGM environments, paving the way for reliable and efficient energy management in the era of SG's.

Khoo, Chee Min (2024) *The Transient Effects Of Shield Tunnelling On A Loaded Pile.* Doctoral thesis, Universiti Teknologi PETRONAS.

This study investigates the transient tunnel-soil-pile interaction under the influence of shield tunnelling-induced effects. Traditionally, the assessment of these effects relied on post-excavation data and simplified analyses. This decoupled solution potentially leads to conservative outcomes and unnecessary mitigation expenses. To address this limitation, the research employs distributed fibre optic sensing technology to capture real-time data on an experiment pile's responses to shield tunnelling effects in a full scale field study and further validated by numerical simulations. The study delineates the extent of the zone of influence, spanning from a distance of 2 times the tunnel diameter behind the pile to 4 times the tunnel diameter ahead of the pile, with peak impacts observed at 1.5 times the tunnel diameter ahead of the pile. Continuous strain measurements from fibre optic sensors reveal dynamic variation in tensile and compressive loads along the pile length, underscoring the need to consider time dependent effects in pile design and analysis. Numerical simulations confirmed significant down drag loads above the tunnel spring line level, consistent with field observations. However, a delayed response is noted in field data, possibly due to excess pore water pressure dissipation and diminishing tunnel face support pressure. The study elucidates distinct outward movement directions observed in the pile as the TBM approaches, followed by lateral deflection returning toward the tunnel upon TBM's passage. This validation strengthens understanding of pile behavior during various tunnel excavation stages, supporting the negative face loss hypothesis. Control of tunnel volume loss is deemed crucial, with an optimal face pressure range recommended at 0.8-1.1 times the overburden pressure. A grouting pressure range of 1.1-1.5 times the overburden pressure is beneficial for minimized ground settlement. Overall, these findings collectively advance the understanding of tunnelling-induced effects on piles, paving the way for safer and more efficient underground construction practices.

Manogaran, M.Devendran (2024) *Biomethane Generation From Co-Anaerobic Digestion Of Chicken Manure And Empty Fruit Bunch.* Doctoral thesis, Universiti Teknologi PETRONAS.

The growth of the poultry and palm oil sectors has led to the generation of chicken manure, rich in nitrogen and empty fruit bunch (EFB), high in carbon in abundance resulting in improper waste management norms which fail to capitalize on their nutrient content. To address this issue, co-anaerobic digestion (AD) is proposed as a conversion method for biomass waste, yielding circular economy outputs in the form of methane, CH4-rich biogas and digestate. The study consists of four stages, dissecting the fundamental aspects for co-AD of chicken manure and EFB. The first objective identifies the optimal pH, moisture and carbon-to-nitrogen ratio using central composite design-based response surface methodology optimization blueprint. This is followed by the second objective to evaluate the kinetic parameters using five different kinetic models whereby the adequacy of the model is reflected by the regression and root mean square error. The third objective evaluates environmental constraints and energy demand of the process for enhanced CH4 yield through a cradle-to-gate life cycle analysis (LCA). The final objective affirms the optimized laboratory conditions for process upscaling via simulation model developed using Aspen PLUS V12.1 supplemented with gross economic potential (GEP) evaluation based on value of feed and products. The numerical optimization indicated pH 7.1, moisture 67 % and carbon to-nitrogen ratio of 24.5 to be optimal, boasting a desirability of 87.3 %. The kinetic study outlined that the modified Gompertz model complements the system well with a regression of up to 99.83 %. Optimized samples also observed enhanced methane generation potential and rate compared to control samples, up to 134.716 mL/gvs and 1.832 mL/ gvs day respectively. The LCA framework identifies the human carcinogenic midpoint impact category as the most detrimental to the environment with 45.708 % degree of accountability. This scenario is primarily due to electricity demand across the biogas production chain which can be avoided by increasing reliance on renewables and leaving out pre-drying of EFB. Process upscaling of the system under optimized conditions is proven via the simulation model developed, observing CH4 composition viii of 26.07 % post reaction configuration, drawing less than 10 % error compared to CH4 composition attained through numerical optimization. Consequently, the GEP is RM 40,826,405, highlighting the significant economic potential of process upscaling the technology.

Md Hanafiah, Nur Hafzareen (2024) *Optimizing Processing Parameter Modifications In Vacuum Bagging Preforming For Oven Curing Of Composite Laminates.* Doctoral thesis, Universiti Teknologi PETRONAS.

To date, out-of-autoclave (OOA) processing, specifically vacuum bagging (VB) preforming with oven curing, has garnered attention from the aviation industry for producing high-performance composite laminate structures compared to the standard VB-autoclave technique. However, the VB-oven cured laminate shows a higher void percentage, resulting in lower interlaminar shear strength (ILSS) and tensile strength, which do not meet the requirements for aircraft structural applications. The currently available research on VB-oven method is insufficient and critically needed to provide details on the effect of VB preforming modification technique on the produced laminate. Hence, the impact of VB preforming parameters (debulking, edge breather, intensifier and types of mould release) on laminate void content, ILSS, and tensile strength was investigated in this research. The study also focused on optimizing the processing parameter modifications in VB preforming techniques for oven cure using the autoclave prepreg material for manufacturing composite aircraft parts. The first stage of experimental work was based on Design of Experiment (DOE) of two-full factorial design, while the second stage of validation and optimization study adopted a central composite design. The abnormalities percentage in the produced laminate was examined using an ultrasonic C-scan with an image processing algorithm. Experimental work was conducted in accordance with ASTM standards: ASTM D3171-99 for void content, ASTM D2344/D2344M-00 for ILSS, and ASTM D3039 for tensile strength. Detailed investigation of VB processing parameters was analyzed using analysis of variance (ANOVA). Results indicated that an optimized VB technique modification with a combination of wax mould release, 30 minutes debulk, each sides of edge breather and one-kilogram intensifier in oven curing had produced laminate with void content, ILSS and tensile strength of 0.34%, 38.96 MPa and 407.44 MPa, respectively, meeting the requirements for aircraft structural applications. Optimizing the processing parameter modifications in VB preforming for oven curing of composite laminates made from standard prepreg material is expected to contribute to the aircraft structural manufacturing industry, where low void content, high ILSS and high tensile strength are critically needed.

Mohd Anuar, Norzana (2024) *Modelling Of Typhoon-Induced Surge Dynamics In Response To Sea-Level Rise In Malaysia's Coastal Regions.* Doctoral thesis, Universiti Teknologi PETRONAS.

In Malaysia, inadequate storm surge models that integrate tidal effects and limited understanding of storm surge dynamics undermine coastal hazard management. This study examines surge and mean sea level trends at four tide gauge stations on Peninsular Malaysia's east coast and one in the southern Gulf of Thailand. It seeks to identify dependencies in surge height between stations, study tide-surge characteristics and concurrent events, and determine return surge levels using Gumbel's extreme value analysis. Historical storm tracks, passing distances, and peak surge heights from 1985 to 2022 were analyzed. Using the MIKE 21 HD FM model, simulations assess storm landfall timing, varied storm tracks, wind speeds, and sea level rise projections (2040, 2060, 2100), affecting surge heights. Coastal storm surge risks are estimated in selected districts, considering six physical variables: coastal geomorphology, slope, elevation, marine depth, land use, and shoreline retreat. Risk maps, developed with the Analytic Hierarchy Process, integrate vulnerability and hazard analyses. Analysis reveals frequent high surges between neighboring stations with mean surge levels occurring every 2 to 2.5 years. Simulated storm-induced surges peak during spring ebbing tide, rather than rising tide, indicating a nonlinear tide-surge relationship. Assessments of typhoon impacts show varied surge levels under Mean Sea Level conditions, rising with projected sea level increases. Kelantan and parts of Terengganu face the highest surges of more than 1.0 m under year 2100 sea level rise, while the southern east coast experiences lower surges depending on storm landfall. Future research should prioritize accurate storm event data for model validation, finer model resolutions for nearshore surge predictions, and enhanced vulnerability assessments using detailed erosion data to refine surge risk evaluations.

Moke, Kwai Cheong (2024) *Blockchain-Based Iot Data Loss Mitigation Model.* Doctoral thesis, Universiti Teknologi PETRONAS.

The emergence of the Internet of Things (IoT) has been recognized as a potentially revolutionary technology for diverse industries and businesses. However, IoT systems are often vulnerable to data loss due to the single point of failure (SPOF) inherent in centralized architecture and inevitable hardware failures. Guided by the Design Science Research Methodology (DSRM), objectively examined the contributing factors to IoT data loss and gaps in the current research works, explored the potential solutions, hence designed a Blockchain-based IoT data loss mitigation (BIoT-DLM) model with objective to improve data veracity. The proposed BIoT-DLM model possesses three key characteristics: decentralized, distributed ledger/storage (DLT) and peer-to-peer (P2P); self-monitoring; and self-healing, it also incorporates Python enhanced data loss mitigation program and underwent empirical evaluation, demonstrated its enhanced strength in mitigating IoT data loss compared to the gaps existing in contemporary centralized infrastructure architecture and the limitations identified in previous research works. It was empirically evaluated, benchmarked against Byzantine fault tolerance (BFT, F = (N-1)/3), and provides measurable results that support self-monitoring. Empirical evaluation of the P2P network reveals its effectiveness in extending transmission range and reducing data packet loss from 110m to 760m (BIoT-DLM). Furthermore, the identification of an optimal routing protocol contributes to establishing a self-healing network. The strength monitoring via capacitance and Python program verification encapsulating Multichain RCP-JSON API systems are the novelties contributed by this research. In conclusion, BIoT-DLM presents a viable solution in IoT data loss mitigation. Nonetheless, the proposed BIoT-DLM model has some limitations in terms of platform openness and data exchangeability at the current stage of research.

Yahya, Muhammad Sani (2024) *A Compact Meandered Monopole Frequencyreconfigurable Antenna For Lora Applications.* Doctoral thesis, Universiti Teknologi PETRONAS.

This research addresses the literature gap in frequency-reconfigurable antennas for global Long Range (LoRa) communications, overcoming challenges posed by diverse LoRa bands due to regulatory variations. Each region has distinct LoRa frequencies, and existing antennas are fixed, limiting their adaptability. The research introduces a dual and triple-band frequency-reconfigurable antenna for LoRa IoT, balancing compactness and versatility through meandered monopoles and RF PIN diodes. The antennas were designed using CST MWS® to switch seamlessly across major LoRa bands (433 MHz, 868 MHz, 915 MHz). With dimensions of 80 mm × 50 mm for the triple band and 40 mm × 42 mm for the dual-band variant, which are smaller than a standard credit card, the antenna can fit diverse IoT devices. The antenna excels with 2 dBi gain, >70% efficiency, and directional radiation patterns for enhanced LoRa IoT technology. As a proof of concept, the lumped elements' equivalent circuit of the antenna is modeled using Advanced Design System software. A comprehensive comparison among simulation, measurement, and the equivalent circuit model is conducted, demonstrating good agreement. The proposed antenna is integrated into TTGO LoRa32, a LoRa wireless communication system based on SX1276 technology for experimental validation. The antenna significantly enhances signal reception, outperforming conventional commercial antennas by an average of 12 dBm at every point up to 300 m. This underscores the practical utility and relevance of the design in wireless communication.

Zulkarnain, Nurul Nazmin (2024) *Development Of Compressive Strength Prediction Model For Non-Destructive Assessment Of Geopolymer Well Cement.* Doctoral thesis, Universiti Teknologi PETRONAS.

The high concentration of calcium oxide in ordinary Portland cement (OPC) leads to the deterioration of the cement upon exposure to carbonic acid in the reservoir, resulting in an increase in both porosity and permeability of the cement. The feasibility of employing geopolymer cement as an alternative for OPC in Carbon Capture Utilization and Storage (CCUS) wells has been recognized. The lack of predictive models for evaluating the compressive strength of geopolymer cement is impeding its effectiveness in cementing operations. The adoption of default model yielded suboptimal prediction outcomes, whereas the implementation of formulation-specific models appears unfeasible for future deployment and commercialization. Therefore, the present study develops the models capable of accurately predicting the strength of 15 pound per gallon (ppg) geopolymer cement. The study developed a database comprising transit time of ultrasonic waves and compressive strength of fly ash geopolymer cement with eight (8) different additives. The database was employed for model development using regression analysis and model validation is conducted at difference pressure, temperature and density. The study developed two (2) different models: NGP-Optimized and NGP-Modified, depending on the difference between transit time at initial curing and the transit time at the intended curing period. NGPOptimized model can predict the strength with the transit time difference between 18.7 and 29.7%, while NGP-Modified model applicable for cement prediction with transit time difference between 12.1 and 18.6%. The novelty of the study is found in three (3) areas, empirical, knowledge and methodology. From the empirical perspective, the study developed two (2) models for predicting the compressive strength of geopolymer cement with the practicality is based on the difference in transit time. In terms of knowledge, a comprehensive database is created, which includes the transit time of ultrasonic waves and the compressive strength of geopolymer cement. Meanwhile, from methodology perspective is the creation of generic predictive models that eliminates the need for adjusting coefficient with every change in formulation.

Khalili, Noran Nur Wahida (2024) *A Fuzzy Optimization Of Air Photovoltaic/Thermal Solar Collector: Design, Mathematical Model And Performance Analysis.* Doctoral thesis, Universiti Teknologi PETRONAS.

The demand of global energy has increased the need to improve the effectiveness of renewable energy, such as solar energy. Harnessing solar energy by using a photovoltaic/thermal solar collector is among the most preferred method due to its higher efficiency compared to individual collector. A photovoltaic/thermal collector model with air as the working fluid was designed and studied in this study. Since the efficiency of the solar collector depends on a variety of environmental factors, including solar intensity and ambient temperature, it is challenging to determine the air mass flow rate that best suits every environmental condition change, that should also balance the input and output energy from the solar collector. An automated control system is essential to promptly respond to sudden changes in operating conditions rather than manual control of fan employed in previous studies to maintain optimal performance. Existing research previously focused on large-sized solar collectors with complex configurations which posed limitations in terms of space requirements, installation flexibility and transportability. Even though larger collectors yield higher efficiency, they may not be practical due to manufacturing complexities. Hence, the solar collector in this study is designed and fabricated in a unique and compact way for better performance analysis. A mathematical model of the photovoltaic/thermal solar collector has also been developed using one dimensional energy balance equations. Performance analysis has been carried out theoretically and experimentally, and the mathematical model has been validated by comparing the experiment results with the simulation results. The designed model uses forced air produced by a fan. Fuzzy logic is useful in managing the dependent variables that enable the designed solar collector model to perform efficiently. To keep the collector's performance at an optimum rate, a fuzzy optimisation methodology has been proposed and developed by integrating Weighted Subsethood-based Algorithm and Fuzzy Subjective Evaluation methods. A set of fuzzy rules have been developed from the fuzzy optimization methodology could manage and automatically decided on the fan speed based on the current surrounding conditions. The fuzzy rules developed could improve and maintain the performance of the built solar collector. It has been found out that in various surrounding conditions, viii setting up the highest air mass flow rate is not always necessary, but opting for optimal air mass flow rate could help in maintaining the balance between the input and output energy of the solar collector.

Mumtaz, Farhan (2024) *A Non-Isolated High-Gain Non-Inverting Interleaved Dc-Dc Converter For Renewable Energy Application.* Doctoral thesis, Universiti Teknologi PETRONAS.

Energy generation using renewable energy sources (RES) is highly appreciated globally owing to their remarkable energy efficiency and eco-friendly nature. DC-DC converters are being drastically utilized in renewable energy generation systems, such as photovoltaic (PV) and fuel cells (FC). RES persist with low-level output voltage; therefore, DC-DC converters are essentially integrated with RES for satisfactory performance. The conventional DC-DC converters persist with issues that includes poor voltage gain, high voltage stress on the components, high input current ripple, and low efficiency. Therefore, to cater the aforementioned issues, this thesis proposed proposes a non-isolated high-gain non-inverting interleaved DC-DC converter. The proposed DC-DC converter topology is comprised of two inductors and these are charging and discharging in series and parallel circuit configurations. The converter topology can generate output voltage with a very high voltage gain of 20 times of the input voltage. The proposed DC-DC converter topology is designed to operate in three modes of operation. Three switches are operated utilizing two distinct duty ratios to avoid the extreme duty ratio while having high voltage gain. Owing to its intelligent design, the voltage stress on the switches is also significantly reduced where the maximum switching voltage stress is only 50% of the output voltage. The maximum diode voltage stress is the 52.5% of the output voltage. The input current ripple is also observed to be optimum 25%. Moreover, a high efficiency of 93.2% is attained by the proposed DCDC converter topology. Furthermore, to verify the performance of the proposed converter, it is implemented with a fuel cell integrated microgrid system. In this regard, the proposed converter outperformed the conventional and other recently proposed converters producing very low voltage ripple of 1% and reducing the current harmonics of the microgrid to 3.22%. As a result, the efficiency and the longevity of the fuel cell also increased substantially.

Shutari, Hussein Ali Mohammed (2024) *Enhancing Wind Energy Harvesting Efficiency and Grid Integration Stability Using Advanced Control Schemes.* Doctoral thesis, Universiti Teknologi PETRONAS.

Wind energy technology is considered as one of the most important and productive energy sources for the future. However, efficiently harnessing wind energy, and grid integration stability remain significant challenges due to the non-linear characteristics of wind turbine output power and the intermittent nature of wind energy. Maximum Power Extraction Algorithms (MPEA) and the design of Power Electronics Converter Control Schemes (PECCS) play a significant role in dealing with these challenges. While many MPEAs are developed, some rely on wind speed sensors or face issues of oscillation which, impact overall system efficiency. Similarly, numerous approaches have been introduced for designing PECCS, but they often neglect the dynamic nature of Wind Energy Conversion Systems (WECS) during the design process and may have limitations in handling nonlinear systems. This thesis proposes a new MPEA and Optimal Design Control Schemes(ODCS) for Power Electronic Converter (PEC) in a grid-tied Permanent Magnet Synchronous Generator-based Variable Speed Wind Turbine (PMSG-VSWT) system. The proposed MPEA is based on the Parabolic Prediction Technique (PPT), is sensor less, offers fast tracking, and effectively resolves oscillation issues encountered in current MPE algorithms. The ODCS is developed using real-time simulation-based optimization, using a new Hybrid Sine Cosine Algorithm and Transient Search Optimization (HSCATSO) in coordination with MPEA. This proposed approach effectively tackles the constraints faced in traditional control schemes. To verify the effectiveness of the proposed approaches, extensive simulations are conducted under various scenarios using MATLAB/Simulink. The obtained results indicate that the coordination between proposed PPT-MPEA and HSCATSO-based ODCS significantly enhanced WECS performance and also the efficiency with an average of 98.04%, outperforming competitive methods by 3.63%.

Afolabi, Funsho Ayobami (2024) *Chemical Enhanced Oil Recovery Application Of Novel Synthesized Cellulose-Based Polymeric Surfactants.* Doctoral thesis, Universiti Teknologi PETRONAS.

Chemical enhanced oil recovery (cEOR) remains one of the most potent tertiary recovery techniques. However, cEOR has its shortfalls like complexity, cost, and environmental challenges. Bio-based polymeric surfactants have been suggested as an alternative to eradicating the challenges of conventional cEOR. Unfortunately, few detailed in-depth studies exist in the literature to investigate the prospects of these materials. The goal of this research was to synthesize a new family of cellulose-based polymeric surfactants, test the EOR functionalities at realistic conditions of salinity and temperature, and evaluate the factors responsible for the performances observed. Two novel materials, D-I and D-II were successfully synthesized by attaching a surfactant macromonomer, DPEA, to the backbone of cellulose sulphate using microwave assisted free-radical random copolymerization. Both biopolymeric materials are stable in ionized and de-ionized aqueous environments alike. They were able to lower interfacial tension to 10-2 mN/m at high temperatures. They also exhibited interesting rheological behaviours where D-I was observed to be a dilatant fluid while D-II is a thermoviscosifying polymer. At optimum conditions, D-II was able to reverse the wettability of a sessile rock from intermediate wetting (90˚) to strongly water wet (0˚) within 1,500 seconds of drop time. D-I had the best recovery performance under secondary injection mode wherein it was able to reduce residual oil saturation to 12% at harsh conditions of 60,000 ppm salinity at 75 oC. While in tertiary injection mode, D-II had the best recovery with final residual oil saturation of 18% at 60,000 ppm and 45 oC. Micromodel analyses revealed that the performances of D-I and D-II were due to the combination of mobility control, IFT lowering and emulsification, wettability alteration, and elasticity. Molecular dynamics simulation revealed that both materials interacted well with oil molecules, while chain dynamics analysis showed that they both have high chain thermal tolerance and good chain extension under shear. With a performance commensurate to that of a commercial polymeric surfactant, the novel polymeric surfactants are regarded as viable cEOR agents for oilfield applications.

AL-SHAIBANI, NAJIB MOHAMMED SULTAN (2024) *In-Situ Analysis Of Thermal Expansion And Defect-Induced Magnetism In Transition-Metals Doped Cubic Silicon Carbide Lattice For Spintronics.* Doctoral thesis, Universiti Teknologi PETRONAS.

Accurate measurement of thermal expansion in cubic silicon carbide (3C-SiC) is challenging for diluted magnetic semiconductors devices. This is due to ex-situ X-ray diffraction and dilatometry technique of high temperature, which often result in thermal expansion mismatches. Non-uniform distributions and controlled doping are crucial to avoid undesirable competition between ferromagnetic and antiferromagnetic states for devices requiring stable magnetization such as magnetic sensors, spin injectors, and spin filters. Two methods were employed in this study. The first one was the real-time inelastic in-situ X-ray scattering, based on kinematical model lattice diffraction at the maximum peak (111) at temperatures ranges of 25° C to 800° C. The second method was the density functional theory incorporating the Generalized Gradient Approximation and the Hubbard model which was systematically implemented to investigate the doping concentration of 3.125% and 6.25 % of Mn+2, Fe+3 and Cr+3 ions in 3C-SiC, respectively. For the 6.25% doping concentration, the distances between the dopants were varied. Two inherent defective models (near, far) were developed on 6.25% that exhibited lowest formation energy. In this study, the real-time in-situ X-ray scattering revealed noticeable difference in obtaining thermal expansion coefficient of 3C-SiC of 2.4 × 10-6 /°C with an average of 3.82 × 10-6 /C°. It was also found that uniform dopants distribution and increasing doping concentrations with varied distances, did not alter the interaction between ferromagnetic and antiferromagnetic states. The structures remained stable in a ferromagnetic state at both concentration levels. The Silicon-defect (near, far) and Carbon-defect (near) in Mn +2 doping, along with the Carbon-defect (near) in Fe+3 and Cr+3 doping, exhibited antiferromagnetic state with zero magnetic moment. In conclusion, the real-time in-situ X-ray scattering has significantly refined measuring the thermal expansion coefficient of 3C-SiC. Furthermore, inherent defects affect the tunability of transition metal-doped 3C-SiC, making them crucial for designing spintronics devices.

Chandran, Krittika (2024) *Sulfur Dioxide Removal Via Intergrated Extractive Photoreaction Using Deep Eutectic Solvent-Mn-Doped Tio2 Under Visible Light Irradiation.* Doctoral thesis, Universiti Teknologi PETRONAS.

With steady growth in SO2 emission over the years, removal of SO2 from the environment is a critical issue in preventing climate change. The current method used to remove SO2 is flue gas desulfurization (FGD). However, the limitations of FGD are the high capital, operating, and maintenance expenses, hence it produces waste, which results in contamination. The development of nanostructured material that could harvest energy from the sun and then convert it to chemical reaction is envisaged, which is a sustainable approach for the remediation of SO2. The aim of this study is to investigate the feasibility of employing the integrated extractive-photoreaction system to remove SO2. Here, a promising manganese doped TiO2-deep eutectic solvent (DES) was developed by synthesizing the DES by mixing the hydrogen bond acceptor (HBA) with hydrogen bond donor (HBD) at 80 °C for 60 min to form the DES. The developed DESs were confirmed by 1H NMR spectroscopy. Choline chloride with ethylene glycol (ChCl:EG) with molar ratio of 1:2 exhibits the potential DES with highest absorption efficiency of SO2 (2.88 mmol/kg). It also has good thermal-stability, high tolerance to water contents, economically feasibility of recycle and robust performance in regeneration cycle with only 3% loss after the fifth cycle using hexane. Studies showed that SO2 is not the only particulate matter (PM) that pollutes the atmosphere, whereas other products including sulfite and sulfate are also PM that is present in the air. Thus, the DES was tested on the absorption efficiency for SO2 equivalent by incorporating titanium dioxide (TiO2) photocatalyst in the system. Visible-light responsive TiO2 was synthesized via precipitation method using TiCl4 as precursor and modified with manganese (Mn) via wet impregnation method. The optical response was redshifted to visible-light range, and the bandgap was significantly narrowed from 3.18 to 2.75 eV. The photocatalytic process was optimized via central composite design (CCD) in response surface methodology (RSM). A good integrated absorption efficiency of the SO2 was obtained at 84.4% under the optimized conditions of 0.25 g/L TiO2 loading, 50 mL of DES and 0.1 wt% Mn under 120 min of visible-light irradiation. This novel capture system which can be prepared on-site is feasible for industrialization and offers an efficient, inexpensive, and safe system for SO2 capture.

Iferobia, Cajetan Chimezie (2024) *Geomechanics Of Shale-Fluid Interaction And Application To Shale Gas Reservoir Brittleness-Fracability Analysis.* Doctoral thesis, Universiti Teknologi PETRONAS.

The response of geomechanical properties following shale interaction with polymercontaining fluids (linear and crosslinked fracturing fluids) needs comprehensive investigation. These fluids due to their high viscosities ensure efficient proppant carrying capacities, better fluid loss control, and maximized flowback recovery. Candidacy selection for hydraulic fracturing has relied on the Brittleness Index (BI). This is considered insufficient in hydraulic fracturing decision-making, especially in brittle mineral-rich and high fracture gradient shale. This raised the need for geomechanical property-driven slight modification of the BI, and onward application in shale Fracability Index (FI) evaluation. A comprehensive investigation of experimental techniques and their applications in shale geomechanical properties evaluations was carried out. Linear and crosslinked fracturing fluids were formulated and used in the saturation of shale samples under reservoir temperature conditions. Samples were of USA Eagle Ford and Wolfcamp shales known for their commercial gas reserves. Mineralogical characterization and elemental composition analysis were carried out using FESEM, EDX, and XRD. MIP was then deployed in the porosity-permeability characterization of shale samples. Geomechanical responses were evaluated through the experimental techniques of uniaxial compression and Brazilian indirect tensile strength testing. Geomechanical correlations were subjected to comparative assessment before application in the evaluation of geomechanical properties. BI was subjected to slight modifications, leading to BI expression as a function of normalized static Young's modulus-Lamé constant ratio, normalized static Poisson's ratio, and normalized fracture toughness. The modified BI was then applied in the determination of FI being expressed as a function of BI and normalized fracture breakdown pressure. Brittleness-fracability analysis was carried out for informed decision-making on shale hydraulic fracturing, with a major leverage on the Streaky-1 well data of Murteree shale gas reservoir interval

Ismail, Asmawi (2024) *Properties Of Diffusion Bonded Aw50 Aluminium Alloy To A36 Steel Using Gallium As An Interlayer.* Doctoral thesis, Universiti Teknologi PETRONAS.

Over the years, the dissimilar joining of steel and aluminium has attracted great concern from the marine industry due to the possibility of achieving a compromise between weight reduction, cost, and strength. However, the major setback encountered with these joints is the insufficient joint quality, primarily due to brittle interfacial Intermetallic Compounds (IMCs). In this research, the feasibility of producing diffusion-bonded A 36 mild steel and AA 5083 aluminium with gallium (Ga) interlayer was investigated. Thereafter, the corrosion behaviour of the joints and the effect of bonding parameters, namely, temperature (525 and 550 oC), holding time (60 and 120 minutes), and surface roughness (800 and 1200 grits) on the properties of the joints, were investigated. Additionally, Response Surface Methodology (RSM) was adopted to facilitate the study of the effect of the bonding parameters. The microstructural characterization was achieved using Scanning Electron Microscopy (SEM), Energy Dispersive X-ray (EDX), and X-ray Diffraction (XRD), while potentiodynamic polarization was used for the corrosion property assessment. Meanwhile, the hardness and impact strength of the joints were characterized using Vickers microhardness and Izod impact tests, respectively. The results revealed that A 36 mild steel and AA 5083 aluminium with gallium (Ga) interlayer joint having a 30 µm diffusion layer containing Fe3Al intermetallic compound was successfully created. Furthermore, the significant bonding parameter is temperature, followed by surface roughness and holding time. Expressly, the corrosion resistance increased with the bonding temperature and the holding time while a contrasting observation was recording for the roughness of the Base Metal (BMs) faying surface. The incorporation of the Ga interlayer led to about 68 % increment in corrosion resistance. Meanwhile, the optimization studies revealed that parameters for optimal impact strength are 550 oC bonding temperature, R800 surface roughness and 60 minutes holding time. Hence, the interlayer diffusion bonding of Ga has greatly improved the corrosion resistance of joints and their optimal impact strength.

Khan, Mudassir Ali (2024) *The Impact Model Of Channelized Debris Flow On Exposed Pipeline Through Experimental And Numerical Analyses.* Doctoral thesis, Universiti Teknologi PETRONAS.

Global climate change has led to an increase in the occurrence of various natural disasters worldwide. Among these catastrophic events, debris flows have caused extensive damage to infrastructure including buildings, roads, dams, and pipelines in last two decades. Therefore, predicting the complex mechanism of debris flow impact on structures are the utmost requirement to design the risk management strategies and protection measures. This study presents the refined impact pressure model of the debris flows by considering the solid volume fraction (αs), Reynolds number (Re), Froude number (Fr), and attack angles (β) through experimental and numerical investigations. The experimental investigations were conducted using small scale (1:15) wave flume on a 2" (52 mm) GI pipe model positioned at a 90^{o} across the flume. Various debris flow models with solid volume fractions ranging from 0.35 to 0.65 were employed to incorporate the wide range of debris flows. The numerical investigations were performed in computational fluid dynamics environment using Hyprework CFD with Acusolve 2022 a finite element-based solver. The Spalart–Allmaras turbulence model and Hershel-Bulkley model were effectively represented the physics and rheology of debris flows in CFD model. Experimental results revealed that all the debris flows are in supercritical regime with Froude number ranging from 2.0 to 6.0 and were characterized as dilute, medium viscous, and highly viscous flows. Dynamic quantities such as velocity, flow depth, and impact pressure varied from 2.85 to 0.80 m/s, 2.5 to 22.70 cm and 10.14 to 7.66 kPa with solid volume fractions. Further, data analysis revealed that normal (CD−90), and axial (CD−0) drag coefficients non-linearly varied with Froude (Fr) and Reynold numbers (Re) for each attack angle (β) . Additionally, solid volume fraction (αs) and attack angles (β) showed significant effect on the impact mechanism of debris flow on pipe model. The findings highlight the importance of considering these parameters in impact modelling to accurately assess the impact on exposed pipelines subjected to debris flow hazards.

Jan, Ahmad Ali (2024) *The Relationship Of Corporate Board Governance Attributes And Sustainability Performance In Islamic Banks: The Moderating Role Of Corporate Governance Regulations.* Doctoral thesis, Universiti Teknologi PETRONAS.

The Sustainable Development Goals (SDGs) highlight the most pressing economic, social, and environmental issues that need to be resolved by the global community, including the Islamic banking industry (IBI), to attain global sustainability. To cope with these issues, this study aims to develop a measurement index for assessing the corporate sustainability performance (CSP) of IBI in the purview of the SDGs. Similarly, this study aims to examine the nexus of Islamic corporate board governance (ICBG) attributes and CSP in Islamic banks in Malaysia with the moderating role of corporate governance (CG) regulations. Using a weighted content analysis technique, this study converts the qualitative information of CG regulations and CSP into quantitative data. Whereas Information about ICBG is obtained from Thomson Reuters DataStream which was also crosschecked with annual reports of the sampled Islamic banks. The empirical analysis is performed using fixed-effect, random-effect, and twostage least squares (2SLS) regression estimations on the balanced panel data taken from 2011 to 2020. The results indicated that the CSP disclosure in Islamic banks is an upward trend, which has significantly increased over time (2011-2020). Secondly, Islamic banks significantly contribute towards achieving the SDGs, where most of the banks have high SDGs disclosure scores. The results further disclosed that ICBG attributes have a positive impact on the CSP at a 5% significance level. The findings also indicated that CG regulations exhibit a moderating effect on the relationship between ICBG attributes and CSP at a significance level of 5%. These findings are consistent with past literature as well as the postulations of legitimacy theory, agency theory, and institutional theory. Besides, this study extends the existing literature by incorporating new Shariah board attributes as well as religious sustainability indicators into the ICBG framework and CSP measurement index. Similarly, this study adds a religious aspect to the postulations of legitimacy theory. Overall, this study provides important insights to the regulators and practitioners of Islamic banks in embedding sustainability into their governance strategy for achieving the SDGs. This would help in recognizing the strong and weak points of their governance procedures regarding the SDGs' achievement.

Kumar, Ganesh (2024) *A Data Harmonization Framework For Heterogenous Textual Datasets Using Token Summarization Method.* Doctoral thesis, Universiti Teknologi PETRONAS.

The recent technological advancement has made todays' data to be more heterogenous and subsequently more complex to analyze. This is because the data comes from variety but related sources and in disparate formats. Also, the data is generated at a very high rate; making it even more challenging to be analyzed by the existing data analytics tools. Resultantly, many studies have been conducted to curtail this manace in different ways such as the application of preprocessing techniques, data mapping, data conversion, data curation, and data fusion. These techniques have recorded a very significant progress in minimizing the heterogeneity of data prior to performing complex data analytics. Few of them focused only on data curation for structured dataset, conversion of unstructured data into structured, and mapping of structuredunstructured data into semi-structured data. However, all the aforementioned techniques handle each data category (structured, semi-structured and unstructured) separately and independently while neglecting cross-task, sharable, and common attributes amongst the datasets. This may lead to the production of less-informed results, thereby less accurate conclusions in the analysis. In this thesis, a data harmonization framework (DHF) that aims at harmonizing heterogeneous textual data from disparate sources (i.e., structured, semi-structured and unstructured) is proposed. DHF contains a series of interconnected modules, amongst which are Extended Preprocessing (ExP) algorithm, Multidimensional Reference Model (MRM) and Data Harmonization (DH). ExP algorithm accepts heterogenous datasets, performs tokenization, lemmatization and stemming each text before mapping the results with MRM. Whereas MRM works by indexing the existing English linguistics words (as corpus) such as context clues, semantic and syntactic. The MRM contains a list of words (scope-based) and their respective score which works as a data dictionary. The DH performs the semantic and lexical matching of the processed words using MRM. At the end, a harmonized dataset and its report are produced based on rule definition which viii uses input, matched, and score of words. In the implementation phase of DHF, various rounds of batches (datasets) have been tested on all participating heterogeneous datasets. For comparison of the proposed DHF results, with the existing studies there were some frameworks proposed in context of structured and unstructured datasets.

Lee, Keat Fong (2024) *Developing The Model Of Creativity In Time-Out Role-Play: A Grounded Theory Study.* Doctoral thesis, Universiti Teknologi PETRONAS.

This research seeks to develop creativity among undergraduates in higher education by building a new pedagogical theory and practice that helps educators to foster students' creativity. A new role-play has been developed to foster students' creative behaviours in classroom setting and identify types of creativity occurs in real-time scenarios with characters of departmental managers and CEOs. This research focused on creativity as person-environment-fit with a blank slate of discipline knowledge in crisis management, and authentic conversations to create a flow using Improv theatre concept in a psychologically safe environment. The methodology adopted was Classic Grounded Theory Method to build an independent theory. Data was collected from two private universities for a pilot study and research. The focus was to observe students' interactions, mindsets, and behaviours in an agile team meeting to solve a company business crisis at a top management level. Semi-structured interviews were used to collect detailed explanations from the fifty-two participants regarding their perceptions on Time-out role-play, learning and thinking styles. Samples were interviewed on their strategies to generate more ideas in fast thinking and refine ideas with just-in-time learning. Grounded Theory coding was used to analyse the data thematically in relation to the research aims and questions. The findings show a significant relationship between thinking, learning communication and leadership, and creativity, which has great potential for pedagogical development. This study also provides pedagogical implications to help the students to think creatively besides improving English speaking competence. Building from this empirical finding, a new theory is adumbrated named: Time-out role-play sustainability theory of opportunistic intelligence. This emphasises that creativity is developed through seeking opportunity to scaffold ideas through collaborative emergence and immediate feedback of the team.

Yaro, Shehu Nura Aliyu (2024) *Rheological And Performance Properties of Asphalt Binder and Mixtures Modified With Waste Palm-Oil Clinker Fine.* Doctoral thesis, Universiti Teknologi PETRONAS.

This study investigates the possibility of employing palm oil clinker (POC) chunks as a sustainable modifier for asphalt binders and mixtures in flexible pavements. The investigation has three stages. First, an optimization technique was used to identify the optimal mixing parameters for POCF-modified asphalt binder (POCF-MAB). Second, the effect of POCF on the binder's conventional and rheological characteristics was measured, and its microstructural properties were investigated using FTIR, SEM, and XRD. The third step focused on analyzing the volumetric and Marshall properties of the POCF-modified asphalt mixture (POCF-MAM) as well as its mechanical performance. Additionally, a statistical optimization and ANN-based prediction approach was developed using the POCF-MAM stiffness and rutting properties to determine its performance based on BS EN 1269726(E) and BS 598110, respectively. The study used varied weight percentages of POCF (2%, 4%, 6%, and 8%). The optimization findings show that 1000 rpm, 51.9 minutes, and 140^{O}C are the optimal mixing conditions for a homogenous blend. The addition of POCF results in a stiffer asphalt blend, whereas rheological testing showed that integrating 4% and 6% POCF improves rutting resistance while maintaining fatigue resistance. Characterization investigation reveals the formation of a new functional group, Si-OH, because of the crystalline structure of Si-O, which improves the properties of the asphalt binder. Volumetric, Marshall, and mechanical performance tests show that the inclusion of POCF-MAB increases mixture performance due to improved POCF-MAB's binding capacity in the asphalt mixtures. The prediction using both statistical and ANN yields high R2 values for both techniques, suggesting good performance, but the ANN method yields improved prediction accuracy with lower RMSE and MRE values. Overall, the results of this study demonstrate that POCF can be utilized as an alternative modifier for asphalt binders and mixtures, which can help address waste disposal issues and enhance sustainability in the pavement industry.

Abdulrab, Hakim Qaid Abdullah (2024) *Optimizing Wireless Mesh Network Deployment Using Fault-Tolerant Routing And Hybrid Metaheuristic Technique.* Doctoral thesis, Universiti Teknologi PETRONAS.

Communication and data transmission in industrial wireless networks necessitates reliability and precision. Besides, the optimal placement of wireless routers significantly enhances the overall performance of industrial wireless mesh networks (IWMN). Therefore, reliable communication (i.e., coverage and connectivity) must be attained to accurately and timely transfer data packets over the wireless mesh network (WMN). However, the functional scenarios of the network itself make it vulnerable to a node or link failure, which impacts the reliability and overall performance. Thus, this research aims first to introduce a fault tolerance-based multipath routing model (MPR) to improve the transmission reliability, lifetime, and latency of a small scale IWMN. Secondly, a novel hybrid Harris Hawk Optimization with Sine Cosine Algorithm (HHOSCA) is proposed to place the wireless routers in a large-scale WMN optimally. Compared with the state-of-the-art, the MPR model has significantly reduced the average network latency (ANL) and power consumption and enhanced the expected network lifetime (ENL) and packet delivery ratio (PDR). Compared to the nearest competitor, the MPR has improved the ANL, ENL, and PDR by 108.3%, 107.6%, and 4.2%, respectively. In addition, the proposed HHOSCA approach has shown superior performance over the competing algorithms regarding connectivity, coverage, and congestion reduction of a large-scale WMN. Numerically, the HHOSCA obtained 99% coverage and 100% connectivity, and the congestion was reduced by 51%. The simulation outcomes demonstrate the effectiveness and efficacy of the proposed HHOSCA in optimizing WMNs, making it a promising approach for enhancing the performance of IWMN.

Aujih, Ahmad Bukhari (2024) *Hybrid Edr-Net+ Architecture With Noise Invariant And Effective Computation For Alternative Classification Of Referable Diabetic Retinopathy.* Doctoral thesis, Universiti Teknologi PETRONAS.

The global prevalence of Diabetic Retinopathy (DR) has heightened the urgency to develop an AI-driven automated referable DR (rDR) screening system. Consequently, there's a rising focus on researching Deep Convolution Neural Network (DCNN) architectures like DR-Net tailored for DR detection on small devices. Although mobile devices hold promise for DR screening due to their compact nature, the noise in captured images poses a significant challenge. This study introduces EDR-Net+, a novel DCNN architecture blending Separable-based Network-in-Network (SEP-based NiN) and Mixed Visual Attention (MixAttn) convolution modules. The noise-invariant performance of EDR-Net+ was evaluated for convergence robustness and predictive efficacy against Subtracted Local Average Color (SLAC) pre-processing. Simultaneously, its computing effectiveness in terms of parameters and hardware efficiency was assessed. EDR-Net+ was tested on benchmark datasets—Messidor-2, Kaggle-EyePACS, and IDRiD—revealing substantial noise invariance compared to baseline models. EDR-Net+ exhibited a remarkable 300% reduction in parameters with a 5% AUROC performance dip compared to baseline models. Moreover, EDR-Net+ displayed significant improvements in latency, deployment memory, and convergence time—by 210.01%, 276.89%, and 123.24%, respectively—compared to EDR-Net + SLAC. In conclusion, EDR-Net+ demonstrates potential deployment on small devices.

Ding, Sie Hao (2024) *Amine Substituted Nh2-Mil-125 (Ti)/Polyvinylidene Fluoride Hollow Fiber Mixed Matrix Membranes For Co2/Ch4 Separation.* Doctoral thesis, Universiti Teknologi PETRONAS.

Amine substituted NH2-MIL-125 (Ti)/polyvinylidene fluoride (PVDF) hollow fiber mixed matrix membrane (HFMMM) is a promising type of amine modified mixed matrix membrane (MMM) in CO2/CH4 separation, particularly in enhancing CO2 permeation that incorporates a filler into a polymer matrix and undergoes amine substitution (Asub) reaction using ammonia solution. However, the development of these membranes is challenged by various factors, such as inner lumen deformations during hollow fiber (HF) spinning, large aggregations with interface void formations, unsuitable amount of filler loadings into the polymer matrix, and deteriorated properties due to improper degree of Asub on PVDF phase in HFMMM. To address these challenges, this study prepared PVDF HFMs by manipulating air gap intervals (5 to 25 cm), HFMMMs development using various NH2-MIL-125 (Ti) loadings (1 to 3 wt%), and subject the resulting HFMMM to Asub reaction using ammonia solutions of varying concentrations (25 to 35 v/v%). The optimized membranes were then coated with PDMS to eliminate possible surface defects. All developed membranes are assessed using various characterization tools, CO2/CH4 permeation, and various permeation models. The results show that the PVDF inner lumen defects are reduced via air gap manipulation and showed highest CO2/CH4 ideal selectivity of 2.92 using 15 cm air gap distance. Besides, good compatibility and acceptable dispersion are observed up to 2 wt% filler loadings, with 530.78 CO2 permeance and the highest CO2/CH4 ideal selectivity of 7.15. Amine substituted HFMMM using 30 v/v% shows improvement in crystallinity, which exhibits the highest CO2/CH4 ideal selectivity of 8.31 with enhanced CO2 permeance. No CO2-induced plasticization is observed up to 10 bar feed pressure. The CO2/CH4 selectivity raised from 3.16 to 5.87 compared to uncoated membrane.

Kasim, Sani Ado (2024) *Integrated Sedimentological, Petrographic, And Geochemical Evaluation Of Paleogene-Neogene Basins, Peninsular Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

Sedimentological and geochemical features of the onshore Paleogene-Neogene basins of Peninsular Malaysia are of importance in better understanding the basins' evolution and geodynamics, but remain not well investigated. The isolated mini basins are half-grabens, which formed along major fault zones. The research is aimed at evaluating the sedimentology and geochemistry of the six Paleogene-Neogene sedimentary succession in order to provide information on depositional environment and processes, sediments transport mechanisms, provenance, paleoweathering and tectonic setting. Using a multidisciplanry approach, including field/facies analysis, petrography, textural/grain-size analysis, and major, trace and rare earth elements contents obtained from XRF and ICP-MS techniques, paleoenvironmental characteristics and depositional processes of the basins were evaluated. Results of the field/facies observations reveal deposition in alluvial-fluvial and shallow lacustrine settings, represented as upper and lower sequences, respectively. The basins' upper sequence lithologies can be broadly divided into conglomerate and sandy facies. These lithologies can be grouped into three main facies associations, including massive conglomerate, stratified conglomerate, and sandstone fluvial deposits, which reflect alluvial fan (debris/gravity flow), gravel braided bar, and channel bar depositional environments, respectively. The Lower sequence is dominated by sandstone, siltstone, and mudstone facies, indicating a low-energy lacustrine environment. Petrographic data indicate that the conglomerates are clast- and matrix-supported and were derived from a proximal source. The sandstones are coarse-grained, poorlysorted, and sub-rounded to sub-angular in texture. They are arkose, sublitharenite to lithic arkose and less feldspathic litharkose in composition. In light of the QtFL/QmFLt ternary diagrams, the sandstones are primarily derived from a provenance area comprising recycled orogen and continental block material, including uplifted viii basement rocks and transitional continental deposits. Grain size and morphometric parameters range are consistent with immature to sub-mature sedimentation under a high-energy fluvial environment.

Reddy, Lekkala Malakonda (2024) *Hydrodynamic Analysis Of Offshore Slender Cylinders With Geometric Surface Modification.* Doctoral thesis, Universiti Teknologi PETRONAS.

For years, different flow control methods have been developed to mitigate vortex induced vibrations (VIV). These vibrations are a canonical problem in fluid-structure interactions and lead to the accumulation of fatigue damage (FD). Estimating and minimizing the FD is an important aspect to assure reliable and operable conditions of the structures. There are two keyways either to mitigate or reduce these vibrations: improving accuracy of semi-empirical tools for better prediction of FD and reducing the vibrations by morphing topography of cylinders. The prediction accuracy of semiempirical models for a riser attached with buoyancy modules can be improved by optimizing the hydrodynamic coefficient database extracted from the experiments. Meanwhile, existence of higher harmonic frequencies can affect the FD due to VIV. Hence it is necessary to understand the effects of higher harmonic frequencies on the performance of the riser. The effects of the modified geometry as a flow control method on the flow features of different cylinders were analyzed and quantified at a subcritical Reynolds number (Re). Four different cylinders namely: smooth circular (SC), single wavy (SW), double wavy (DW) and harbour seal vibrissae (HSV) cylinders with five different wavelength ratios were investigated. By optimization technique, the prediction of fatigue damage and response frequency was 0.932% and 8.488% under predicted while 32.73% and 36.17% under predicted for optimized and default database respectively when compared to test results on an average for five configurations. At the optimal wavelength ratio, the HSV cylinder reduced the drag by 20.58% and 17.89%, while the lift coefficient was reduced by 96.42% and 95.58% for $Re = 3.0 \times 103$ *and* 3.9×103 receptively, when compared to SC cylinder. Through this study, it can be observed that by optimizing the hydrodynamic coefficient database, the responses of the riser can be predicted accurately to take necessary mitigations and a better understanding on the use of passive flow control method to reduce the hydrodynamic forces and controlling the VIV of cylinders is achieved.

Soomro, Afzal Ahmed (2024) *Analysis Of Smote-Based Data Augmentation And Machine Learning Models For Burst Pressure Prediction Of Oil And Gas Pipelines.* Doctoral thesis, Universiti Teknologi PETRONAS.

Burst pressure plays pivotal role in pipeline integrity. By giving information on the remaining strength of corroded pipe sections, it supports the oil and gas industry's decision-making regarding maintenance and fitness for service. Current traditional approaches, have limitations like high expense, conservatism, and computational complexity, respectively, for predicting the burst pressure of corroded oil and gas pipes. The major reason for conservatism in the available models is the lack of effective and ample datasets. To get around most of these issues and offer more effective solutions, in this study, the generalization capability of machine learning models has been improved by improving and enriching the publicly available datasets. To achieve these two main objectives, the first SMOTE method for data preprocessing that has balanced and augmented the dataset has been applied, and five machine learning models have been developed by using the dataset collected from literature and the dataset produced by finite element analysis in this study to check the prediction accuracy. Secondly, the developed model was validated with publicly available models. Five machine learning models were developed after the aforementioned data preprocessing methods were applied, and it became clear that the preprocessing method in conjunction with sophisticated machine learning techniques had a substantial impact on the models' generalization. All five models were effective. The prediction accuracy for the five models was 0.99, 0.98, 0.98, 0.97, 0.96, and 0.95, respectively. Validation scores have improved from 0.8 to 0.98 for E, 0.87 to 0.97 for XGBRegressor, 0.8 to 0.90 for RF, 0.78 to 0.97 for LGBM, and 0.78 to 0.98 for DT, respectively. This improvisation in validation means that the generalization has been improved after applying the SMOTE technique to the dataset. The testing accuracy of the machine learning models increased greatly when trained on the smote-based augmented dataset. The developed machine learning model may propel integrity assessment of corroded oil and gas pipelines with better generalization for fitness for services in industry

Saleem, Muhammad Shoaib (2024) *mpact of Mindful Organising and Collective Psychological Capital on Safety Behaviour: Moderating Role of Safety Stressors in the Malaysian O&G Downstream Industry.* Doctoral thesis, Universiti Teknologi PETRONAS.

This research investigates the factors influencing safety behaviours within the oil and gas downstream industry, considering individual and collective constructs. Specifically, the study explores the relationships between mindful organising (being proactive in identifying potential risks and hazards and taking necessary precautions to prevent accidents and errors), collective psychological capital (a sense of sharedness among team members regarding their perceptions of psychological capabilities), safetyrelated stressors, and individual safety behaviours. The research aims to provide organisations with valuable insights into strengthening their safety arrangements by focusing on the behavioural aspect. The study has expanded and validated the principles of the high-reliability organisation through mindful organisation and the positive psychological element in oil and gas operations, providing a unique blend of variables to foster individual safety behaviours. Data was collected through a cross-sectional survey approach. The study included 366 survey responses from operational and production workers in the downstream oil and gas industry, mainly in Malacca, Kedah, Pahang, and Terengganu. The proposed model was evaluated using the Structural Equation Modelling technique (SEM) with SmartPLS. The findings revealed that both mindful organising and collective psychological capital positively impacted safety performance behaviours. Furthermore, safety-related stressors were found to influence safety compliance and participation negatively. Further, safety role conflict and role ambiguity were found to weaken the positive effects of mindful organising and collective psychological capital on safety compliance behaviour. However, the moderating role of safety-related stressors between mindful organising, collective psychological capital, and safety participation was insignificant. This research extends high-reliability organisation (HRO) paradigms and positive psychology to the oil and gas industry. The findings have significant implications for ix the downstream operations of the oil and gas sector, as adopting collective constructs and mitigating the effects of safety role stressors can enhance safety performance. By understanding the relationships between these variables, organisations can better design and implement safety measures within their operations. Further research warrants the exploration of additional antecedents for mindful organising and collective psychological capital that can counter stress elements in the workplace for better safety outcomes.

Son, Ngo Tung (2024) *A Hybrid Compromise Programming Based Genetic Algorithm For Multi-Objective Optimization.* Doctoral thesis, Universiti Teknologi PETRONAS.

This research introduces a hybrid method, CP-based GA, which synergizes Compromise Programming (CP) with Genetic Algorithms (GA) to address multiobjective optimization (MOO) challenges in the scheduling and planning (SP) field. Key MOO challenges include managing conflicting objectives and optimizing complex decision-making scenarios within high-dimensional solution spaces. The CP-based GA is meticulously tailored for various SP applications such as team selection, task assignment, and vehicle routing, and their performance is compared against traditional solvers using distance-based and hypervolume indicators for evaluation. Findings from these metrics reveal a significant enhancement in the proposed method's ability to leverage business referential values in constructing the compromise problem, leading to a superior performance that outstrips traditional GA-based methods. The integration of CP-based GAs with heuristic searches, such as local search, evolves into a versatile hybrid algorithm that improves solution quality and achieves a delicate balance among multiple objectives compared to other classical search strategies. This approach has demonstrated superior performance in different decisionmaking scenarios, showcasing substantial improvements over existing methods. This research represents a milestone in SP, effectively bridging the gap between the complexities of MOO modeling and the practicalities of algorithmic implementation. The immense potential of these applications in SP decision-making and operational efficiency sets a robust foundation for future explorations in SP optimization techniques. The outcomes of this study provide groundbreaking insights and practical solutions, making a substantial contribution to the scheduling and planning optimization field.

Abdullah, Talal Ali Ahmed (2024) *Sig-Lime: An Enhancement Of Lime For Explainable Cardiac Arrhythmia Classification From ECG Signals.* Doctoral thesis, Universiti Teknologi PETRONAS.

Cardiac arrhythmia represents a significant health concern, necessitating early and accurate classification for effective treatment and enhanced patient outcomes. The high accuracy of deep learning models in detecting arrhythmias from electrocardiogram (ECG) data is offset by their lack of interpretability, limiting their clinical utility. This research introduces a novel interpretable deep learning framework that addresses this critical gap, underscoring the need for algorithmic decision-making processes to be transparent in medical applications. We address the challenges faced by Explainable Artificial Intelligence (XAI) in signal data analysis, particularly the limitations of the Local Interpretable Model-Agnostic Explanations (LIME) method, which struggles with the complex, non-linear dynamics of ECG data and the preservation of temporal dependencies. Our solution encompasses two novel data generation methods: B-LIME, utilizing bootstrapping to maintain temporal relationships, and Sig-LIME, which incorporates signal segmentation and noise introduction for superior data generalization. We also enhance LIME by integrating a Random Forest model to better capture the complexity and non-linearity of ECG signals, significantly improving the explanation's credibility, stability, and local fidelity. Heatmap visualization techniques further augment our approach, providing clinicians with an intuitive understanding of model decisions. Our enhancements undergo rigorous evaluation through visual assessments, ANOVA tests for feature stability, and Average Euclidean Distance (AED) measurements for local fidelity. The ANOVA test results reveal a significant improvement in stability, with traditional LIME showing an f-statistic of 0.76 and a pvalue of 0.4689, whereas B-LIME and Sig-LIME both demonstrate an f-statistic of 0.0 and p-values of 1, indicating a marked enhancement in stability. Furthermore, LIME's average Euclidean distance of 17.24 contrasts sharply with B-LIME's reduction to 6.99 and Sig-LIME's outstanding reduction to 0.49, showcasing the superior local fidelity of our methods.

Abioye, Kunmi Joshua (2024) *Minimizing Palm Oil Decanter Cake Ash Deposition Through Co-Gasification With Alum Sludge.* Doctoral thesis, Universiti Teknologi PETRONAS.

The utilization of palm oil decanter cake (PODC) for waste-to-energy purposes presents a promising alternative, addressing both environmental concerns and the increasing demand for sustainable energy sources. However, the inherent ash slagging behaviour in mono-combustion of PODC result in diminished heat transfer and shortened lifespan of combustion reactors. This study aims to mitigate PODC ash deposition problems, examine thermo-kinetic behavior, and enhance syngas production by co-gasification with alum sludge (AS). Through the Ash Fusion Test (AFT), determination of slagging indices based on elemental composition, and X-ray diffraction analysis (XRD), the ash fusibility behaviour of PODC and AS was examined. The thermo-kinetic behaviour was examined through Thermogravimetric Analysis (TGA), with Coats-Redfern methods estimating activation energy (Ea) and pre-exponential factor (lnA) using twelve reaction mechanisms. Co-gasification experiments investigated the combination of PODC and AS under varied operating conditions (temperature: 700–900 °C, air flow rate: 10–30 mL/min, particle size: 0.25– 2 mm), utilizing air as the gasification agent in a fixed bed horizontal tube furnace reactor. The findings revealed that the addition of AS significantly improved the ash fusion temperature of PODC during co-combustion, especially under higher AS dosages. Slagging and fouling indices indicated that 50% AS addition rendered the slagging tendency of co-combustion ashes negligible while XRD revealed the formation of high melting point Silicon oxide (SiO2), Nonacalcium tris(dealuminate) [Ca9Al6O18] and Hercynite [FeAl2O4] at 1200 °C. Thermogravimetric analysis (TGA) demonstrated two degradation ranges for AS and blends, in contrast to PODC. Kinetic studies identified 50PODC+50AS blend as exhibiting the best reaction rate in Range I with models P3 and P4 (Power law) [R 2 = 0.9996], and in Range II, 50PODC+50AS also demonstrated the highest reaction rate with model A3 (Avrami-Erofeev) [R 2 = 0.9987]. Co-gasification results highlighted the positive effects of temperature and ix particle size, and a negative effect of air flow rate on syngas yield. Optimal CO+H2 composition (39.48 vol.%) was achieved at 900 °C temperature, 10 mL/min air flow rate, and 2 mm particle size. In conclusion, the 50PODC+50AS blend exhibits superior suitability for efficient bioenergy production, underscoring its exceptional potential in addressing ash-related challenges and contributing valuable insights for environmentally friendly solutions.

Aboelazm, Eslam Atef Abdelaziz (2024) *Transition Metal/Graphene Composites for High-Performance Hybrid Supercapacitors Derived From Cyano-Bridged Coordination Polymers.* Doctoral thesis, Universiti Teknologi PETRONAS.

This thesis aims to advance energy storage materials to meet evolving technological demands, with a focus on finding a scalable production method for electrode materials with high energy and power densities and extended cycle life. It explores the significance of Porous Coordination Polymers (PCPs) and the relationship between the proportion of reduced graphene oxide (rGO) and the potential for achieving high specific capacitance and robust cyclic stability. A novel method is employed to convert CoNi-CP sheets into CoNi-C on rGO, forming CoNi-C/rGO hybrids. Particular optimization confirms the desired material structure and morphology, and the CoNiC/rGO composite emerges as a standout, boasting a specific capacitance of 1177 F g-1 at 1 A g-1 , energy density of 31.6 Wh kg-1 at a power density of 750 W kg-1 and a capacitive retention of 84% over 8000 charging cycles. Distinctive morphology, composition, and rGO ratio enhance charge transfer and electrolyte diffusion. The study advances by incorporating superior transition metal chalcogenides for improved redox activity, energy density, and cyclic stability. The CoNi-S/rGO composite, strategically crafted to capitalize on the synergistic advantages of sulfur-bridged CoNi-S and rGO, demonstrates exceptional performance. With a specific capacitance of 3308 F g-1 at 1 A g-1 , outstanding high-rate capabilities, impressive energy density (50.2 Wh kg-1 at 750 W kg-1), and capacitive retention rate of 84% over an extensive 35,000 cycles. This composite marks a substantial stride forward in hybrid supercapacitor technology. In the latest exploration, attention turns to transition metal selenides, presenting promising alternatives to battery-type Faradaic electrodes. The synthesis of the CoNi-Se/rGO composite for the first time showcases distinctive faradic behaviour, achieving a specific capacitance of 2957 F g-1 at 1 A g-1 and a high energy density of 73 Wh kg-1 at a power density of 1500 W kg-1 . Exceptional high-rate capabilities, low charge transfer resistance, and sustained performance over 20,000 cycles underscore the potential of CoNi-Se/rGO as a superior electrode material for high-performance energy storage applications.

Abusalim, Samah W.G. (2024) *Hierarchical Deep Learning Model for Teeth Objects Detection And Classification In Intra-Oral Dental Images.* Doctoral thesis, Universiti Teknologi PETRONAS.

Dental education stands to gain greatly from Augmented Reality (AR), the core idea of which is to integrate 3D models into real-world live video streams. Such an application, however, requires advancement in Computer Vision, especially to detect and classify teeth. Towards this end, this thesis presents a Hierarchical Deep Learning classification model designed to identify multiple teeth by leveraging contextual and spatial information from intra-oral dental photograph images. The study initiates the collection of a wide range of intra-oral dental images followed by a comprehensive image preprocessing procedure, including inclusion and exclusion criteria, granular level definition, image resizing, data augmentation, and data labeling. Following that, discriminative deep feature representations are extracted through the utilization of various deep learning blocks including YOLOv6, YOLOv5-based attention mechanism, and YOLOv5-based hybrid pooling technique. These deep learning blocks are employed in a hierarchical manner. In this hierarchy, the output of each block serves as the input for the next one, allowing the sequential extraction of contextual information from intra-oral dental images. As the data progresses through this structured sequence, the deep learning blocks not only extract this contextual information but also enhance the quality and robustness of the feature representations. These refined features are then consolidated into a single, comprehensive representation. This consolidated representation encapsulates the essential characteristics of the individual tooth, making it highly effective for tooth classification tasks. Extensive experiments were conducted on the collected intra-oral dental photograph images dataset, comprising diverse images depicting seven different tooth classes. In the test set, the proposed model achieved an overall mAP, recall, and F1-score of 88%, 0.999, and 0.94%. Notably, the most significant improvement is observed in the classification of occluded and less visible teeth.

Alashhab, Abdussalam Ahmed (2024) *Online Ensemble Machine Learning Model for DDoS Attack Detection and Mitigation in Software Defined Networks.* Doctoral thesis, Universiti Teknologi PETRONAS.

Software-defined networking (SDN) offers improved flexibility, scalability, and ease of innovation by decoupling the control plane from the data plane. SDN holds the promise of empowering next-generation networks with secure, reliable, and well managed capabilities, catering to the growing demands for high data rates and uninterrupted connectivity. However, the vulnerabilities inherent in SDN are exploited by malicious actors, leading to significant security concerns, such as the alarming rise in Distributed Denial of Service (DDoS) attacks. Traditional methods for mitigating these attacks often suffer from low accuracy in distinguishing between legitimate and illegitimate traffic. Recent advancements have applied machine learning techniques to enhance this accuracy, yet these methods fall short in detecting zero-day and low-rate DDoS attacks due to their limited feature scope. To address these challenges, this research proposes an online ensemble machine learning model that leverages enhanced online training and feature selection methods. The online learning approach enables the model to continuously adapt to new and evolving DDoS attacks, ensuring that it remains effective even as new protocols and applications emerge. The model is trained and evaluated using a comprehensive dataset that includes high and low-rate DDoS attacks within an SDN-simulated environment, implemented using Mininet and the Ryu controller. Experimental results demonstrate that the proposed model achieves a 99.2% detection rate, outperforming comparable models on a custom dataset as well as various benchmark datasets, including CICDDoS2019, InSDN, and slow-read-DDoS. The model's efficacy in DDoS defense was further validated across diverse SDN topologies and in comparison with existing models. This work establishes a strong foundation for proactive threat identification in SDN, significantly enhancing network security against evolving cyber threats.

Ali, Saad (2024) *Nobel Metal Nanoparticle Decorated Graphene Nanoplatelet Reinforced CU Matrix Composite for Thermal Management Of Smart Electronics.* Doctoral thesis, Universiti Teknologi PETRONAS.

Graphene reinforced Cu matrix composites are promising materials for thermal management in smart electronics, however, their effectiveness is limited by weak graphene/Cu interfacial interactions, hindering enhancements in mechanical and thermal properties. These composites predominantly depend on conduction, while efficient heat dissipation necessitates both conduction and convection. This study explores enhancing the graphene/Cu interface with Au and Ag decorated graphene nanoplatelets and Ag decorated nitrogen-doped nanoplatelets (Au-GNPs, Ag-GNPs, Ag-N-GNPs). The effects on the composites' physical, mechanical, and thermal properties were compared with undecorated GNP/Cu and sintered Cu. Additionally, the influence of improved interface and porosity on thermal management of a commercial LED was examined. Optimized sonication parameters for Au-GNPs-3 hours of sonication time at 40% amplitude-were used to synthesize Ag-GNPs and Ag-N-GNPs. Composites, including pure Cu, undecorated GNP/Cu, and decorated GNP/Cu (AuGNP/Cu, Ag-GNP/Cu, and Ag-N-GNP/Cu), were fabricated via low-pressure cold pressing and sintering in an Ar/5%H2 atmosphere. Analytical techniques like XPS, Raman spectroscopy, FTIR, and TEM imaging confirmed the optimal sonication parameters with lower defect density, higher functional groups, and higher exfoliation states, for uniform distribution of Au/Ag nanoparticles on GNPs. Decorated GNP/Cu composites showed significant microhardness improvements, with Ag-GNP/Cu achieving the highest increase of 60.45% compared to sintered Cu. Thermal conductivity enhancements were observed in decorated GNP/Cu composites (for both high and low porosity samples) compared to undecorated and sintered Cu, although they remained below commercial Cu's value. LED temperature testing indicated a reduction in operating temperature for high-porosity samples compared to sintered Cu. Sintered Cu reduced LED temperature by 8.57% compared to commercial rolled Cu, highlighting the effective of porosity in convective heat transfer. LED luminous efficiency was retained above 90% in high and low porosity samples for undecorated viii and decorated GNP/Cu composites. However, it dropped below 90% for undecorated sample i.e., 3-GNP/Cu (84.56%) and sintered Cu (80.24%). The 0.1-Ag-GNP3.40/Cu composite, with a thermal conductivity of 135.59 W/mK and 22.94% porosity, achieved highest reduction in LED operating temperature, 15.83% compared to sintered Cu and the highest luminous retention of 97.21%. The study concludes that the thermal management capability of composite heat sinks relies on both conductive and convective heat transfer mechanisms. The proposed noble metal decorated GNP reinforced Cu, with an improved GNP/Cu interface (enhancing conduction) and a porous matrix (enhancing convection), offers a viable solution for thermal management in smart electronics.

Ali, Shah Syed Quaid (2024) *Enterprise Sustainability Risk Management and Firm Performance of Malaysia Oil and Gas Industry: Moderating Role of Intellectual Capital.* Doctoral thesis, Universiti Teknologi PETRONAS.

In the current dynamic business landscape, the escalating prominence of sustainability risks has heightened pressure to prioritize emerging sustainability risks, particularly in vulnerable sectors like oil and gas (O&G). Business entities implement enterprise sustainability risk management (ESRM) to manage the broad spectrum of sustainability risks to maximize financial and nonfinancial performance. However, businesses fail to effectively implement ESRM due to a lack of knowledge, expertise, skills, and organizational processes. Accordingly, this study examines the effect of ESRM on firm performance (financial – NOPAT, ROA, ROE, Tobin's Q; nonfinancial – ESG performance) under the moderating role of intellectual capital (IC) in Malaysian O&G companies because IC results in effective ESRM practices. The data on ERSM and ESG performance was gathered using content analysis technique while financial data was collected from the Refinitiv Eikon Database spanning from 2012 to 2021. The direct relationship between ESRM and firm performance is underpinned by the notion of Stakeholder theory. Resource-based view theory is employed for the moderating effect of IC. The ANOVA test results indicate that ESRM implementation has significantly increased over the years in the Malaysian oil and gas industry. Additionally, the study reveals that ESRM has a notable positive impact on Tobin's Q with a coefficient value of 0.5003 and ESG performance with coefficient values of 0.0179, 0.0323 and 0.1949 respectively. However, ESRM practices have a negative influence on ROE (coefficient: -0.2039). It is worth noting that the effect of ESRM on NOPAT and ROA was statistically insignificant. Results based on the moderating variable reveal that IC has a significant moderating role in enhancing the positive impact of ESRM on NOPAT, ROA, Tobin's Q, and ESG performance. Nonetheless, the relationship between ESRM and ROE is negatively influenced by the moderating role of IC. The findings offer valuable insights to practitioners, policymakers, and stakeholders within the Malaysian O&G industry, with a particular focus on enhancing firm performance through ESRM and IC. This study recommends that Malaysian O&G companies consider implementing ESRM practices to cope with sustainability risks. Furthermore, O&G companies should emphasize IC, which aids in comprehending sustainability risks and enhances the effectiveness of ESRM implementation. Such measures are anticipated to fortify risk management and subsequently contribute to improvements in the sustainability performance of O&G companies in Malaysia.

Aliyu, Yusuf (2024) *Enhanced Multi-lingual Sentiment Analysis on English-Hausa Tweets Using Deep Learning Techniques.* Doctoral thesis, Universiti Teknologi PETRONAS.

Public opinion is now crucial for making informed decisions in both business and politics. Sentiment analysis plays a key role in understanding this public opinion. Social media is an essential platform where people share their opinions and feelings about various entities. Most of the users commonly employ mixed languages or codeswitching within their posts. This results in a diverse and complex linguistic context. However, this phenomenon can negatively affect the accuracy of sentiment analysis, for a low-resource like Hausa language. Prior researchers have predominantly concentrated on sentiment analysis within single-language data rather than in codeswitched data. The evolution of this content has created a demand for sentiment analysis systems capable of handling code-switching text, particularly in multilingual environments. This research delves into advancing sentiment analysis methodologies. Specifically focusing on code-switching tweets in Hausa-English. The methodology used in this research incorporates embeddings in Deep Neutral Network (DNN) and Transformer architecture techniques. Commencing a proposed novel sentiment analysis framework and a novel stemming techniques algorithm for the Hausa language. This aims to enhance accuracy performance and address challenges posed by code-switching in low-resource language. The study systematically refines hyperparameters and identifies optimal strategies in the techniques. The proposed framework results outperformed existing benchmarks in SemEval-2023 Task 12 and AfriSenti, attaining an outstanding F1-score of 92.0% and an accuracy of 91.9%. The framework emphasises its significance for sentiment analysis in multilingual contexts by highlighting the framework's adaptability to other low-resource languages. Furthermore, the research contributes to the field by surpassing state-of-the-art benchmarks, establishing the proposed framework as a state-of-the-art solution for sentiment analysis in multilingual and low-resource language contexts.

Alzu'bi, Khalid Mhmoud Khalid (2024) *Assessment Of Construction Productivity For Indoor Activities Using Computer Vision And Deep Learning.* Doctoral thesis, Universiti Teknologi PETRONAS.

Current manual inspection and monitoring practices of construction productivity (CP) for indoor activities are time-consuming and dependent on the experience of inspectors. This is particularly noticeable when it comes to technical aspects like evaluating the quality and quantity of construction activities. As the construction industry undergoes a transformative phase amidst the emergence of the fourth industrial revolution (IR 4.0), there is a growing exploration of technological solutions aimed at enhancing the monitoring process for CP. The aim of this study is to develop a model based on computer vision (CV) techniques for quantities measurement and CP assessment of indoor construction activities (bricks laying, plastering, tiling, and painting). To achieve these tasks, this study outlines three distinct objectives. Firstly, conduct a comprehensive review of a variety of monitoring technologies and analyse factors affecting their implementation in construction projects using the relative importance index (RII) and analytic hierarchy process (AHP). The second objective entails evaluating and developing a model for classifying indoor construction activities. Lastly, developing a robust CV model for quantities measurement and CP assessment of indoor construction activities. To achieve this, a Mask Region-Based Convolutional Neural Network (Mask R-CNN) and CV techniques are used. The developed model was tested in real-world construction sites and proved to be effective in evaluating CP across various indoor construction activities. The quantity measurement model attained an accuracy of about 96% for measuring the area of all activities. While CP assessment model achieves an accuracy of about 97% for bricks laying, 94% for plastering, 96% for tiling, and 93% for painting. Regular assessing and monitoring using the developed model serves as a proactive approach for identifying potential issues, tracking adherence to project timelines, and facilitating timely decision-making. Moreover, it contributes to site safety and reduces costs by minimizing unnecessary site visits.

Awan, Maheen Iqbal (2024) *Investigating the Interplay of Experienscape, Service Inclusion, and Service Captivity in Shaping Service Well-Being of Tourists With Physical Disabilities.* Doctoral thesis, Universiti Teknologi PETRONAS.

Researchers in Transformative Service Research (TSR) have focused on consumer wellbeing, yet there's a notable lack of attention to disability and accessibility issues within the tourism and hospitality sectors, despite their prevalence and importance. This sector, although holding significant potential for enhancing consumer well-being, still lack satisfactory accessibility standards for tourists with disabilities, leading to a state of "partial accessibility" due to systemic neglect. While legal requirements are often met, there's room for improvement in addressing the specific needs of tourists with physical disabilities. Therefore, the aim of the study was to assess the relationships between experienscape, service inclusion, tourist service well-being, and service captivity in the context of tourists with physical disabilities when they avail the services rendered by the Malaysian tourism and hospitality industry. Both qualitative and quantitative approaches have been used for scale development and data collection respectively. A self-administered questionnaire was used to collect data from tourists with physical disabilities, as a result of which 354 valid responses were received. The findings of the study revealed that all components of experienscape have a significant impact on the service inclusion except for cultural experienscape. Similarly, service inclusion, social, and natural experienscape were found to have a significant positive impact on tourist service well-being. Service inclusion mediates the relationship between sensory, functional, and social experienscape and tourist service well-being. While service captivity was found to only moderate the relationship between social experienscape and tourist service well-being. The theoretical contribution of this study lies in its exploration of the often-neglected intersection of disability, accessibility, and the tourism and hospitality sectors within the framework of transformative service research. On a practical level, the findings have significant implications for the Malaysian tourism and hospitality industry, emphasizing the need to enhance accessibility and cater to the specific requirements of disabled travelers, ultimately fostering a more inclusive and satisfying travel environment. Furthermore, from a societal perspective, this research underscores the importance of inclusivity, advocating for a tourism and hospitality sector that embraces diversity and contributes to a more equitable society where all individuals can partake in enriching travel experiences without hindrance.

Foo, Khor Siak (2024) *Investigation And Modelling of Span And Tween Surfactants On Methane Hydrate Crystallization.* Doctoral thesis, Universiti Teknologi PETRONAS.

Gas hydrate formation has its advantages and disadvantages. Kinetic hydrate promoters are used to accelerate gas hydrate formation process by incorporating more gases into the hydrate structure that is important for gas separation, transportation, and storage application. On the other hand, gas hydrate formation in flowline tubular and pipeline especially in deepwater hydrocarbon production can cause total production blockage and poses operation risks. Kinetic hydrate inhibitors are used to delay or inhibit gas hydrate formation. Biodegradable nonionic surfactants ester sorbitan SPAN and the ethoxylated derivatives, TWEEN surfactants were studied as gas hydrate control chemicals in various production systems. The novelty of the research findings revealed the factors describing how the SPAN can promote hydrate induction time whereas the TWEENs are rates inhibitive in a in gas-oil-water multiphase system. This work aims to experimentally study the impact of SPAN and TWEEN on CH4gas hydrate formation in gas-oil-water multiphase system. SPAN caused lower interfacial tension (IFT) of oil-water in range 3.60 to 5.30mN/m, with smaller mean size droplet diameter (2.2um 27.9um) to form more stable water-in-oil emulsion compared to TWEEN (IFT 8.20 11.50mN/m with mean droplet diameter 919.5 3249.8um) in an oil-in-water emulsion. Using the cyclopentane hydrate in SPAN and TWEEN rheology study suggested the hydrate slurries followed the non-Newtonian behavior. Thermodynamically, the surfactants would not enhance the hydrate subcooling due to inability to form a direct hydrogen bonding with the gas hydrate structure. TWEEN-80 at 2.0% (v/v) delayed the CH4 formation rate with relative inhibition power of 134% slower compared to the blank sample. All TWEEN surfactants showed approximately the same gas consumption 0.28 mole CH4 as in the blank system. For multiphase systems that were treated with SPAN surfactants; the total CH4 consumption was reduced to less than 0.20 mole at equilibrium point. The CH4hydrate onset induction time was predicted and validated using classical nucleation viii theory while the kinetic rate constant was successfully modeled with Englezos equations. The modelling work was valid within experimental conditions of 274.15K to 277.15K using Peng Robinson equation of state and van der Waals quadratic mixing rule for fugacity calculation. Two mechanisms were proposed to distinguish how the SPAN could enhance the rate while TWEEN to delay hydrate formation rate. Lastly, the multiphase flow study contributed important knowledge for TWEEN-80 to delay and inhibit gas hydrate formation in synergy with methanol, to explore two potential applications of TWEEN-80 to preserve deepwater subsea oil producer well and to remediate the hydrate blockage in subsea pipeline.

Gadipudi, Nivesh (2024) *Deep Supervised Light Weight Networks for Visual Odometry Estimation.* Doctoral thesis, Universiti Teknologi PETRONAS.

Visual odometry involves the computation of an autonomous agent's pose by anaylzing images. Utilizing deep learning to estimate visual odometry enhances robustness against noise. Training neural networks requires immense annotated real-world data, but synthetic data can be used to complement the training process. Nevertheless, a metric is necessary to identify the gap between synthetic and real-world datasets to produce more generalizable networks. Additionally, learning temporal dependencies from neighbouring frames improves visual odometry accuracies. Using recurrent networks increases the number of learnable parameters, which increases computational costs to study temporal dependencies. On the other hand, non-essential features extracted from networks lead to larger trajectory drifts. Therefore, this research aims to develop more generalizable and efficient methods to overcome the above three constraints. These were done using three approaches. The first approach, synthetic to Real gap Estimation, was developed to solve the need for a metric to estimate the disparity between a synthetic and real-world dataset. In the second approach, windowed pose optimization was developed to investigate the imposition of geometric constraints from trajectory consistency to learn temporal dependencies exclusive of recurrent neutral networks. Finally, the third approach, spatial attention, was used to investigate the imposition of geometric constraints from trajectory consistency to learn temporal dependencies exclusive of recurrent neural networks. Finally, the third approach, Spatial Attention, was used to investigate the influence of significant features that are being used for motion estimation using a spatial attention mechanism. The first approach estimated the distance between real-world to enhanced virtual datasets is 6-10 times the distances between real-world to virtual datasets. The second approach, using trajectory consistency, yield a rotational error of *3.06 deg/100m*, and the training time is 41 *ms*, while the inference time is 8 ms. The third approach, using spatial attention, yield a rotation error of 3.26 deg/100m, and the inference time is 1 ms, speeded up by 47 times compared to DeepVO, a state-of-the-art method.

Haruna, Abdurrashid (2024) *Facile Fabrication Of Pom@MOF-808(Zr) Nanocomposites For Catalytic Oxidative Desulfurization Of Fuel Oil.* Doctoral thesis, Universiti Teknologi PETRONAS.

Fuel oil consumption has consistently increased due to the growth of human population and global energy demand. However, the high sulfur content in fuel oil is endangering the human health and environment. The removal of sulfur compounds is necessary for petrochemical industries towards achieving safe and sustainable environment. Recently, catalytic oxidative desulfurization (ODS) has been identified as one of the most effective technologies for deep desulfurization. At present, metal-organic frameworks (MOFs) supported with polyoxometalates (POMs) have emerged as an effective approach for developing high-performing catalysts for ODS application. In this study, we synthesized a series of POM@MOF-808 nanocomposites composed of transition-metals-substituted Keggin-type PW11 and MOF-808(Zr) using one-pot solvothermal approach. Various analytical methods were employed for the characterization of the catalysts including Fourier transform infrared, X-ray diffraction, field-emission scanning electron microscopy, high-resolution transmission electron microscopy, nitrogen adsorption–desorption isotherm, and X-ray photoelectron spectroscopy. The resulting POM@MOF-808 composites exhibited good catalytic activity toward the ODS of benzothiophene (BT), dibenzothiophene (DBT), and 4,6-dimethyldibenzothiophene (4,6-DMBT) in n-dodecane. The effect of temperature, catalyst dosage, and oxidant-to-sulfur molar ratio was investigated by one-factor-at-atime approach. Moreover, PW11Mn@MOF-808 indicated a DBT conversion of 99.59% within 30 minutes, which is 1.147 times higher than that of MOF-808 with a DBT removal of 86.85%. The optimal reaction conditions have been determined at 50 °C, 30 mg, and O/S of 5. The percentage conversion of different sulfur compounds followed the order DBT> BT> 4,6-DMBT. Remarkably, PW11Mn@MOF-808 showed good reusability with no obvious loss in its initial activity after recycling 10 times. The kinetics of ODS followed pseudo-first-order model, with a calculated rate constant of 0.113 min−1 and apparent activation energy of 27.54 kJ mol−1, enthalpy (ΔH = 24.85 kJ mol−1), entropy (ΔS = −0.1867 kJ mol-1 K −1), and Gibbs free energy (ΔG = 85.15 kJ ix mol−1). The results indicate that the ODS process is endothermic, non-spontaneous, but favorable under moderate conditions. A probable ODS mechanism has been proposed, overall, the catalytic process developed in this study holds great promise for industrial applications. These findings provide an insight into the synthesis of POM@MOF catalysts, contributing to sustainable advances towards oxidative desulfurization of fuel oil.

Hasan, Rumaisa Abu (2024) *Assessment Of Mental Resilience Using EEG Based Effective Connectivity Measures.* Doctoral thesis, Universiti Teknologi PETRONAS.

Resilience is a defence mechanism against mental illness. Its assessment is conventionally done using multiple psychological questionnaires, which requires a tedious screening procedure and tend to have self-reporting bias due to the social stigma of mental illness. Although there are some neuroimaging tools that have been explored for resilience assessment, these modalities are expensive and less applicable outside clinical settings. Electroencephalography (EEG) is one of the cost effective tools that can be used for such studies, however, the literature reports only a few studies that utilize EEG as the stand-alone tool to assess resilience. The findings were limited to disease-focused population and resting brain state, showing weak-to-moderate performance of the EEG neuromarkers. In this study, brain activity from healthy adults is analysed using spectral, functional connectivity (FC) and effective connectivity (EC) features at resting and task conditions to assess mental resilience. An early childhood education classroom is developed using virtual reality (VR) to deliver the mental imagery task for resilience assessment. The EC features achieved the highest accuracies (>85%) in assessing resilience levels. The differences in EEG neuromarkers selected for resting and task conditions reflect the distinct mechanisms of trait-resilience and the dynamics of resilience respectively. Moreover, the beta and gamma brainwaves are observed to be dominant in assessing resilience. The EC neuromarkers for binary resilience levels were more than 80% (Rest: 54/64; Task: 68/84) selected from within these frequency bands. Findings from this study contribute towards bridging the gap on brain mechanism of resilience, and the research-practice gap to implement an EEG-based resilience assessment system in workplace settings. It highlights the possibility of developing customized-based VR environment to emulate actual work routines for resilience building training.

Hashwan, Saeed Salem Saeed Ba (2024) *Development of Film Bulk Acoustic Resonator For Carbon Dioxide Gas Detection Using Functionalized Zeolite.* Doctoral thesis, Universiti Teknologi PETRONAS.

The spread of hazardous gases in the environment caused by the new industry sectors threatens our health and planet. Therefore, the demand for gas sensors to detect harmful gases is significant. Currently, there are several techniques for carbon dioxide detection such as electrochemical, optical, and electrical. However, these techniques suffer from some issues such as low detection accuracy, measurement complicity, and large size. Therefore, there is a need for gas sensors of small size, highly sensitive, and capable of being integrated with CMOS fabrication technology to detect harmful gases in the environment. The current piezoelectric FBAR sensors suffer from low resonance frequency. Thus, this research aims to develop a piezoelectric MEMS sensor for gas detection applications with resonance frequency of 9 GHz and sensitivity of 50 ppm. The first aim is to develop a mathematical model that expresses the relationship between the device frequency and its sensitivity. To achieve this aim, a relationship between the weight of gas molecules and FBAR frequency changes was investigated. The device with a higher frequency was found to be more sensitive. The second part of the first aim is to investigate the influence of the sensor parameters and to select the optimal parameters of the FBAR that allow the FBAR to work at higher frequency. Additionally, the finite element analysis was used to validate the optimal parameters using COMSOL and CoventorWare software. The second aim is to fabricate the FBAR sensor, as well as to develop a highly sensitive material. Finally, the developed FBAR sensor was characterized using scattering parameters. The functionalized zeolite with 60 %wt APTES has shown a higher capability for CO2 adsorption with four folded enhancements and was found to be more than 4000 µmole/g through the TPD test. These promising outcomes reveal the option of the FBAR sensor and zeolite for the development of the CMOS-compatible sensor with higher sensitivity

Jimenez Soto, Grisel (2024) *Carbonate Architecture Modelling and Characterization of Miocene Isolated Build-Ups In Central Luconia Province, Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

This thesis presents a customized modeling workflow for hydrocarbon exploration and development in carbonate reservoirs within the central Luconia province. By integrating diverse datasets and employing advanced geostatistical techniques, including Multiple Point Statistics (MPS) and Forward Stratigraphic Modelling (FSM), the study effectively captures the complexity of carbonate reservoir heterogeneity and rock type distribution. The research focuses on two carbonate fields, TX and EX, utilizing a multidisciplinary approach that incorporates core samples, well data, seismic data, and satellite imagery. The application of MPS proved essential when traditional modeling techniques failed to accurately represent carbonate facies distribution and diagenetic processes. A significant contribution of this thesis is the development of a comprehensive training image library derived from satellite images, combined with geobodies and trend maps from spectral decomposition attributes. These were integrated into MPS simulations, enabling a precise representation of genetic processes. The study also explores the spatial distribution of geobodies and their influence on carbonate build-up evolution. Heterogeneities such as reef rims, karsts, and tight layers were identified as critical factors impacting reservoir characterization. Additionally, the research highlights the role of palaeobathymetry, sediment accumulation, wind direction, and tectonic and topographic features in shaping platform morphology, with particular emphasis on the northeast winter monsoon's significant impact. The use of MPS helped the identification of areas with high reservoir potential, optimizing exploration and development strategies. The integration of multiscale data improved the accuracy representation compared to traditional geostatistical methods like Sequential Indicator Simulation (SIS), and validation against well and seismic data proved valuable for regional assessments. In conclusion, this thesis advances geostatistical modeling workflow for carbonate reservoir characterization, offering valuable insights for hydrocarbon exploration and development in carbonate build-ups.

Konjing, Zainey Bin (2024) *Sedimentology, Palynofacies & Palynostratigraphy of the Upper Oligocene-Middle Miocene Nyalau Formation, Bintulu Sarawak Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

The Late Oligocene-Middle Miocene Nyalau Formation forms an exceptional outcrop exposure within the onshore of central Sarawak. Detailed facies analysis was conducted on twenty-eight outcrops for this formation which record approximately 800m thick within Bintulu and adjacent areas. Sixteen samples were selected mainly from different sandstone facies for petrographic analysis. In addition, one hundred twenty-four samples were collected from different localities for palynological analysis including forty-three samples for palynofacies analysis. Throughout the study, data from sedimentological and palynological analyses were compiled and integrated for depositional environment interpretation and to propose local pollen zones. The sedimentary successions within the study area are composed of seventeen lithofacies which are divided into six facies associations. These facies associations are arranged in stacking order and represent a cyclicity of deposition. The regional facies changes across the study area reflect the fluvial-tidal transition in the proximal where marine processes of tidal and waves are much more prevalent within the distal part. This inferred that the sedimentary units were developed within mixed energy settings such as coastal plain and near shore environments. Thus, environments such as mixedenergy estuary, barrier island and lagoon including marine embayment were the major depositional systems that developed during the Nyalau Formation time. Based on petrography, the sandstone samples are categorized as sublitharenite and litharenite based on dominant lithic fragments. The highly quartz composition of the studied sandstones that with common lithic grains corresponded to recycled oregon character in terms of provenance. Palynological analysis proposes three pollen assemblage zones that are comparable to the pollen zone in Sarawak Basin. Based on palynomorph assemblages, the Late viii Oligocene – Early Miocene had undergone wet climatic conditions with occasional seasonally dry conditions. The acme of Casuarina type pollen and high diversity of rain forest assemblages in several samples suggest intermittent super wet climate during the Eary Miocene. Palynofacies analysis reflect marginal oxic to dyoxic basin and proximal suboxicanoxic shelf. The abundance of phytoclasts and common amorphous organic matter (AOM) with moderate to low percentage of palynomorphs strongly suggest strong fluvial and freshwater input into shallow marine areas of deposition. The very low representation of marine palynofacies elements in the samples implies a short-lived marine incursion might have occurred during the deposition of the sediments.

Mohammed, Sulafa Abdamageed Saadaldeen (2024) *Investigation On The Role Of Triazolium And Imidazolium-Based Ionic Liquids As Potential Electrolyte For CO2 Electrochemical Reduction.* Doctoral thesis, Universiti Teknologi PETRONAS.

Carbon dioxide (CO2) emissions have resulted in worldwide environmental issues. CO2 electrochemical reduction (CO2ER) reaction holds significant promise as a technology since it can be integrated with renewable energy sources. The current challenges associated with this process are low electrochemical stability of the catalyst/electrolyte, high overpotential, low current density, and low faradaic efficiency. Furthermore, the reaction mechanisms and the roles of catalyst are still unclear. Ionic liquids (ILs) are gaining attention for CO2ER due to their unique properties such as reducing overpotential, increasing current density, and improving electrochemical stability. The main objective of this study is to investigate the role of ionic liquids in the CO2ER reaction. Different ILs including two novel ILs that contain 1,2,4-triazolium as cation were synthesized and characterized. CO2 absorption capacity for seven ILs were determined using an isochoric saturation method and compared with predicted solubility. Triazolium-based ionic liquids demonstrated higher solubility of CO2 when compared with imidazolium-based ILs of different anions. The highest capacity, with a value of 0.252 (mol CO2/mol IL), was exhibited by 1,4-dibutyl-1,2,4-triazolium bis(trifluoromethylsulfonyl)imide. The results show that the molecular orbital energy levels of ILs play a significant role in CO2 capacity. It was found that the anion's highest occupied molecular orbital (HOMO) energy level has a greater impact on solubility than the cation's lowest unoccupied molecular orbital (LUMO) energy level. The reduction potentials of the selected ILs were evaluated experimentally using cyclic voltammetry (CV) and compared with the theoretical values obtained using computational modeling. The results showed that the reduction stability of the ionic liquid is not relying solely on the individual lowest unoccupied molecular orbital (LUMO) values of cations or anions, but also the molecular interaction (hydrogen bond interaction, electrostatic or misfit interaction, and van der Waals forces) significantly influences the stability. Moreover, the CO2 reduction peaks, and the current density of different electrolytes were evaluated using linear sweep voltammetry (LSV), cyclic ix voltammetry (CV), and chronoamperometry (CA). The addition of 1-ethyl-3-methylimidazolium tetrafluoroborate [EMIM][BF4] to the 0.1 M NBu4PF6 acetonitrile solution demonstrates that the reduction's onset potential significantly decreased by 320 mV. It was concluded that the ILs with long alkyl chain reduce the efficiency of CO2ER reaction and the selection of ILs with short alkyl chain, low LUMO value of cation, and high HOMO value for anions as well as the suitable organic solvent enhance the performance of CO2ER reaction in terms of reduction stability, CO2 capacity, applied potential, and current density. This new finding can be applied to enhance the selection criteria of ionic liquids for the better utilization in CO2ERR.

Najib, Yasmeen Nadhirah Binti Ahmad (2024) *Enhanced Alternating Direction Method of Multipliers for Large Scale Wireless Sensor Network Localization.* Doctoral thesis, Universiti Teknologi PETRONAS.

Wireless Sensor Networks (WSNs) have seized the forefront of the technology discourse as they ride the wave of advancing data analytics. Largescale WSNs are now integrated into numerous smart city projects. Node localization, a vital aspect of WSNs, remains a challenge for large-scale WSNbased applications. Nonetheless, there is a shortage of existing methods to address the complex problems of large-scale localization. WSNs typically employ node estimation methods with a low-rank matrix, such as the Euclidean distance matrix (EDM), which leads to the application of matrix completion techniques. Among these, the alternating direction method of multipliers (ADMM) stands out as a particularly compelling and widely adopted iterative approach. However, ADMM's reliance on singular value decomposition (SVD) renders it unsuitable for matrices of substantial dimensions, such as those encountered in the context of large-scale WSN localization. In light of this, a pioneering method, named the enhanced-alternating direction method of multipliers (E-ADMM) is proposed. EADMM incorporates Lanczos approximation as a cost-effective substitute for the resource-intensive SVD, thus solving the large-scale matrix completion problem intrinsic to WSN localization on a grand scale. For a better approximation of the partial EDM, enhanced local adaptive steps which consider the residual between the approximated values and the original values are introduced. These steps are critical for obtaining accurate results. A comprehensive experimental evaluation, including both synthetic datasets (100 to 15,000 sensor nodes with obstacles) and real dataset named UTD19, which consists of over 20,000 static loop detectors (installed on urban highways in 40 cities worldwide), revealed the outstanding performance of the proposed method. UTD19 dataset, which E-ADMM consistently outperformed existing techniques, including successive low-rank viii matrix approximation (SLRMA) and orthogonal rank one matrix pursuit (OR1MP), in terms of accuracy and computational efficiency. With an average relative error (RE) of 4.75E-06 and a mere 300.93 to 580 seconds of computational time to solve a 10000 × 10000 matrix. The proposed method not only demonstrated its proficiency in efficiently completing a large-scale matrix as vast as 15000 × 15000 but also gave insight into the intricate challenges associated with large-scale WSN localization.

Nesan, Kartikeyan Patma (2024) *Factors Influencing Machinery Safety and A Holistic Team Approach Preventive Plan In A Power Plant.* Doctoral thesis, Universiti Teknologi PETRONAS.

The frequency of machinery accidents in Malaysia are increasing to a perturbing level which involves machineries that are utilised in power plants. The current research agrees that there is lack of awareness on machinery safety among employees in power plants that lead to the safety issue within the framework of process safety management (PSM). However, the existing safety analysis methodologies have limited focus on factors of machinery safety research and the relationships between the factors to mitigate power plant accidents. The present study also looks into a holistic team approach preventive plan with suitable PSM elements involving all levels of power plant employees to improve machinery safety awareness. A comprehensive literature review revealed that the eight critical factor elements that influence machinery safety are machine reliability (MRe), machine integrity (MIn), machine availability (MAv), legal compliance (LC), working space (WS), operational control methods (OCM), hardware interface design (HID) and equipment aging (EAg). Data were collected from 397 respondents in a power plant through a Likert Scale questionnaire of factor elements with specific statements. The level of awareness among employees was conducted through respondents' profile and descriptive analysis using SPSS software. Structural Equation Modelling (SEM) measurement model was designed based on the data of the questionnaires by conducting Confirmatory Factor Analysis (CFA) using Smart-PLS. A hypothesis testing was conducted to establish the relationship between the factors using a relationship model that was validated and verified. The study's findings revealed that EAg and MAv are the primary factors contributing to a lack of awareness among employees. The relationship model analysis and hypothesis testing study showed that MRe, MAv and EAg were factors that did not have significant impact on other factors, indicating independent factors. Study further proved that MAv (0.702) and EAg (0.710) have the lowest R2 value among other factors which indicated lowest awareness percentage (MAv = 70.2%. EAg = 71.0%) in contrast with the relationship viii between the factors, which also benchmarked the theoretical framework of the research study. Study also revealed that accidents mostly happened in turbine area and non-executives have higher safety awareness compared to executives. A Holistic Team Approach (HTA) preventive plan incorporating employees of all levels was constructed and designed which effectively addressed the lack awareness at the MAv and EAg factor levels, as well as the safety concerns pertaining to turbines and executives. Decision analysis combined four key components of PSM which are employee participation, incident investigation, regulatory compliance and mechanical integrity to assess the efficacy of a preventive strategy. The novelty of the research lies in the combinational approach of using a statistical and preventive plan approach to cultivate a collective sense of ownership and accountability for safety across all level of employees, leading to a heightened level of proactivity and efficacy in the management of machinery safety. This study is expected to help power plant company to enhance the employee safety knowledge on machineries and to reduce machinery hazards at workplace. This offers power plant companies the opportunity to consistently enhance their safety protocols.

Nisa, Zaib Un (2024) *Biochar-Based Compatibilized Thermoplastic Nanocomposites for Erosion Resistance of Oil and Gas Pipelines.* Doctoral thesis, Universiti Teknologi PETRONAS.

Solid particle erosion results in progressive loss of materials caused by the repeated impact of small solid particles. It is an important issue in oil and gas industries because their pipelines are often exposed to aggressive erosive environments. There is a continuous flow of viscous oil and gas liquid along with trapped gases like carbon dioxide and hydrogen disulfide, sand, and dust particles, which slowly result in erosion of the internal surface. Thermoplastic polymers include several applications to be used as a coating or material replacement for different applications. The thermoplastic polymers polyamide, polyphenylene sulfide, and polyether sulfone were explored based on reported the lowest erosion rates due to their better ductile behavior, fracture toughness, and tensile strength. To improve their wearability and add-on thermal stability, high strength, abrasion resistance, and modulus properties biochar synthesized from plant waste and SADR-4370 compatibilizer were used as modifiers. In material applications, SADR-4370 is designed to produce better mechanical results by increasing the interfacial adhesion between matrix and filler. So, the erosion properties of thermoplastic polymers were tailored by synthesizing their coagulation-processed nanocomposites using the biochar of coconut shells. The selected optimized composition of the PPS@BC nanocomposite was treated with different concentrations of SADR-4370 (0.5%, 1%, 1.5%, 2%, 2.5%, and 3%) to be studied for erosive variables. It was observed that the CP-2.5 sample with 2.5% SADR-4370 has shown maximum abrasion resistance with a wear rate of 0.260 mm3 /cycle. The measured tensile strength, flexural stress, and compressive yield strength of CP-2.5 were calculated to be 42.45 MPa, 33.55 MPa, and 0.37 MPa respectively. The erosion rate measured by ASTM G76 standard of the best sample CP-2.5 was remarkable with a magnitude of erosive resistance of 3.94×10-9, 3.84×10-9, and 1.87×10-9 m3 /kg for the respective impact angles of 30°, 60°, and 90° with silica erodent. Hence, the nanocomposite can be utilized potentially for erosion resistance and protection of the pipelines of oil and gas industries.

Raheem, Al Nuaimi Ahmed T (2024) *Free–Piston Engine Linear Generator Optimization and Cycle–To–Cycle Variations Control Using FLC to Enhance Stability and Performance.* Doctoral thesis, Universiti Teknologi PETRONAS.

The researchers have developed and explored alternatives to conventional engines. One of these alternatives is a free piston engine linear generator (FPELG). Given the lack of a crankshaft in the FPELG, several challenges appeared, the most significant of which is piston motion control (PMC). Thus, the problem highlighted in this research is the cycle-to-cycle (CTC) variations. Moreover, this challenge is influenced by variations in operating parameters, including lambda (L), injection position (IP), and ignition timing (IV). Therefore, the main research objectives are: to investigate the combustion characteristics and identify the critical parameters that influence the performance and stability of FPELG. Moreover, to optimize identified operating parameters of the FPELG experimentally to achieve high performance. Furthermore, to develop the FPELG model, including robust and efficient control to achieve the high stability of FPELG. The research methodology is structured based on these objectives, starting with the identification and development of mathematical models, simulations, and experimental test rigs for FPELG. CNG-H2 is specified as a fuel type. This is followed by the calibration and validation of the model using prototype data. Subsequently, by employing the RSM methodology on the experimental data, the most optimal values for the determined operating parameters are obtained. Following that, a new fuzzy logic-based control strategy that uses the IV as a control variable as well as the optimum operating parameters to achieve high stability and performance of FPELG. The results indicate that the optimum conditions are as follows: L = 0.96, IV = 0.53 m/s, and IP = -14.9 to achieve the projected maximum performance, i.e., in-cylinder pressure = 27.87 bar, IMEP = 7.6 bar, and combustion efficiency = 39.64%, and to achieve the projected minimal emission, i.e., CO = 9531.41 ppm, CO2 = 2.4%, HC = 551.75 ppm, and NOx = 113.737. In addition, the FLC maintained the TDC within 0.26 s, which is short compared to other control techniques. FLC was approximately 48% more robust and efficient than the PID. In summary, FPELG stability and performance are enhanced by using optimization and robust control for the parameters that have a significant impact on FPELG.

Rasangika, Ambagaha Hewage Dona Kalpani (2024) *Experimental and numerical investigation on vibration-assisted heat transfer of heat sinks under sinusoidal and square wave shapes.* Doctoral thesis, Universiti Teknologi PETRONAS.

As electronic components become packed, they generate more heat. Therefore, introducing efficient cooling systems in a limited space becomes a challenge. When traditional cooling methods are insufficient, the application of vibrations shows promise in miniaturizing cooling systems by improving heat transfer. Hence, this study investigates the effect of vibration on both conventional and thin plate-fin heat sinks under forced convection, estimating the potential of vibration to reduce the size of cooling systems. The impact of vertical vibration on heat transfer of conventional heat sinks is experimentally investigated, and numerical results were validated with experimental measurements. The numerical study is performed using ANSYS/FLUENT software and User Defined Functions (UDFs) are developed in C++ to obtain the vibrations. The results reveal that utilization of vertical vibration with square and sinusoidal vibration leads to a maximum enhancement of to a 13% and 11% in Nusselt numbers, while enhancement with horizontal vibration is recorded as 27% and 16%, respectively. This enhancement enables a potential of a maximum 44 % reduction in Reynolds number. Moreover, the study numerically investigated vibrationassisted heat transfer of thin plate-fin heat sink and compared it with conventional heat sink at constant Reynolds and heat flux of 1000 and 6250 W/m2 . Utilization of square and sinusoidal vibration on thin plate-fin heat sink leads to a maximum 36% and 20% increase in Nusselt number values. This enables a maximum 51 % reduction in Reynolds number, indicating a further reduction in the size of the cooling system or fin. The study revealed that an increase in the Reynolds value from 1000 to 2000 resulted in a 20% and 12% decrease in vibration assisted Nusselt value for square and sinusoidal vibrations, respectively. Additionally, novel heat transfer correlations are established using Least Square fit method. These correlations encompass the key parameters of vibration frequency, vibrational amplitude, and Reynolds number under square and sinusoidal vibrations.

Rashid, Alidu (2024) *[Geochemical, Mineralogical And Palynological Characterization of Carboniferous-Triassic Shale Formations, Peninsular Malaysia.]()* Doctoral thesis, Universiti Teknologi PETRONAS.

This research is a comprehensive study that encompasses mineralogical, sedimentological, and geochemical analysis of six distinct shale formations spanning the Carboniferous to Triassic eras in Peninsular Malaysia. These formations include the Dohol, Gua Musang, Telong, Kepis, Bera and Kati Formations. Several studies have been done to determine the source rock potential of formations in Peninsular Malaysia, and the results show that the rocks mostly have low potential due to low TOC and mature organic matter. The reason for this occurrence is unknown; this research is focused on combining organic and inorganic proxies to understand the trends in organic matter distribution in the region and the possible causes for that occurrence. Also, most of the research done on these formations in this study are lithological in nature however, lithological analysis alone cannot provide information on the detailed processes the rocks have undergone. A comprehensive study is needed to understand the geologic make-up of the rocks. This will be achieved by combining facies description, XRD, XRF, SEM, ICPMS, TOC, rock eval pyrolysis, vitrinite reflectance and palynological analysis were employed to determine the lithological description, depositional environment, hydrocarbon generation potential, provenance, tectonic setting, paleo weathering and paleoclimate of these shales. The facies description revealed that the shales from the six formations shared comparable characteristics with just small differences in colour and texture. It was also revealed that the shales were deposited by low-energy currents from debris flows. The shales in the formations are primarily composed of clay minerals such as kaolinite, chlorite, and illite. Other minerals the shales contain include quartz, feldspars, and muscovite. The shales have a low potential to yield hydrocarbons due to their low organic matter content and matured organic matter. The kerogen in the shales is predominantly type II and type III. The low organic matter in the shales was caused by high terrigenous influx, low marine productivity, oxic-sub oxic conditions and arid nature of the depositional environment. The rare earth elements (REEs) present in the various shales are significantly depleted, with the Dohol viii Formation exhibiting relatively higher levels compared to the other formations. The shales from the Dohol Formation were formed in a passive margin setting while the shales from the Gua Musang, Telong, Bera, Kati, and Kepis Formations were formed in an active margin setting. However, it shows that all of the shales are from a collision zone. The study also showed that all of the shales come from a felsic source, arid region and have undergone a lot of weathering. The palynological study shows that the shale samples contain only Dictyophyllidites, Laevigatosporites, Florschuetzia levipoli, Zonocostites ramonae, Sapotaceae/Meliaceae, and Calophyllum pollen. It was concluded that the shales from the six formations, namely the Dohol, Gua Musang, Kepis, Kati, Bera, and Telong Formations, have low hydrocarbon generation potential due to the low TOC and mature nature of the organic matter. This is because of the high terrigenous influx of sediments that occurred to prevent the storage of this organic matter, the oxic to sub-oxic conditions in which the sediments were deposited, the low marine productivity, and finally the tectonically active depositional environment. The shales were also deemed to be from a shallow part of a deep marine environment based on the depositional model generated.

Salaheen, Marsail Ghaleb Al (2024) *Optimizing and Modelling Treated Oil Shale Fly Ash (OSFA) Based Mortar Cured in Carbonized Condition.* Doctoral thesis, Universiti Teknologi PETRONAS.

Oil shale fly ash (OSFA) is proven as a self-cementitious material and can be used in various applications in the construction industry and building technology to minimize environmental risks and promote sustainability. The previous studies concluded that the utilization of OSFA in construction materials presents one basis for a sustainable future. However, this utilization negatively affects the strength and durability of construction materials. To address these issues, this study aims to explore the optimal pretreatment conditions for effectively utilizing OSFA as a cement replacement material, thereby achieving superior outcomes. The OSFA samples were calcined at different temperatures ranging from 550°C to 1000°C with 150°C intervals for 2, 4, and 6 hours. A total of 40 different mixes were prepared and tested with cement replacement ratios between 10% and 30%, with underwater and CO2 curing. The results demonstrate that the calcined samples for 2 hours proved the highest pozzolanic activity and compressive strength. The maximum effect of calcination temperature by reducing the organic content and increasing the structures of crystalline appeared at 850°C. The compressive strength of samples incorporating treated OSFA experienced a remarkable improvement of up to 200% when subjected to CO2 curing in comparison to samples cured with water. Response surface methodology (RSM) was applied to develop a predictive model on compressive strength. The developed model is suitable for the interpretation of OSFA in cementitious matrix with high degrees of correlation above 90%. The optimal compressive strength was achieved at a 30% replacement level, a temperature of 550°C for 2 hours, and 56 days of curing in a CO2 environment. The absolute relative deviation between the experimental data and the theoretical model was 5.4%. Regarding artificial neural network (ANN) modelling, it demonstrates high accuracy with 0.9828 correlation in predicting compressive strength for treated OSFAbased mortar under pretreatment conditions, replacement percentage, curing method, and age. This research not only provides a valid, and reliable application in the viii construction engineering field, but also underscores the strength of the developed models for optimizing OSFA utilization in cementitious compositions.

Saleh, Alashmori Ammar Mutahar (2024) *Adoption of Blockchain by Software Development Companies in Malaysia: A Readiness Framework and Influential Factors.* Doctoral thesis, Universiti Teknologi PETRONAS.

This study examines Blockchain technology adoption within Malaysia's software development industry, focusing on the readiness factors necessary for integration. Despite the technology's growing popularity and its potential to enhance competitiveness in the digital era, detailed insights into the adoption factors in this specific sector are lacking. This research addresses this gap by developing and empirically validating a conceptual framework that assesses the interplay of technological, organizational, and environmental factors influencing Blockchain adoption. The framework posits that trialability, security (technological factors), cost, innovativeness, facilitating conditions (organizational factors), and market dynamics, regulatory support, and partner readiness (environmental factors) are critical to adoption readiness. Data from an online survey of 251 decision-makers in the industry were analyzed using structural equation modeling (SEM) with IBM SPSS and Smart PLS. Results confirm that these factors significantly contribute to the readiness for Blockchain adoption, explaining 71% of the variance in adoption readiness. This study not only fills a critical gap by providing a targeted examination of Blockchain readiness in Malaysian software companies but also offers practical insights with its validated framework. The findings assist companies in strategizing Blockchain integration effectively, recognizing the importance of evaluating key readiness factors to mitigate risks associated with technology adoption.

Shafee, Farah Amira Binti Ahmad (2024) *Framework Of Urban Lakes Management Under Different Environmental Conditions in Australia and Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

A comprehensive understanding of the dynamics of lake changes, coupled with the implementation of scientifically grounded management strategies, holds the potential to not only enhance decision-making in water-resource management and land-use planning but also generate greater support for these crucial initiatives. Objectives of this study consists of to access the significant benefits that the public derives from lakes and role and impact of the lakes on quality of life, to rank the issue pertaining to lake management that lead to adverse effects water quality, and to developed and validate framework to overcome the issues pertaining lake management were investigated. A mixed methods approach was used to examine the issues that have been raised and develop a range of recommendations to address them. A set of questionnaires was distributed to participants who stayed within the district of the case study area, which is Malaysia and Australia. A total of 320 valid responses were obtained. From the review of collected data, the identified variables and parameters were subjected to appropriate statistical tests to establish reliability and validity. The proposed framework comprises four main categories derived using analysis and structural equation modelling (SEM), which consist of issues that cause concern for lakes, such as support to improve lake management, financial support needed to improve the lakes, and benefits derived from people patronizing lakes. Composite reliability and Cronbach's Alpha were adopted to evaluate the construct-level reliability. Reliability test shows that level of reliability is good reliability with Cronbach Alpha value 0.875 construct with 27 items for the first phase and 0.798 with 31 items for the second phase. the structural model's validity was evaluated. Coefficient of Determination (R2) result show that benefits have a score of 0.184 indicating moderate while support to improve lake has a value of 0.271 which indicates high strength, indicating good acceptability. Large, medium, and small effect sizes are defined as Effect Size (f2) values of 0.35, 0.15, and 0.02 correspondingly. The result shows that the effects are medium and small x size effects as seen from the values obtained. The model determines an appropriate fit and strong predictive significance because the Q2 values are greater than zero. Path coefficient results show that two hypotheses were supported. In contrast, one was not, with the supported hypotheses having a p-value of less than 0.05. The most significant path (T = 3.262) was found between Concern (H.C.) and Benefits (B), which is followed by Concern (H.C.) and Support (S), with values of 2.147, all having a p-value of 0.000. The structural model evaluated using the statistical indicators reveals significant relationships between variables, supporting some hypotheses while rejecting others. The proposed framework provides better understand and manage water sustainability lakes in Malaysia. The findings are that the lake encourages patronage of nearby facilities and helps to appreciate the cost of residential development within its vicinity. Many lake admirers indicate that they engage in exercise, which improves their fitness and well-being. In addition, the contribution of lakes relieves stress and enables people to think and reflect on certain issues affecting them. These recommendations apply to a wide range of settings, including urban areas and other environments where the design and creation of blue spaces can enhance human health and well-being.

Sharif, Zubair (2024) *Adaptive and Priority-Based Resource Allocation for Efficient Resources Utilization in Mobile Edge Computing.* Doctoral thesis, Universiti Teknologi PETRONAS.

Mobile Edge Computing (MEC) offers cloud-like services at the edge of mobile networks to address the conventional cloud computing limitations such as high latency. This paradigm enables faster data processing and reduced latency, which is crucial for real-time and response-sensitive applications. However, it is often constrained by limited resources that its efficacy greatly depends on some forms of effective and efficient task scheduling and resource allocation to sustain better resources utilization. Moreover, in some critical conditions, the precedence of tasks is crucial, as schedules must be carefully arranged as tasks with urgency conditions should be served earlier than others that are latency tolerant. To mitigate these issues, this thesis presents a priority-based task scheduling and resource allocation (PTS-RA) mechanism for efficient resources utilization in MEC for health monitoring systems. Upon receiving tasks, their urgency levels are initially determined; subsequently, priority-based task scheduling is performed. For this purpose, two queues are maintained: tasks are sorted into either a priority-based or a normal task queue, depending on their urgency or latency requirements. Tasks in the priority queue are processed locally, while others can be sent to the cloud if MEC resources are unavailable. After task scheduling, the next step is to perform a priority-based resource allocation to efficiently utilize the available resources in MEC. There are three scenarios for resource allocation: when available resources are more than the number of tasks, when resources are available but insufficient to meet the tasks' demands, and when no resources are available. These three scenarios will be tackled by considering the availability of resources, thereby satisfying the maximum number of tasks according to their latency requirements. Critical comparisons were made to evaluate the performance of the proposed method with closely related techniques such as the NBIHA, CORA-GT, ASE, FCB-HMS, and SDFC. The simulation results show significant improvements with the proposed method: average latency decreased by approximately 9.5%, and task scheduling efficiency and average response time improved by 16.57% and 12.05%, respectively. ix Additionally, task execution time is reduced by around 13-17%, resource utilization enhanced by 18.56%, and network usage and energy consumption decreased by 19.16% and 12-15%, respectively.

Usman Bello (GOT (2024) *Oxidative Stability and Poor Cold Flow Improvements Of Biodiesel Using Natural-Derived Antioxidants.* Doctoral thesis, Universiti Teknologi PETRONAS.

Biodiesel's low resistance to oxidation and poor cold flow properties when expose to certain pro-oxidizing conditions such as lights, air, high and low temperatures, moisture, and residues of metal, etc were identified as major limiting factors hidenring its borader acceptance and large-scale production. However, improving its oxidative stability (OS) and cold flow properties using natural antioxidants, especially those derived from biomass wastes, is a low-cost, socially and environmentally friendly approach. Therefore, this work harnessed the potentials of palms fruit, banan, ang mango peels as green sources of natural antioxidants wjose liquid extracts were recoverered via supercritical fluid extraction (SFE) using CO_2 flow rate of 5.0 mL/min, a fixed pressuere of 25 MPa, and temperatures ranging from 40-80°C at extraction times of 30-150 mins. Subsequently, quantificatiob of the target bioactive compounds: quercetin, gallic acid, and beta-carotene were achieved using High-performance liquid chromatography (HPLC) while Fourier Transform Infrared (FT-IR) was used y\to identify the presence of the expected functional groups presents in the sample extracts. Free radicl scavenging capacitu of the recover exyracts against 2, 2 -dipphenyl-1-picrylhydrazyl (DPPH) radicals was examined in mono, binary, and ternary mixtures ($S_1 – S_2$), whose effectiveness was experessed interms of inhibitory concentrations (IC_{50}), total phenolic content (TPC), total flavonoid content (TFC), and total carotenoid content (TCC). Among the blends, a superior activity was presented by a ternary mixture ($S._9$) corresponding to an IC_{50} value of 76.21 µg mL and a TPC of 242.38 mg GAE/g. Optimization of the biodesel's induction period (IP), which is the time taken for the onset of oxidation to occur when exposed to air or oxygen at elevated temperature, was carried out using central composite design (CCD) for the chosen process variable namely extract's dosage ,mixing speed and reaction time against the response (IP). Accordingly, the optimal conditions that accounted for the maximum IP value of 17.59 h were a dosage ratio of 1.24, a mixing speed of 496.66 rpm, and a reaction time of 64.99 min, also, the recovered peel extracts were effective in elevating the longevity of the biodiesel from an IP value of 2.43 h for the pure biodiesel to a range of 3.39 h to 18.04 h for the extracts blended biodiesel.

Tukkee, Ali (2024) *Exploring The Solar Vortex Engine: Design and Operational Parameters Perspective.* Doctoral thesis, Universiti Teknologi PETRONAS.

The power generated by the solar chimney power plant (SCPP) is limited due to its dependence on the height of the chimney structure, to which an optimum value exists because of thermal and frictional losses. The solar vortex engine (SVE) aims to remove this limitation by replacing the tall chimney structure with an air vortex column that is generated by a short structure called the vortex generator. However, the capability of the vortex column in replacing the physical chimney is still not proven, and the suitable location for the wind turbine is debatable among researchers until now. The basic thermodynamic principle of the system is not yet established as well. In addition, the effects of many design and operational parameters are still unknown. In this study, different design parameters were investigated experimentally and using numerical simulations by ANSYS Fluent software. A comparison between the SVE and SCPP through different simulation cases was also considered to determine the appropriate location for the wind turbine and prove the validity of the SVE as a substitute to the SCPP. Additionally, mathematical models were developed for a thermodynamic power cycle and an exergy analysis that describe the basic thermodynamic principle and evaluate the potential of the system. The experimental results showed that a 1 m extension in the solar collector canopy radius or the absorbing surface beyond the canopy increases the power output potential by 95 and 22%, respectively. The simulations revealed that the suitable location for the wind turbine of the SVE is at the outlet hole of the vortex generator where a high turbine pressure drop potential is observed. In comparison with the SCPP, the air velocities at the vortex generator outlet hole and chimney base were 1.82 and 1.56 m/s, respectively. Furthermore, the turbine pressure drop did not affect the generation and sustainability of the air vortex. Thus, the 1 m high vortex generator successfully replaced the 8.6 m high chimney, eliminating the limitations faced with the SCPP. The thermodynamic processes that comprise the ideal SVE power cycle closely resemble the ideal gas turbine Brayton cycle. The cycle analysis showed that the power output of the plant is mostly influenced by the air viii velocity at the vortex generator outlet. The input exergy of solar radiation is 93% of the input energy, and 92.32% of the exergy is lost at the solar collector absorptive surface. The energy conversion efficiency of the SVE is low, similar to the SCPP. The energy conversion efficiency at 12:00 PM was 0.00009%, while the second law efficiency showed that a much higher value of 0.006% is achievable under reversible conditions. So, the system's performance can be improved significantly if exergy losses are minimized, which is also clear from the calculated high values of the exergetic improvement potential.

Vasudevan, Mugashini A/P Alagari (2024) *Development of Acute Myocardial Infarction (AMI) Biosensor Using Palm Oil Biowaste-Derived Graphene Nanocomposites.* Doctoral thesis, Universiti Teknologi PETRONAS.

Graphene, which is known for its exceptional conductivity, mechanical strength, and chemical properties, is at the centre of biosensor technology. However, producing graphene on a large scale and in high quality is challenging using conventional methods, as it requires high temperatures, complexity and time-consuming processes. In particular, chemical vapour deposition (CVD) has its limitations in transferring graphene while metal substrates are difficult to etch and recycle. In this study, graphene was synthesised from lignin, a bio-waste of oil palm, by a one-step CO2 laser scribing method, which is an alternative that enables large-scale production. A three-dimensional porous morphology of laser-scribed graphene (3D LSG) was successfully produced. Raman spectroscopy, FT-IR, and XPS analyses confirmed the production of graphene from lignin. However, the synthesised 3D LSG showed disadvantages such as high defects, high resistivity, impurities, and poor conductivity. To address these limitations, 3D LSG nanocomposites were synthesised by a hydrothermal method, integrating molybdenum disulphide (MoS2), nitrogen-doped graphene quantum dots (N-GQDs), and lignin-derived silver nanoparticles (Ag NPs). Characterisation included assessments of surface morphology, crystallinity, chemical composition, functional groups and conductivity. The subsequent investigation focussed on their potential as highly sensitive green biosensors for the detection of the biomarker troponin I in acute myocardial infarction (AMI). The optimised 3D LSG nanocomposite/screen-printed carbon electrode (SPCE) was modified layer-by-layer on the surface and immobilised with aptamers. The 3D LSG nanocomposite biosensors were tested with troponin I concentrations ranging from 1 nM to 100 aM. The detection limit for troponin I in the 3D LSG/MoS2/Ag NPs-2.0 and 3D LSG/MoS2/N-GQDs/L-Ag NPs nanocomposites was 100 aM, while the detection limit for the LSG_N-GQDs_Ag NPs-1000 nanocomposite was 1 fM. These biosensors exhibited excellent troponin I detection capabilities in human serum. The analytical performance of these biosensors is attributed to the large surface area, binding affinity, electroconductivity and properties of the 3D LSG nanocomposites, which were enhanced by the addition of supporting nanomaterials. This green biosensor represents a promising approach for the detection of lethal disease biomarkers and could serve as inspiration for green friendly and early detection methods.

Yaari, Abdullah Mohammed Saad Al (2024) *Mathematical Model for Nanofluid Thermophysical Properties In Heterogeneous Porous Media For Enhanced Oil Recovery.* Doctoral thesis, Universiti Teknologi PETRONAS.

Nanofluids are a promising solution for improving oil recovery in the oil and gas industries. The petrochemical industry uses the two-phase Darcy law to predict and optimize oil production using Nanofluid. Various models have been proposed, considering essential mechanisms like wettability and interfacial tension. Even though nanoparticles can alter the thermophysical properties of the base fluid (water), recent models do not account for or simulate the effects of the thermophysical properties changes of the nanofluid on the enhanced oil recovery. This research investigates a new mathematical model to simulate Nanofluid flooding into a 2-dimensional and 3-dimensional homogeneous porous medium, as well as a 2-dimensional heterogeneous porous medium for enhanced oil recovery. The model's applicability extends to considering the thermophysical properties by using empirical correlations in relative permeability for nanofluids and oil as functions of temperature and volume fraction (VF). The governing equations derived from Darcy's law, mass conservation, concentration, and energy equations are numerically evaluated using a time-dependent finite element method. Focusing on three nanoparticles: SiO2, Al2O3, and CuO. The findings revealed that optimizing temperature, VF, and flow rate significantly improved the thermophysical properties of the Nanofluid. Notably, increasing the inlet temperature (353.15 K) and VF (4%) at a flow rate of 0.2 ml/min enhanced oil displacement, improved sweep efficiency, and increased oil mobility. However, oil recovery decreased when the VF exceeded 4% or the temperature surpassed 353.15 K. By comparing the thermophysical properties of different nanoparticles with oil recovery factors, the study determines SiO2 as the most effective nanoparticle. Remarkably, SiO2 exhibits the lowest density and highest thermal capacity. Notably, the highest oil recovery factor of 37% is achieved at 353.15 K when using SiO2 at 4%.

Yusoff, Ir Mohd Nizam Bin (2024) *Mechanism For Mitigating Stress Corrosion Cracking In P91 Materials Within High-Temperature Oxygenated Environment.* Doctoral thesis, Universiti Teknologi PETRONAS.

P91 materials, crucial for the construction and safe operation of critical infrastructure, particularly in power generation, face significant risks due to their susceptibility to stress corrosion cracking (SCC) in high-temperature, oxygen-rich environments. Despite their critical role, a comprehensive understanding of their SCC behavior under such extreme conditions has been lacking. This study hypothesizes that an in-depth analysis of microstructural transformations and the protective role of oxide layers can significantly mitigate SCC risks. The primary aim is to elucidate the mechanisms that inhibit crack propagation in P91 materials in environments of high-temperature steam and oxygen. Objectives include examining the formation and impact of thin oxide layers on metal surface protection, understanding the Film Rupture Mechanism (FRM), and exploring microstructural changes affecting SCC behavior. Employing a specialized stress corrosion cracking test rig with an autoclave system, this study meticulously investigates the SCC phenomena through prolonged exposure to specific conditions, examining the formation of oxide layers, carbide precipitation, void formation, and microcrack coalescence. Quantitative findings reveal that oxide layers, as thin as 20 microns, formed under high-temperature conditions (up to 568°C) and varying oxygen concentrations (7 to 5500 ppb), play a pivotal role in protecting the metal surface from further damage. Notably, tests conducted at 568°C with a high oxygen level of 5500 ppb resulted in significantly longer failure times (up to 1400 hours), underscoring the efficacy of oxygen in enhancing the formation of protective oxide layers. The discovery of FRM, which cyclically ruptures and re-passivates thin oxide layers under stress, offers a novel perspective on delaying crack propagation. Detailed observations of microstructural transformations reveal variations in hardness and crack propagation behavior, highlighting the complexity of SCC. Specifically, the study demonstrates that higher mechanical loads significantly reduce failure times, emphasizing the interplay between mechanical stress and environmental conditions in SCC progression.

Zakaria, Muhammad Syamil Bin (2024) *Experimental and Numerical Investigation of Submerged Convective Cooling In Orthoghonal Machining of AZ31 Magnesium Alloy.* Doctoral thesis, Universiti Teknologi PETRONAS.

Magnesium alloys are lightweight materials which exhibit high specific strength. Dry cutting is a common practice in machining this material which always results in an excessive rise in temperature due to the absence of cooling at the cutting zone. The low melting point of AZ31 magnesium alloy always puts the process to the inevitable builtup edge (BUE) and built-up layer (BUL) formation. This study implemented novel work in orthogonal machining of AZ31 magnesium alloy via submerged convective cooling (SCC), to compensate for the absence of cooling in dry cutting. Computational fluid dynamics (CFD) modelling was implemented in designing and developing a SCC module and experimental studies were conducted to evaluate the machinability of AZ31 magnesium alloy in SCC and dry conditions. Finite element modelling (FEM) was developed in investigating the influence of cooling in SCC on the serrated chip formation. Result from CFD simulation revealed a small inlet/outlet diameter and high flow rate significantly contributed to 50% in reduction of tool temperature, due to high heat transfer coefficient of cooling fluid in the SCC. From the experimental results, both BUE and BUL were observed in dry and SCC conditions, but the severity of these wear mechanisms decreased remarkably under SCC conditions. SCC recorded up to 15% reduction in cutting temperature and a reduction of 6% and 12% in cutting and feed force, respectively. The chips produced in dry cutting were continuous, while SCC was short and discontinuous because of cooling effect in SCC lead to material brittleness. FEM demonstrated a lower temperature at the primary shear zone in SCC caused the chip to experience low ductility hence aided chip breakability. SCC turning increased the microhardness by 60.5%, while dry turning exhibited a 49% increase in microhardness and the surface roughness was improved by 10.8% in SCC. Based on the results obtained, SCC cutting was a preferred technique over dry cutting for its outstanding performance on the machinability of the AZ31 magnesium alloy.

binti Mohammad Jakeri, Mazni (2024) *Adaptive Security Activity Selection Model for In-House Web Application Development in the Malaysia Public Sector.* Doctoral thesis, Universiti Teknologi PETRONAS.

Adaptive security activities are a list of recommended security activities to be integrated smoothly with the software development life cycle (SDLC) to produce secure application software. The need for adaptive security activities arises from emerging factors and constraints, which contribute to underutilization of security measures in early software development phases. Besides, various published secure frameworks and guidelines lead to difficulties for developers in comparing, selecting, and determining the right resources for applying security activities. Seceral security activity selection models have been proposed to select and recommend security activities. However these models were focused on certain factors or as a solution for specific constraints, and thus the recommended security activities were not adaptive. Therefore, the Adaptive Security Activity Selection (ASAS) model was proposed to fill the gap between the difficulties in selecting the security activities and satisfy all the constraints faced by the development team for each criterion by proactively measuring, evaluating, ranking, and recommending adaptive security activities. It differs from the existing security selection models, where it combines the criteria and constraints in recommending the security activities. Hence, the ASAS model was adaptive due to its flexibility and ability to change to suit different and evolving conditions in recommending security activities to meet the development teams' requirements. The model consisted of three integrated Multi-Criteria Decision-Making (MCDM) methods, namely Analytic Network Process (ANP), Reference Ideal Method (RIM), and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE). The model has been evaluated in a case study involving four in-house web application development teams in Malaysian public sector agencies. The model was able to recommend adaptive security activities for the requirement and design phases based on the constraints faced by the development teams for each criterion simultaneously. The model has been verified by experts in software development. Inadequate experience, skill, and knowledge, excessive workload, and ix insufficient budget allocation emerged as the primary constraints in evaluating and recommending adaptive security activities. The model has successfully recommended security activities by measuring and evaluating the security activities with the value of constraints for each criterion simultaneously.

binti Mohd Johari, Siti Aminah (2024) *Utilization of Dairy Waste Scum Oil for Biodiesel Production Via Microwave Heating over Lithium Modified Eggshell Catalyst.* Doctoral thesis, Universiti Teknologi PETRONAS.

The common renewable energy that has been identified is biodiesel which has green and environmentally friendly properties. Many researchers have generated biodiesel from non-waste materials, such as vegetable oil, which could create food conflict, unlike oil from waste that could aid in waste management. Although various transesterification methods exist, there is a pressing need for more economical and rapid approaches such as microwave heating that emerge as a potential solution. This research study utilized dairy waste scum oil (DWSO) as the feedstock to produce biodiesel via microwave-heating transesterification. To enhance sustainability, the catalyst used in the process was synthesized from kitchen waste, specifically, eggshells is employed. Further enhancement involves modification with lithium metal (Li-ECaO), which acts as metal support. This choice of alkali metal is due to the limited study of its role in supporting the eggshell catalyst and its advantageous basicity. The eggshell-based CaO (ECaO) and Li-ECaO catalysts were successfully synthesized and characterized by current techniques in terms of the physicochemical and textural properties of prepared catalysts. The pore size of Li-ECaO (24.16 nm) was larger than ECaO (15.33 nm) and showed good thermal stability until 800℃. Several reaction parameters including LiECaO catalyst loading (1 – 5 wt.%), methanol to oil molar ratio (6 – 18:1), temperature (55 – 75℃) and reaction time (5 – 25 min) were optimized using response surface methodology (RSM) according to Box-Behnken design (BBD). The highest biodiesel production of 90.50% was attained under optimized conditions of 3 wt.% catalyst loading, 18:1 methanol to oil molar ratio, the temperature at 65℃ and 25 min of reaction time. The transesterification reaction showed a good fitting with pseudo-first order kinetic model with R2 of 0.88 and 38.86 kJ/mol of activation energy (Ea). The thermodynamic analysis showed the process was endothermic. Additionally, the reusability of the Li-ECaO was significantly stable until 4th reaction cycle. By applying optimized conditions for scale-up production of 1.20 million kg annually, net present viii value (NPV) and payback period were determined to be RM 16.84 million and 7.65 years respectively. This economic analysis shows that industrial scale for DWSO biodiesel production could be potentially viable with 15 years lifetime project.

ur Rehman, Adeel (2024) *Investigation of Glycols-based blend as Gas Hydrate and Corrosion Inhibitor Experimental and Modelling Approach.* Doctoral thesis, Universiti Teknologi PETRONAS.

In the oil and gas production industry, flow assurance is crucial for ensuring smooth operations. However, gas hydrate formation in pipelines presents a major challenge, obstructing hydrocarbon production, conveyance, and processing. Additionally, CO2-induced corrosion in transmission pipelines exacerbates the issue. Traditional gas hydrate inhibitors like Methanol and Monoethylene Glycol have limitations such as vapor loss and excessive loading. To address these challenges, this study aimed to assess the potential of blending ionic liquids (specifically tetramethylammonium hydroxide) and amino acids (specifically Glycine) with monoethylene, diethylene, and triethylene glycols at ratios of 1:1, at concentrations of 5%, 10%, and 15% by weight, to mitigate hydrate plug formation and pipeline corrosion. The isochoric constant cooling method was used to investigate hydrate liquid vapor equilibrium (HLVE). Higher concentration can shift the hydrate liquid vapor equilibrium (HLVE) curve to lower temperatures and high-pressure regions as well the corrosion. The Glycine and monoethylene glycol (MEG) blends shows 23% better inhibition as compared to pure MEG The HLVE data for the pure and blends has been compared. Dickens and QuinbyHunt Model was used as a prediction model to validate the experimental results accuracy for which most of the results are in the average error range of 0.6 and showing R 2 value near to 1. Weight loss method and Linear Polarization resistance was used to find out the corrosion rate and corrosion inhibition efficiency to evaluate the corrosion inhibition performance. Results showed that TMAH-blends gives 99.75 % corrosion inhibition performance and on the other side Glycine-blends showed 85.42% corrosion inhibition efficiency. Lastly, to evaluate the environmentally friendly nature of the selected IL and Amino acid and their blends biodegradability index (B.I) has been calculated. B.I calculations showed that TMAH and its blends are not readily biodegradable, while amino acids and it blends showed very good benign nature. Summarizing to this, it has been found that synergistic effect of Glycols with TMAH viii (IL) or Glycine (Amino acid) can work as a multi-tasking inhibitor, which not only inhibits the hydrate formation but also corrosion inhibition can be protected by using these blends with comparatively better biodegradability

Ur Rehman, Obaid (2024) *Investigation On Behaviour And Fouling Characteristics of Crude Oil Blends And Development of Modified Fouling Model.* Doctoral thesis, Universiti Teknologi PETRONAS.

Blending of different types of crude oils is necessary for oil refineries to meet specific feedstock composition, especially when cheaper opportunity crude oils are available. However, blending incompatible crude oils can result in the precipitation and deposition of asphaltenes, leading to severe fouling in the crude preheat exchangers. Previous studies on fouling mechanisms and fouling models mainly focused on neat crude oils and did not consider the compatibility of crude blends. This research aims to experimentally determine asphaltenes precipitation behavior of selected crude oils and their blends using Automated Flocculation Titrimeter (AFT). Different crude oil blends were prepared to analyze the effect of change in different components of crude oil. The study of fouling characteristics at appropriate operating conditions was carried out using the Annular Flow Fouling Research Unit (AFFRU). A new model was developed for the fouling prediction which accounts for the compatibility characteristics of crude oil blends. It was found that the incompatibility of blends was mainly governed by the reduction in solvent power of the oils. The compatibility of blends was found to be a direct function of wax content of the blend. The aliphatic chains in the molecular structure of asphaltenes provide stability with wax molecules. This is due to the presence of van der Waals forces that contribute to the increase in compatibility between asphaltenes and wax. The results showed a direct relationship between the initial fouling rate of crude oil blends with their compatibility which found to follow a power law model. The most unstable blends showed acute fouling. This relationship was embedded into the existing fouling rate prediction models. The proposed new model was validated using experimental data and yielded R-squared value of 0.866. The results of this study will contribute to the enhancement of mitigation strategy for fouling in refinery heat exchangers, particularly in cases involving incompatible crude oil blends.

Ahmed Ja'e, Idris (2023) *Development Of A Numerical Optimization Tool For Fpso Mooring Line Parameters.* Doctoral thesis, Universiti Teknologi PETRONAS.

As the exploration of oil and gas progresses into deeper waters, efforts to utilise optimization techniques in automating the mooring design process are continuously being explored. However, the selection procedure of mooring line parameters which is a critical aspect of mooring system design has remained based on a trial-and-error approach heavily depending on the experience of the engineers. Hence, the main objective of this research is to develop a numerical optimization tool (MooOpT4FPSO) that optimizes mooring line design parameters of FPSO using Regrouping Particle Swarm Optimization (RegPSO) technique. The numerical tool is an integration of a RegPSO algorithm (developed in MATLAB) and a commercial software OrcaFlex, with the capability to simultaneously optimize azimuth angles, line radius, line length, and line diameter of turret FPSO. Achieving this objective is multifaceted, including investigation of the influences of FPSO mooring line parameters on hydrodynamic responses, mooring and riser tension in intact and damaged conditions using a fully coupled dynamic analysis approach. Furthermore, with the help of OrcaFlex and the adoption of the integrated design methodology, the developed numerical tool was used to generate the safe operation zones for risers. In addition, the influences of first and second-order wave forces on the optimization process were investigated. Case studies have been considered in which the optimised parameters from MooOpT4FPSO have yielded a 3-5% reduction in single line lengths with a corresponding reduction in platform offset ranging from 48 -63%. The inclusion of second-order wave forces is found insignificant in the optimization process with a reduction of only 0.12% in line length. In addition, different mooring line groupings were studied. For the mooring group of 4x3 at 30 degrees from wave heading, reduction of the mean surge offsets of 72% and 22% resulting from single- and double-line failure respectively were predicted. A similar decrease of 39% and 35% in mean surge offset were recorded in the 3x3 configuration when one group is at 15 degrees. The application of the developed optimization tool has yielded line parameters with reduced platform offset.

Ibrahim, Muhammad Bello (2023) *Geospatial Temporal Framework On Landslides Mitigation Strategies For Pipelines.* Doctoral thesis, Universiti Teknologi PETRONAS.

This research has proposed a newer method of improving landslide susceptibility development and utilization. A 50-year return period of five years intervals of susceptibility maps was proposed to monitor the degree of deterioration of the slope surfaces caused by the landslide. The susceptibility mapping was developed using data mining techniques and remote sensing data. These improvements in landslide susceptibility mapping were used to establish a landslide mitigation strategies framework for pipelines. The proposed framework is expected to help prevent the continued pipeline failures caused by landslides. Support Vector Machines (SVM) and Artificial Neural Network (ANN) were used to develop the prediction models and conduct the temporal analysis of the landslides. Eight statistical indices, which include Root Mean Square Error (RSME), F-Measure, Sensitivity, Specificity, Absolute Mean Error (AME), Area Under the receiver operator curve (AUC), Accuracy (ACC), and Kappa, were used to validate the predictions. AUC values of 0.879 were obtained for the susceptibility models developed from the SVM algorithms, indicating outstanding predictive performance. Nevertheless, all the indices proved that the algorithms used in the models had performed well. Sensitivity analysis (SA) was employed to check the performances of the 12 landslide conditioning factors. The frequency ratio (FR) analysis was also conducted to establish the relationship of these factors with the landslide occurrence. Findings from the landslide analysis (landslide hazard maps, susceptibility maps, temporal occurrence of the landslides, and deterioration level of the slopes relative to the pipelines) were incorporated into the framework of landslide mitigation strategies for pipelines. The framework was subjected to semi-quantitative validation to check its usability in a real-life scenario. A semi-structured interview with experts from various construction industries was conducted to validate the developed framework with current practices. Overall, positive responses were obtained from industry experts.

Iqbal, Asif (2023) *A Flexible Spectrally Constrained Multiband Multicarrier Signal Design And Channel Estimation For Channel Sounding Applications.* Doctoral thesis, Universiti Teknologi PETRONAS.

The problem of channel sounding and channel characterization for wireless communication has been studied for many years. Lately, software-defined radios (SDRs) are being exploited for channel sounding to obtain channel impulse response (CIR). The SDRs allow cost-effective and efficient implementation of orthogonal frequency-division multiplexing (OFDM) based sounding systems. However, there are still vital challenges that need to be addressed. First, the SDR hardware has limited system bandwidth. Second, the OFDM waveform suffers from a high Peak-to-Average Power Ratio (PAPR). Third, radio spectra are getting congested, and regulations on spectrum allocation impose spectrum constraints on the sounding waveform. This work addresses all these challenges by introducing a new flexible spectrally constrained multiband multicarrier signal design and its use in channel estimation for channelsounding applications. First, a flexible channel sounder architecture was developed using commercial SDRs. Secondly, a new phase-modulated multiband-OFDM (MBOFDM) waveform was designed to provide low PAPR. Thirdly, a novel iterative timedomain channel estimation method called the spectrally constrained time-domain (SCTD) method was developed to reduce the residual error of correlation due to spectrally constrained waveforms. Furthermore, an averaging-based SCTD method is introduced for the low energy per bit to noise power spectral density ratio ($Eb/N0$) regime scenarios. The results from numerical experiments show an improved PAPR performance for MB-OFDM signal design. The results show that the proposed SCTD method supersedes the conventional techniques for stationary and mobile frequencyselective channel scenarios within ten iterations. Subsequently, it is observed that the proposed SCTD method requires 50% fewer pilots to provide similar performance compared to conventional methods. It is also observed that the proposed SCTD method provides an average of 6 dB mean squared error (MSE) advantage for low $Eb/N0$ regime cases. It can be concluded that the proposed system is a viable option for ultrawideband (UWB) channel sounding.

Junaid, Muhammad (2023) *Development Of Boron Doped Reduced Graphene Oxide For Ac Electroluminescence Emission From Heterostructure Device.* Doctoral thesis, Universiti Teknologi PETRONAS.

In recent years, graphene-based light-emitting devices have become the key focus in the field of display technology. Graphene is zero bandgap material, and the bandgap can be induced in graphene by the chemical substitution doping for the electroluminescent emissions. The induced bandgap in graphene is unstable because graphene-based active layer become oxidized in open air environment. The oxidation of graphene makes the light emission process temporary and also limits the lightemitting area. The Electroluminescence (EL) effect from graphene can be observed through heteroatom doping by inducing the optical bandgap with the energy density of states (DOS). The boron-doped reduced graphene is proposed as an active layer for the heterostructure light-emitting device, which inhibit the oxidation of the active layer. In this work, microwave-assisted hydrothermal synthesis of boron-doped reduced graphene oxide (B-rGO) and an active layer for a heterostructure light-emitting device, is performed. The B-rGO-based heterostructure device, comprised of B-rGO, barium titanate, silver ink, and ITO-coated PET substrate, was fabricated using a screenprinting method. The synthesis of B-rGO was confirmed by FESEM, EDX, FTIR, and XPS spectroscopic techniques, where maximum boron doping of 6.51 at. % was attained. To further analyze the optical behavior of B-rGO, the UV-Vis and PL spectroscopic analyses were also performed, where the bandgap from 2.53 to 2.86 eV has been observed with an enhanced electrical conductivity of 0.816 S/cm. The fabricated heterostructure device was tested with a variable voltage source (0-150 VAC, 1-5 kHz). Particularly, visible light emission was achieved in the spectrum range from 460 to 472 nm, with an increased emissions area (8 ×10 mm) and lifespan. This work shows that the rGO surface doped with Boron can be utilized to fabricate graphenebased light-emitting devices with increased lifespan and light-emitting area.

Subramani, Indra Gandi (2023) *Nanoflower Enhanced Capacitive Nonfaradaic Milk Allergen Biosensor.* Doctoral thesis, Universiti Teknologi PETRONAS.

The bovine milk allergenic protein, 'β-lactoglobulin', is one of the leading causes of milk allergy, especially in children. This research has developed a novel label-free nonfaradaic capacitive aptasensor to detect β-lactoglobulin using laser-scribed graphene (LSG) electrode technology incorporated with hybrid nanoflower (NF). Firstly, the novel hybrid nanoflower was synthesized using 1,1′-carbonyldiimidazole (CDI) as the organic molecule and copper (Cu) as the inorganic molecule via effortless one-pot biomineralization technique by tuning the reaction time and concentration. Then, five individual capacitor-like triangular LSG electrodes were effortlessly fabricated on polyimide (PI) film with micron gap (MG) spacing of 30, 66, 95, 125 and 180 µm, via one-step CO2 laser irradiation and investigated towards dielectric biomodification. An optimum microgapped (~95 µm) sensor in terms of good reproducibility was selected to construct milk allergen biosensor. The CDI-Cu NF was fixed on the pre-modified PI film-made triangular junction of the LSG microgap specifically to immobilise aptamer and capture milk allergen (β-lactoglobulin). The fine-tuned CDI-Cu NF revealed the flower-like structures were viewed through field-emission scanning electron microscopy (FESEM). Fourier-transform infrared spectroscopy (FTIR) showed the interactions with PI film, CDI-Cu NF, oligoaptamer and β-lactoglobulin. The nonfaradaic sensing of milk allergen β-lactoglobulin corresponds to higher loading of oligoaptamer on the 3D-structured CDI-Cu NF, with an extensive linear range detection from 1 ag mL -1 to 100 fg mL -1 and attomolar (1 ag mL -1) detection limit (S/N=3:1). Validation of the detection was performed with ELASA. The sensitivity and stability of the biosensor was 0.025 [(ΔC/C0)/ (ng mL -1)] and 73.41%, respectively. This novel CDI-Cu NF/LSG microgap aptasensor has excellent potential for the detection of milk allergen with high specificity and sensitivity.

Ali, Kashif (2023) *Examining The Indirect Impact Of Soft And Hard Total Quality Management Practices On Sustainable And Quality Performance: A Study Of Malaysian Manufacturing Smes.* Doctoral thesis, Universiti Teknologi PETRONAS.

In the digital era, organizations have undergone enormous and constant changes, both at social and technical levels. Moreover, organizations, especially Small and Medium-sized Enterprises (SMEs) have faced numerous challenges to achieve sustainability. Some notable challenges include how the multidimensional perspective of Total Quality Management (TQM) practices promotes sustainable performance in the digital era. The digital transformation symbolized industry 4.0 (I4.0), which has created a disruptive effect on the production systems. Although I4.0 and TQM have shared the same objectives. However, the existing TQM literature paid less attention to the multidimensional perspective, especially in the digital era. The multidimensional perspective highlights that TQM consist of soft (social) and hard (technical) practices. The people related factors fall under soft and process and technology related factors fall under hard TQM practices. Moreover, TQM and Agile Manufacturing have been credited with improving sustainability and quality performance. To date, there has been limited research that investigated the causal relationship among the study variables. The present study addresses this research gap. The purpose of this study was fourfold. Drawing on Sociotechnical Systems theory (STS), it first identified the TQM key factors and then examined the interrelationships among these factors. Secondly, it examined the effect of TQM practices on agile manufacturing. Thirdly, it investigates the mediating role of agile manufacturing between TQM practices and outcome variables. Lastly, it examined the moderating role of firm size on the hypothesized relationships. Data was collected from 298 Malaysian manufacturing SMEs using a stratified sampling technique. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to test the hypothesized model. The findings indicate that top management commitment, customer focus, training, process management, and information and analysis are the key drivers of TQM. The findings support the multidimensional perspective of TQM in I4.0. Another major finding of this study was ix that agile manufacturing partially mediates the proposed relationships. Moreover, the findings show that firm size was not fully moderated by the hypothesized model. This study concludes that the multidimensional perspective of TQM and agile manufacturing are critical for manufacturing SMEs to achieve sustainability and quality performance. Furthermore, these factors are also important for firms to sustain in I4.0. Policymakers and SMEs need to realize the importance of TQM and agile manufacturing and embark on it for a sustainable SME sector and a digital economy.

Rafiq, Waqas (2023) *Performance Evaluation Of Reclaimed Asplhalt Pavement Materials Usin Crude Palm Oil As A Rejuvenating Agent.* Doctoral thesis, Universiti Teknologi PETRONAS.

Environmental problems and asphalt binder high prices justify the utilization of reclaimed asphalt pavements (RAP) in bituminous mix production. The aged binder has high stiffness in recycled materials and causes different problems such as low fatigue and resistance against swcracking and workability issues, that can be answered by utilizing rejuvenating agents. This study discusses the effects of different percentages (20-100%) of recycled asphalt pavement (RAP) and crude palm oil (CPO) (8-10%) on Marshall properties, volumetric properties, Indirect tensile Strength (IDT), moisture damage, stiffness modulus, fatigue life and rutting properties. In addition, for the statistical analysis, an analytical tool response surface methodology (RSM) was used for designing and statistically analyzing the experimental results. Numerous characterization and microstructure level investigation techniques were performed including; Rheology (penetration, softening point, dynamic shear rheometer), Morphology (Atomic Force Microscopy, Field Emission Electron Microscopy), Chemical Analysis (Fourier transform infrared spectroscopy0. The microstructural analysis showed that the incorporation of CPO in virgin and RAP aged binder changed the structure of aged and virgin binder by new and unique phase formations. Experimental results showed that stability and indirect tensile strength increased in recycled asphalt pavement material up to 80%. The validation of RSM models were done by conducting additional experiment, the prediction for all the performance responses were excellent with small errors of 1.73% to 4.83%. fatigue prediction models were also developed to estimate the fatigue life of asphalt mixtures. CPO incorporated RAP mixes significantly exhibit high fatigue lives of 38% in comparison with control mixtures at higher 60% RAP. The rutting performance of the mixes was compromised marginally using CPO in comparison to the control mix. Hence recommending 10% CPO with 60% RAP material representing a potential use as bio-binder and recycle material for the highway construction industry.

Ullah, Farman (2023) *Enhanced Pec Hydrogen Production Of Novel Gqds And Cuo Doped Tio2 Based Photocatalyst Simulated Via Dft Calculations And Experimental Strategies.* Doctoral thesis, Universiti Teknologi PETRONAS.

Photoelectrochemical (PEC) water splitting technique is one of the most promising, cost-effective, and environmentally friendly techniques for solar H2 production. However, the system efficiency has been adversely affected by the presence of wide bandgap material leading to less visible light absorption and rapid recombination of e-/h+ pairs in photoanode component of PEC cell. Herein this work, both theoretical and experimental studies were performed to elucidate the optoelectronic properties and charge transfer characteristics of the TiO2 based photocatalysts to enhance their photocatalytic performances. Different computational models including un-doped, C/Cu doped TiO2 rutile bulk models, TiO2 rutile (110) and (011) surface models, bilayered CuO and GQD modified TiO2 rutile (011), tri-layered CuO/GQD@TiO2 and GQD/CuO@TiO2 rutile (011) heterostructure were designed and simulated using Hubbard's modified DFT + U approach. Among all the designed models, the optimized CuO/GQD@TiO2 rutile (011) heterostructure model presented the lowest energy bandgap (1.36 eV), enhanced visible light absorption (~750 nm), and reduced recombination of the charge carriers. Based on this outcome, GQD and CuO modified TiO2 based photocatalysts were synthesized at different calcination temperature (300-600°C) and calcination durations (1-3 hrs) via hydrothermal synthesis technique for the un-doped, GQD@TiO2, CuO@TiO2, CuO/GQD@TiO2, and GQD/CuO@TiO2 heterostructure configurations. The optimized tri-layered novel CuO/GQD@TiO2 photocatalyst, calcined at 450oC for 3hrs demonstrated maximum H2 production up to 34,466 µmol g -1 h -1 with photoconversion efficiency ~ 9.01 %. The tri-layered photocatalyst also exhibits a stable production of H2 in a continuous treatment for 48 hrs in a PEC environment. Overall, the presented mechanistic insight and targeted strategy of incorporating metal oxide and zero-dimensional carbon material into TiO2 photocatalyst provides a fresh perspective in producing H2 efficiently using PEC approach.

Ahmad Sheikh, Nadeem (2023) *Mhd Free Convection Flow Of Casson And Brinkman - Typefluids Using Caputo Fractional Derivatives.* Doctoral thesis, Universiti Teknologi PETRONAS.

Nanofluids and hybrid nanofluids are new classes of nanotechnology-based heat transfer fluids, obtained by dispersing and stably suspending nanoparticles in base fluids. The addition, these nanoparticles or hybridized nanoparticles sufficiently improves the working ability of industrial fluids which is requirement of the modern era, these days. In regular nanofluid, a single type of nanoparticles whereas in hybrid nanofluid two different types of nanoparticles are suspended in a base fluid which may be of Newtonian nature or of non-Newtonian. Therefore, in this thesis, different types of nanoparticles and hybridized nanoparticles are used. The MHD free convection flows of Casson and Brinkman-type fluids, nanofluids and hybrid nanofluids in a vertical channel are considered. In addition, instead of conventional modeling, fractional analysis is used to develop partial fractional differential equations. These fractional models are based on ideas of Caputo fractional derivatives. These fractional models are solved using two integral transformations namely the Laplace and Fourier sine transforms. The exact solutions for velocity and temperature are developed in terms of special functions. The corresponding results for skin friction and heat transfer rate are also computed. For the sake of correctness, the present solutions are reduced in a limiting sense to the published solutions in the literature. By using Mathcad software, the effects of embedded parameters are examined in various graphs and tables with detailed discussion. Results showed that the enhancement in heat transfer rate is caused due the addition of nanoparticles and hybridized nanoparticles. The exact solutions obtained in this thesis are quite useful, as they can be used by other researchers working in the numerical or experimental field for the sake of comparison and verifications of their results.

Alam, Md. Azad (2023) *Synthesis And Characterization Of Aluminum Based Hybrid Composites For Engineering Applications.* Doctoral thesis, Universiti Teknologi PETRONAS.

Scratches, indentation and sliding wear is a serious problem when materials are exposed to static or moving components of automotives, hence selecting a suitable material with high hardness, strength and high wear resistance is vital in numerous engineering applications. The objective of the present work is the synthesis and investigations on the physical and mechanical properties of the aluminum-based composites. Distinct combination of aluminum-based composites were synthesized by powder metallurgy technique, viz, (i) (Al-SiCμ) composites, (ii) (Al7075-TiCμ-TiCn) bimodal composites, (iii) (Al7075-TiC(μ+n) - GNP) hybrid composites. In the first investigations, Al composites reinforced with x wt.% SiC (x = 5, 7.5 and 10) microparticles were synthesized. The hardness and density of the Al/SiC composites were found to be improved by increasing SiC content, and the composite with 7.5% SiC revealed higher density and microhardness. In the second study, Al alloy Al7075 based bimodal hybrid composites reinforced with TiC micro and nano particles were synthesized. The reinforcement content and process parameters were optimized using RSM based ANOVA analysis. The density and microhardness of the Al7075-TiC bimodal hybrid composites are found to be increased with content of TiC particles. The properties of the bimodal hybrid composites containing 3 wt. % nano TiC are better than other hybrid composites. In the third investigations, morphological characterization and wear behavior of GNP/TiC(μ+n) reinforced Al7075 hybrid composites were investigated. The contents of GNP (0, 0.5, 1.0 and 1.5 wt.%) were added to (Al7075+10 wt.% TiCμ+ 3 wt.% TiCn) nanocomposites. The influence of GNP content (0, 0.5, 1.0 and 1.5 wt. %) on the microhardness, wear resistance and tensile strength were studied. An increase of ~ 49% in UTS was observed in hybrid composite as compared to pure Al. The results establishesthe optimized input parameters within the scope of the research and outcome of the study also revealed that the hardness, tensile strength and wear resistance of the hybrid composites is enhanced by the combined effect of reinforcements GNP with micro and nano TiC particles and hence suitable for desired engineering applications.

Hezam Saeed, Anwar Ameen (2023) *Development Of Kenaf-Based Magnetic Biochar Adsorbent For Cadmium Ions Removal.* Doctoral thesis, Universiti Teknologi PETRONAS.

World water resources are polluted due to the release of many pollutants such as dyes, heavy metals, and others into water resources. Cadmium is a non-biodegradable heavy metal that has many toxicological effects on human health and is detrimental to the environment. Adsorption is the most widely used cadmium removal technique due to its effectiveness and simple operation. This study develops a kenaf-based magnetic biochar adsorbent for removing cadmium ions from model wastewater Raw kenaf fibers were firstly pre-treated with two techniques i.e. Chemical treatments (impregnation of kenaf fiber with sodium hydroxide), and thermal treatments (slow pyrolysis), before application in a batch system. Based on this, a synthesized magnetic biochar adsorbent was synthesized via a novel method using the precipitation of kenaf biochar with iron oxides (Fe3O4) and the sonication process. The synthesized biochar was characterized using (a vibrating-sample magnetometer VSM), Scanning electron microscopy (SEM), X-ray powder diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and X-ray photoelectron spectroscopy (XPS). Kenaf-based magnetic biochar adsorbent possessing the highest surface area of 175.55 m2 /g showed the highest adsorption capacity of 72.90 mg/g and removal efficiency of 96.20% for cadmium ions at the optimum adsorption parameters (dose 0.2 g/mL, pH 5.24 and cadmium concentration 64.84 mg/L. The ANOVA analysis showed a correlation coefficient (R2) of 0.969, Fvalue of 35.11, and p-value less than 0.05 which indicated the significance of the model and lack of fit was non-significant which showed good fitting of the experimental data to the quadratic model. Adsorption of cadmium ions onto magnetic biochar adsorbent followed Langmuir isotherm and the pseudo-second-order kinetics with correlation coefficient (R2) of 0.995 and 0.990 which indicated that the adsorption was combined chemisorption and physisorption process that occurred by the formation of a monolayer of cadmium ions. Thermodynamic studies suggest the feasibility of the spontaneous and endothermic nature of adsorption. Physical methods of sonication showed the best results with only a 9.5 % loss of adsorption capacity after five cycles of regeneration of viii magnetic biochar. A magnetic biochar-based adsorbent was utilized for the adsorption of cadmium ions in the fixed-bed column study. The adsorption capacity was found to be increasing and the adsorption performed better with higher bed depths. The flow rate of 14 mL/min, bed height of 9 cm, and inlet concentration of 25 mg/L were optimum for the column adsorption of cadmium ions. The breakthrough curve analysis of column adsorption proved that the experimental data fitted better to the Yoon-Nelson model with correlation coefficients (R2) of 0.980. As a result, magnetic biochar has proven to be an efficient and sustainable adsorbent for removing cadmium ions from wastewater.

Sadiq, Alishba (2023) *Functional Connectivity Approach Based On Resampling Technique Of Rs-Fmri For Classification Of Alzheimer's Disease Subtypes.* Doctoral thesis, Universiti Teknologi PETRONAS.

Observing brain connectivity patterns is one of the most effective approaches for analyzing brain functions. The resting-state functional magnetic resonance imaging (rs-fMRI) is a promising tool to analyze brain connectivity patterns. It is established that resting-state neuroimaging signals exhibit fractal behavior such that it can be broken down into fractal and non-fractal components. The fractal signals originate from heart oscillations, breathing, and system noise, obscuring the neuronal activity of the brain. With the presence of fractal components, the functional dynamic of spontaneous neural activities may not be accurately represented by the conventional correlation of rs-fMRI signals. Therefore, the fractal components of the BOLD signal need to be reduced to address this issue. In this work, SBS connectivity is used to distinguish Alzheimer's and mild cognitive impairment patients from healthy controls, eliminating the oscillations from the rs-fMRI BOLD signal. The principle of SBS algorithm is based on resampling by non-integer factors of the power spectrum of the BOLD signals over 5 segments. Subsequently, the cross-power spectrum is determined, followed by geometric mean operation. For validation, the SBS connectivity is utilized for accurate diagnosis of two stages of Alzheimer's disease (AD) and mild cognitive impairment (MCI) from normal controls (NC). Significant connections evaluated using p-value are selected and input to a classifier to classify AD/MCI vs. NC. The proposed classification method has shown excellent performance with an average accuracy of 98%. Both binary and multiclass classification outperformed the conventional Pearson correlation-based connectivity and benchmark approaches. This work demonstrates the great potential, not only for AD diagnosis but also for other neurological disorders. In summary, the proposed method has the potential to open up new brain connectivity methods for diagnosis.

Gurusamy, Nedunchelien (2023) *Learning Algorithms And Biomechanical Motion-Based Knee Energy Harvester.* Doctoral thesis, Universiti Teknologi PETRONAS.

Portable electronic gadgets are typically limited by the battery's operational lifetime. The situation will be exacerbated if the battery replacement is difficult or costly. Undeniably, batteries only have a limited operating period and in many circumstances, the power grid infrastructure is not easily reachable for recharging. As a result, biomechanical energy harvesting research has gained prominence as researchers keep exploring alternative energy sources for power generation. The flexion and extension of the human muscles don't only support the human's movement but also could help in terms of energy harvesting. The motion of the human anatomical joint is capable of producing electrical energy with the assistance of an appropriate harvesting mechanism. The research presented in this study has demonstrated a holistic approach through modelling and simulation to harvest energy from the knee biomechanical motion. This study begins with a thorough analysis of the knee angle transition exhibited by humans based on their height, gender and motion speed. This was achieved by utilizing the developed predictive machine learning model utilizing the KNN regression algorithm to predict knee angle. The predictive machine learning model scored 2.39° and 3.39° for mean RMSE and 0.985 and 0.988 for R2 for walking and running respectively. Next, the bidirectional knee motion is converted to unidirectional by using the developed gear mechanism before channeling it to the compound gear train to amplify the knee angular speed 25 times. This means the 1° of knee angle disregard to the direction will be amplified to 25°. Finally, the amplified knee angular speed will drive the electromagnetic generator at a higher RPM to generate higher power. The designed biomechanical energy harvester with a 0.35 kg load is able to generate RMS power ranging between 8.63 W and 13.95 W with minimal user effort to actuate the generator which ranges between 5.25 N and 10.5 N. The overall results obtained in this research for knee angle transition, gear mechanism for unidirectional motion and electromagnetic generator have been established through validation.

Hussain, Haizatul Hafizah (2023) *Flow Assurance Investigation Of Nitrogen Gas Intrusion On The Waxy Crude Oil Pipeline Restart.* Doctoral thesis, Universiti Teknologi PETRONAS.

Waxy crude oil transportation within a production pipeline often contributes to flow assurance issues. Wax deposition within the production pipeline poses challenges to production operators during pipeline restart especially during planned maintenance or unexpected shutdown. A higher pump capacity is required to disintegrate the coagulated wax deposits to fulfil pumping requirements. Nitrogen gas has been extensively used in enhanced oil recovery however no parametric study has been done on the effect of nitrogen gas intrusion on waxy crude oil pipeline during the restarting process. The present research aims to investigate the effects of different parameters of nitrogen gas intrusion to ease the restarting of the waxy crude oil pipeline. The experiments were performed by a waxy crude oil pipeline flow loop rig, while the statistical analyses were carried out using Minitab ® 19 software. It was revealed that as the gas injection flow rate increased, the restart pressure is reduced. The restart pressure can be decreased as high as 68% when nitrogen gas was injected at 3 l/min at the highest crude oil flow rate, 5 l/min. In contrast, it was discovered that gas injection pressure reduced the restart pressure by up to 62%, however up to 3 bar only, before the restart pressure increased again when the gas injection pressure is enhanced. The crude oil flow rate and gas injection flow rates facilitated the restarting process by reducing the duration for flow initiation by 74%. The crude oil flow rate was also found to reduce the outlet pressure by 43%. From the statistical analysis, full second order quadratic equations were developed, which could assist the production operators in determining the best parameter configurations during the nitrogen gas intrusion to ease the waxy crude oil pipeline restart. The optimized restart pressure, duration for flow initiation, and outlet pressure is 1.005 bar, 13.5 s, and 0.684 bar, respectively. The regression models were adequate, evidenced by R2 values with less than 5% error. The nitrogen gas intrusion not only lowers the pipeline restart and outlet pressure, but also shortens the duration for flow initiation for a smooth transportation of waxy crude oil.

Kanwal, Noreen (2023) *Psychosocial Factors Affecting Health and Well-Being through Mediating Stimuli: Injustice and Silence, under Technological Moderation.* Doctoral thesis, Universiti Teknologi PETRONAS.

The oil and gas industry in Malaysia plays a significant role globally due to its significant shares in public revenue, exports, and oil and gas reserves. However, the performance of the industry and the occupational health and safety conditions have recently declined. The Department of Statistics of Malaysia reported that, in 2021, the occupational fatal injury rate in the oil and gas and mining industry was 8.98 times higher than the country's overall occupational fatal injury rate. Addressing that, this study examined the mediating effects of perceived organisational injustice and employee silence and the moderating effects of technological interventions on the relationships of psychosocial hazards with the health and well-being of office employees. A multistage sampling technique was employed: companies were first selected through systematic random sampling technique, and convenience sampling technique was then used to select respondents. A total of 399 respondents participated in the online survey. All statistical data analyses were conducted using IBM SPSS and Smart PLS. Preliminary data analyses, such as normality, multicollinearity, and common method bias tests, were conducted, followed by structural equation modelling and multigroup analysis. The obtained results indicated the mediating effects of perceived organisational injustice and employee silence on the relationships of psychosocial factors (i.e., job demand-control imbalance, effort-reward imbalance, and work-to-family conflict) with health and well-being. Furthermore, perceived electronic monitoring significantly strengthened the negative effect of employee silence on health and well-being. Meanwhile, social media support did not significantly moderate the relationships of psychosocial factors with health and well-being. Besides that, the effects of psychosocial factors on health and well-being were significantly different between those who work online from anywhere (Group A) and those who work at the office (Group B). In particular, the effects of effort-reward imbalance and work-tofamily conflict on the health and well-being of employees who work online from viii anywhere were more substantial, while the effect of job demand-control imbalance on the health and well-being of employees who work at the office was found more substantial. Overall, this study presented significant theoretical, methodological, and practical contributions. The obtained findings can substantially support policymakers in their efforts of improving policies related to the health and well-being of employees, particularly in the oil and gas industry

Shammugam, Sreedevi (2023) *Top Management Team Characteristics And Their Impact On Firm Performance With The Role Of Diversification As A Moderator: An Empirical Study On Large Non-Financial Companies In Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

Numerous studies restated the significance of the senior management team's roles in determining the organization's future direction. TMT also involves individual experiences, values, personalities, and interactions into strategic behaviors, which can influence the organization's outcomes. Hence, to fulfill the financial support of the said organization, global business is always required for new sets of skills, knowledge, and capability of the TMT. This study explores the set of characteristics of top management team including demographic traits, psychosocial traits, cognitive traits, and group factors and how it is influences the strategic choices of an organization based on Upper Echelon Model (1984) as a foundation. Moreover, the vital role of the CEO's leadership structure as the significant determinant of the firm performance is based on the obtained evidence from large non-financial Malaysian companies. In addition, this study also addresses the impacts of diversification as a moderating role between TMT characteristics and firm performance. The company's financial performance is measured by the accounting value of ROA. The sample for the study contains 192 nonfinancial large Malaysian listed companies for the year of 2014-2019. A multivariate analysis is adopted in this study, and hierarchical regression analysis using the STATA statistical software is adopted to suit the requirement of considering cross-sectional data in the analyses. The findings reveal that demographic, psychosocial, managerial cognitive, group characteristics, and the CEO leadership structure are significant predictors of firm performance by combining all the factors into single research. Women's participation in the TMT and psychological characteristics which known as black box among the scholars is substantial and positively impacts the firm performance. The moderating role of diversification dimensions is also significant, impacting the firm's performance. Overall, this empirical study contributes the literature and gives theoretical and practical implementation for policymakers and the top ix management of companies as TMT characteristics associated with high profit of the companies.

Siddiqui, Muhammad Aadil (2023) *A Machine Learning Based Multiclass Classification Model Using Ftir Spectroscopy For Evaluating The Lard Adulteration.* Doctoral thesis, Universiti Teknologi PETRONAS.

> Food safety, interpreting spectroscopic data, and predicting physical, chemical, functional, and sensory properties of various food products are the fundamental concerns in the field of food science. The highly correlated spectral profiles of similar food types make it difficult for the conventional statistical methods to detect adulteration in lower quantities. Deep learning (DL) models are the current state-ofthe-art technique used in food science and can learn interpretable representations of the data. The ability of DL models to handle high dimensional data makes it a good candidate for the analysis of spectroscopic data reducing the need for preprocessing. Therefore, an efficient and accurate identification method is investigated in this study using an infrared spectroscopy (IR) technique combined with machine learning (ML) for meat adulteration detection. To accomplish this, pork meat is used as the adulterant in meat samples. Lard was extracted and mixed with meat samples of chicken, beef, and lamb using different proportions. Samples were made and preprocessed for multivariate analysis. The principal component analysis (PCA) is used for reducing the dimensions and for identification of the correlation between the species. The ML methods are utilized for regression and classification of the collected samples. All classifiers are tuned for the optimal performance using the different hyperparameters. Furthermore, the R square and RMSE values are compared for these methods. For multiclass classification, a DL model named DeepLard is developed with feature extraction and classification block. The performance comparison was carried out using the augmented and non-augmented data sets. DeepLard classifier outperformed the classical learning classifiers using the augmented data set. Overall, the DL model developed has the potential to detect the lowest adulteration quantity of lard (10%) successfully by utilizing the complete raw spectrum obtained through IR spectroscopy without the need of any preprocessing

Adam, Abdullahi Abbas (2023) *Studies On Novel Composite Biopolymer Electrolytes Based On Methylcellulose-Pectin-Potassium Phosphate-Zinc (Ii) Complex For Application In Electrochemical Capacitors.* Doctoral thesis, Universiti Teknologi PETRONAS.

Solid polymer electrolytes (SPEs) derived from biopolymers have been intensively explored for use in electrochemical devices due to their great flexibility, low cost, and environmental sustainability. However, biopolymer-based electrolytes cannot meet the expectations of practical applications at room temperature due to their low ionic conductivity. Over the years, improving the performance of this class of electrolytes has been the focus of intense research and development, notably polymer blending, plasticization, and structural functionalization. In this study, the aim is to synthesize novel all-biopolymer solid electrolytes based on methylcellulose-pectin blend (MC/PC) doped with potassium phosphate (K3PO4) and glycerol plasticizer using an ultrasonication-assisted solution casting technique. Results from X-ray diffractometry (XRD) and differential scanning calorimetry (DSC) show that blending of MC with PC, complexation with K3PO4 and incorporation of glycerol have all effectively decreased the crystallinity and glass transition temperature (Tg) of the prepared solid biopolymer electrolytes (SBEs). Results from Fourier transform infrared spectroscopy (FTIR) and energy dispersive analysis (EDX) equally successful blending of MC with PC. Furthermore, the prepared samples were subjected to conventional optimization as well as statistical optimization using the response surface methodology (RSM) and artificial neural networks (ANN). Electrochemical studies results obtained have shown the superiority of statistical optimization with MC/PC/K3PO4/glycerol (30/70/60/41.37) being the best SBE. This sample exhibits high ionic conductivity (2.99×10-4 Scm-1), wide potential window (4.19 V) and high cation transference number (0.96). To further improve the performance of the SBEs for device application, varying amounts of colloidal Zn (II) complex were added to prepare the composite biopolymer electrolytes (CBEs). Physical characterization using XRD, FTIR, DSC and thermogravimetric analysis (TGA) shows that the CBEs exhibit highly amorphous structure with appreciable thermal stability. Moreso, electrochemical characterization reveals that the optimum CBE (containing 8ml Zn (II) complex) recorded an ionic ix conductivity of 2.21×10-3 Scm-1 , a potential window of 4.89 V and a cation transference number of 0.963. In addition to remarkable biodegradable behaviour, this sample also shows excellent recyclability by retaining about 86% of its initial conductivity after recycling five times. Furthermore, the prototype EDLC fabricated from the optimum CBE demonstrates a good performance (3.59 Whkg-1 , 276.84 Wkg-1) suitable for practical application.

Abu Talip, Ruwaida Asyikin (2023) *Investigation of Pyrazolium Based Ionic Liquids as Electrolyte for Dye Sensitized Solar Cell (DSSC).* Doctoral thesis, Universiti Teknologi PETRONAS.

Dye-sensitized solar cell (DSSC) has emerged as a better alternative to the previous two generations of photovoltaic technologies owing to its reasonable cost, simplicity in fabrication, and availability of raw materials. The introduction of ionic liquids (ILs) into the electrolyte of DSSCs are due to their high ionicity and negligible vapor pressure. However, the viscous nature of ILs resulted in less power conversion efficiency (PCE). This study aims to investigate pyrazolium based ionic liquids as the electrolyte for DSSC and to evaluate the relationship between the photovoltaic parameters and electrochemical properties of the fabricated cell using the ILs-based electrolyte. The evaluation of the photovoltaic parameters and electrochemical properties of the fabricated DSSCs were done using I-V characterization and EIS, respectively. COSMO-RS was used in three ways viz. prescreening the potential cation and anions, explaining the physicochemical and transport properties of the ILs, and the interaction between the cation with TiO2. The triiodide-based ILs are especially having significant difference in terms of physical and thermal character from their precursor, iodide-based ILs. Cell 4-1-pz of 1-butyl-2-methylpyrazolium iodide and triiodide showed the highest PCE which is 4.76 %. Cell 4-1-pz showed a considerably higher short circuit current (Jsc) and fill factor (FF) than other cells attributable to the high ionic conductivity and the triiodide stability constant (Kstab) of the formulation H. Moreover, EIS revealed cell 4-1-pz has a better electron transport and dye regeneration process as depicted in the low Rt and high Deff and DI_3-. The increment in the length of the alkyl chain has decreased the recombination as observed in cell PenMim, 5-1-pyrr, and 5-1-pz that exhibited high teff and low Keff compared to their analogs of propyl and butyl alkyl chain. From this study, it can be deduced that the ILs are able to affect the electron transport and recombination processes in the fabricated DSSCs which is beneficial in improving cell efficiency.

Hussain, Ali (2023) *Videogames-as-a-Service: Role of In-Game Virtual Content Purchase on Adolescents' Video Game Addiction and Delinquent Behavior.* Doctoral thesis, Universiti Teknologi PETRONAS.

Online video games have emerged as a popular entertainment activity among adolescents. However, the growing popularity of online video games in many cases also leads to addiction and the development of delinquent behavior in adolescents, a phenomenon that has drawn a lot of interest. By using self-determination theory and cultivation theory, this study aims to provide refraction on how in-game virtual content purchasing can also develop online game addiction which can consequently lead to deviant behavior in adolescents. Firstly, current research conceptualizes, develops, and validates the scale of in-game content purchase motives (IGCMP) and in the next phase by collecting the data from 446 online games further examines the role of IGCPM on video game addiction (VGA) and delinquency with the moderating effect of preventive measures between purchase behavior and VGA. The Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to test the formulated hypotheses. The finding revealed that all the dimensions of IGCPM except the desire of achievement and social interaction are positively associated with in-game content purchase behavior which significantly leads to game addictive behavior. Further results indicated that video game addiction is a strong predictor of delinquent behavior in Malaysian adolescents. Apart from parental monitoring other factors (resource restriction and attention switching) are reflected as significantly weakening the relationship between in-game content purchase and video game addiction. The implications of this study are significant for various stakeholders. Game developers can benefit from insights into responsible monetization practices and the design of effective safeguards against addiction and delinquency. Parents, educators, and policymakers can gain a better understanding of the potential risks associated with in-game purchases and formulate appropriate educational and regulatory measures.

Jamaludin, Amirul Aliff (2023) *The Synergy Approach Of Taguchi Method And Rsm On Numerical Analysis Of Pdc Cutter Design Optimization.* Doctoral thesis, Universiti Teknologi PETRONAS.

Polycrystalline diamond compacts (PDC) were developed in 1964 and have since become known as exceptional cutting tools in oil and gas industry due to their extreme hardness and wear resistance. One of the greatest challenges faced by PDC cutter is "hard rock" drilling application. Therefore, the enhancement of PDC cutter performances becomes very critical. However, it raises the question on how the optimization of parameters could be done effectively. Previously, the configuration of PDC cutter parameters relied heavily on the experience and involved a trial-and-error process. However, the trial-and-error method is very time consuming, where numerous parameters have to be controlled. This thesis aims to provide new insight into the performance optimization of these cutters under different drilling conditions. The beginning of this research is focuses on the establishment of numerical model by using ANSYS explicit dynamic finite element analysis (FEA). In this section, the established numerical model are validated by comparing it with the existing experiment data. Besides, an integrated optimization approach based on Taguchi method and response surface methodology (RSM) analysis was utilized to optimize the performances of PDC cutter. In this research, the simulations experiments have been conducted by using L18 Taguchi's experimental orthogonal arrays design to identify only the significant parameters. As a result, cutter diameter, back rake angle, side rake angle, cutting edge angle and diamond layer thickness was identified as significant geometrical parameters that have a great influence on PDC cutter performances. Finally, the desirability function analysis is performed to simultaneously enhance all three mechanical specific energy (MSE), wear rate and penetration rate of PDC cutter under one set of optimal geometrical parameters condition. Results of the optimal multi-performance optimization show that the cutter diameter of 13.03 mm, back rake angle of 2º, side rake angle of 29.8º, cutting edge angle of 30º and diamond thickness layer of 2.83 mm results the best performance of MSE, wear rate and penetration rate. From this study, it can be conclude that achieving the optimal parameters condition can critically affect productivity and performance of PDC cutter. Therefore, the results drawn through this viii study can be of great significance to the practitioners, in optimization PDC cutter parameters with a minimum number of experiments runs and manufacturing cost.

Mohd Aris, Muhammad Naeim (2023) *Gaussian Process-based Inversion for Estimating Hydrocarbon Depth and Resistivity in Marine Controlled-Source Electromagnetic Application.* Doctoral thesis, Universiti Teknologi PETRONAS.

In marine controlled-source electromagnetic (CSEM) data interpretation, governing equations for electromagnetic (EM) waves are solved using partial differential equation (PDE) solvers to produce hypothetical reservoir model, and inversion scheme is utilised to refine the model by comparing it with the observational set to estimate the reservoir property. The PDE-based inversions are robust to describe the geophysical model, however, these approaches are effective when only a limited number of forward solutions are considered. It becomes impractical in the inverse modelling where many solutions are required to obtain a global-scale search. These conventional approaches also require high computational time to solve the linear systems due to its determinism, hence no uncertainty quantification of estimation involved. Addressing these gaps, this research proposes to develop Gaussian process (GP) regression model with squared exponential covariance function using marine CSEM computer experiment outputs. To efficiently estimate the geophysical properties (i.e., hydrocarbon depth and resistivity), GP-based inversion methodology is then developed by integrating GP as the forward model and gradient descent as the optimization method in the scheme. This research validates the accuracy of the forward and inverse models performed on different cases of estimation (depth or/and resistivity) by computing error and quantifies the estimation uncertainty by conducting hypothesis testing. Provided that some geophysical inputs are known, two software tools are used to develop the hypothetical model and acquire the EM data. GP is then fitted to the data to evaluate many EM responses at various unobserved input specifications. In the proposed scheme, gradient descent, where mean squared error act as the objective function, is used to find the optimal solution for the observational set. This research uses mean absolute deviation and root mean squared error to validate the forward models, whereas absolute error between the optimal solution and true value is used to validate the estimate. Magnitude error for both models is ensured to be lesser than 5%. For the hypothesis testing, if the observational data viii that fall beyond the GP predictive variance is less than 5%, the null hypothesis is assumed to not be rejected. As the result, GP is capable of evaluating many EM forward solutions without significantly increasing the computational complexity. The inversion scheme can estimate the hydrocarbon property efficiently with small errors and low time consumption. For the uncertainty quantification, all the observational sets significantly fall within the predictive variance at a significance level of 0.05.

Nallakukkala, Sirisha (2023) *Performance Evaluation and Kinetic Study of CO2-Rich Natural Gas Hydrate Formation for Produced Water Treatment.* Doctoral thesis, Universiti Teknologi PETRONAS.

Oil and gas production yield substantial quantities of by-product known as produced water, which poses disposal challenges due to its complex composition and high costs. Conventional desalination techniques face limitations in treating this water due to low recovery rates, fouling, scaling, and high energy consumption. Hydrate-based desalination has emerged as a promising alternative, that can desalinate saline water due to its ice-like structure at favorable conditions. This study aims to assess a hydratebased desalination reactor's performance by utilizing CO2-rich natural gas hydrates to treat produced water. Comparative analysis under varied feed volumes and pressures demonstrate the reactor's potential and provide scientific insights into effective gas hydrate-based desalination. Further, the reactor is modified to enhance kinetics. Relevant data and landmarks for selecting the appropriate gas systems for high water production and metal removal from produced water during hydrate-based desalination are provided. The mixed gas combination of CO2+C3H8 (70:30) provided the highest subcooling temperature at 4 ºC and 2.0 MPa. Furthermore, the kinetics of CO2 hydrate formation under different conditions are investigated. Optimal parameters lead to 45- 50% water recovery and 63-86% desalination efficiency, with lower subcooling favoring removal efficiency while decreasing water recovery. Subsequently, the kinetics of mixed gas hydrate in treating produced water produced 67-70% water recovery, in 53 mins and 47-66% desalination efficiency at 2 MPa. Machine learning models were applied to predict the removal efficiency and the support vector machine proved to have better predictive power in predicting removal efficiency by statistical, graphical, and sensitivity analysis. In summary, hydrate-based desalination offers a viable solution for produced water treatment. The study's findings shed light on optimizing reactor performance and gas composition for enhanced water recovery and desalination efficiency.

Nguyen, Ho Thi Thao (2023) *Blended Learning Acceptance Factors in Undergraduate Programs: A Case study of a Vietnamese University.* Doctoral thesis, Universiti Teknologi PETRONAS.

The advent of communication technology has impacted all sectors of life both constructively and destructively including the education system worldwide. The recent wildcard shock Covid-19 pandemic has seen an abrupt increase in communication technology adoption (e.g., social media platform, Massive Open Online Course (MOOC) etc.,) to provide desperate replacement for physical mainstream education. The inevitable failure rate of this solution was reported worldwide especially in countries which do not have a proper framework for online education. Despite the large volume of previous studies in online education, adoption of both fully online and blended learning has no conclusive success outcomes despite of available shared use of tools, platform, media, syllabus. Obviously, a clear guideline on best practice is scarce. The main aim of this study to propose the framework for blended learning acceptance factors in undergraduate programs in Vietnamese higher education context based on identifying key factors influencing students' acceptance towards blended learning, acknowledging their implementation challenges faced by the students, lecturers and the higher education institution in blended learning implementation, and the assessing quality dimensions of blended learning implementation in undergraduate programs. The study employed a triangulation mixed methods approach in which data collection was conducted on administrators, lecturers, curriculum developers and students via stakeholder surveys and semi-structured interviews. On the quantitative approach, IBM AMOS version 24 was employed, in which Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) were used to analyze the survey results whereas thematic analysis was used qualitatively to identify the emerging themes and subthemes from the interview findings based on research objectives 1 and 3. Descriptive analysis was employed to analyze the survey results whereas thematic analysis was used to identify the emerged themes and sub-themes of interview findings of the research objective 2. The key findings were acceptance factors for blended viii learning using MOOCs from stakeholders' view on identifying key factors influencing the student acceptance towards blended learning, acknowledging the implementation challenges, and identifying the quality dimensions of blended learning delivery. The stakeholders' views indicated that learning ecosystem, leaners' competence and experience, perceptions towards relevance of blended learning using MOOCs could influence students' acceptance towards blended learning. Additionally, the stakeholders presented challenges faced by the students, challenges of offline mentoring sessions faced by lecturers, and challenges of MOOCs management faced by the higher education institution. Importantly, the stakeholders argued that the dimensions of the quality in blended learning implementation should include the alignment among teaching, learning, and assessment approach, learning material development, and the service quality of blended learning and student satisfaction. The final outcome of this study suggested a proposed framework for blended learning acceptance factors which integrates the curriculum design, pedagogy, lecturers' professional development and institutional policies.

Oyewale, Oyelakin Idris (2023) *Examining Causal Relationship of Servitization, and Green Servitization on Sustainable Performance: Mediating Role of ISO 14001 on Malaysian Public Listed Manufacturing Firms.* Doctoral thesis, Universiti Teknologi PETRONAS.

The continuous production activities of manufacturing firms have increased emission (Co2) and depletion of resources and becoming contemporary problem that requires an urgent shift to efficient utilization of limited available resources. This has become a great concern among manufacturing firms' industry due to the associated problem of physical flow of energy and materials through the ecosystem. In recent times, many consumer product manufacturing firms are facing resource sustainability issues arising from sporadic demand of various products that is leading to increased resource usage and waste management problems. As a result of this enormous waste and emission of carbon produced by the manufacturing firms during operations, future generations are at risk of resource and environmental sustainability. Specifically, firms are facing huge sanctions in the form of monetary costs from government and consequently affect their overall sustainable performance. Some manufacturing firms are challenged by not taking proactive measures to mitigate against environmental pollutions arising from unsustainable production materials, leading to huge waste and high cost of production. Hence, there is a need for the operation of green servitization as an alternative production process for better sustainable and environmental performance. In light of this problem, the current study carries out an extensive review of studies in environmental and operational management and thereafter employed a quantitative methodology in three research design phases; identifying dimensions for survey measurement instruments, survey validation and pilot study, as well as data analysis through the use of SPSS and SmartPLS-SEM. Findings show that out of the seven direct viii relationships hypothesized involving Servitization dimensions (Offerings, Resources, and Activities) and Green Servitization dimensisons (Green Products, Green Internal Competencies, Green Maintenance, and Green Digital Technology) on Sustainable Performance, only 2 direct hypotheses were supported out of secven tested hypotheses while mediation effect of ISO14001 supported all the seven (7) indirect relationships. In conclusion, the outcome of the current study could serve as a platform for educating and creating awareness of the importance of promoting the benefits of green production practice among public listed consumer product manufacturing firms' for achieving higher sustainable performance.

Rosli, Nurfatihah Syalwiah (2023) *Remaining Useful Life Prediction Of Air Booster Compressor Motor Cooler Using Optimized Deep Learning Model.* Doctoral thesis, Universiti Teknologi PETRONAS.

Air Booster Compressor (ABC) motor cooling system plays a critical role in preventing overheating. However, at present, Air Temperature Cold (ATC) and Motor Air Temperature (MAT) of the motor cooler are not closely monitored to indicate motor cooler degradation which leads to unplanned plant shutdown. To address this issue, data-based predictive maintenance techniques are being developed to predict the Remaining Useful Life (RUL) of the motor cooler. However, the limitation of sufficient run-to-failure data for motor coolers can affect the performance of RUL prediction models. Furthermore, current deep learning approaches used in RUL prediction such as Deep Neural Networks (DNN), Long-Short Term Memory (LSTM) and Gated Recurrent Unit (GRU) are prone to lose important information and have limited capability to capture long-term dependencies in sequential data. To address these limitations, a combined mathematical model is proposed to represent the actual dynamics of the ABC motor and cooling system. Then, this model is used to generate degradation data for RUL prediction model development using a hybrid technique that integrates the advantage of spatial management from Convolutional Neural Network (CNN) with the sequential analysis capabilities from GRU. The proposed methodology involved collecting actual data from a utility plant to model the ABC motor and its cooling system. This model successfully represents the actual trend with a mean absolute percentage error of 0.68%, achieving the benchmark of less than 1%. Then, the hybrid CNN-GRU prediction model is then optimized using a hybrid of Particle Swarm Optimization and Genetic Algorithm (PSO-GA) to identify the best hyperparameters for the model. The result showed that the proposed model exhibits higher accuracy with a percentage improvement of up to 80% with faster training time compared to non-optimized and non-hybrid deep learning methods. The model achieves the lowest RMSE of 13.52 and the lowest SF of 102, indicating its accuracy and robustness. This makes it highly effective for predictive maintenance planning, cost savings, and prolonging equipment lifetime.

Suppiah, Raja Rajeswary (2023) *Development Of Geopolymer Cement For Low Temperature, Low Pressure Oil Well Cementing.* Doctoral thesis, Universiti Teknologi PETRONAS.

Well cementing is one of the important systems in oil and gas drilling. It provides support and protection to the casing, prevents the movement of fluid through the annular space outside the casing. However, Ordinary Portland Cement (OPC) used are having issues with its strength since it takes a long period of time to develop and lots of rig time losses for waiting on the OPC to set. For that purpose, the petroleum industry is also striving for developing highly strength oil well cement and environmentally friendly cementing systems for oil well application to have a sustainable well as well as reducing the environmental impacts and greenhouse gas emissions. This study has focused on new formulation for geopolymer cement using fly ash as an alternative to Class G cement which should be able to give better compressive strength and cement setting hence indirectly reducing the CO2 emission from the Portland cement manufacturing and process. The linear equation produced from this research predicts the cement compressive strength at various density, curing temperature and curing pressure as well as allow cement operator to design cement formulations using the correct amount of strength material to add. The newly formulated geopolymer cement were tested against API 10B R2 testing procedures requirement to qualify as oil well cement. It was found that the cement formulations developed in this study for a range of temperature from 30 to 90 degree Celsius and pressure 1000 to 3000 psi has a density range from 10 to 17 ppg with addition of light weight extender and barite. It has also reduction in plastic viscosity of 11% as the ratio of solid to liquid reduced, the thickening time dropped from 5 hours at 300C to 3 hours at 900C. The compressive strength increases up to 12 M of NaOH concentration and reduces as the concentration increases. The proof-of-concept design of geopolymer cement on the ability to prevent gas migration and better strength and durability through the cement matrix was proved in the lab.

Umair, Muhammad (2023) *Deep Learning Model For Sea State Classification Using Visual-Range Sea State Images.* Doctoral thesis, Universiti Teknologi PETRONAS.

Wind-waves exhibit variations both in shape and steepness. Their complex, asymmetrical nature constitutes a sea state. A sea state can be divided into 13 classes. Its classification plays an important role in maritime operational safety. Traditional sea state classification methods involve statistical descriptions of wave parameters and numerical wave modelling. They are operationally and computationally expensive as they depend on large amounts of bathymetrical, meteorological, and oceanographic data and involve numerical computations. Deep learning has been recently introduced in sea state classification studies. The existing solutions, however, lack a publicly available benchmarked sea state image dataset, and their classification accuracy can be further improved. To mitigate these issues, a sea state classification method based on deep learning and a visual-range sea state image is proposed. In this context, a novel visual-range sea state image dataset was designed and developed. An extensive offshore and onshore field data collection study across West Malaysia was conducted, and 1.7 million sea-state video frames and corresponding wind data were acquired. A dataset was proposed that consists of 100,800 equally distributed images of four sea states. The dataset benchmarking was performed using 19 state-of-the-art deep learning image classification models. Based on the optimal model from benchmarking experiments, a sea state classification model was systematically designed, developed, tested, and improved. The proposed model yielded an overall classification accuracy of 88.7%, which is an 8.5% improvement in classification accuracy over the top-performing state of-the-art model. To further establish the accuracy of the results, they are validated by maritime experts. Additionally, a 72% decrease in model parameters was achieved. Moreover, during the course of the study, a sea horizon line detection method for rough sea state is proposed and tested. The proposed method accurately identified sea horizon lines in 87.4% of test images while the traditional projection-based method achieved ix 50% detection rate. The proposed method's' mean difference between ground truth and detected sea horizon line slope was 1 degree, with a standard deviation of 1.3 degrees.

Tuan Sulong, Tuan Syahylah (2023) *Synthesis And Characterization Of Cu/Cnts Catalyst For Co2 Hydrogenation Into Methanol And Methyl Formate.* Doctoral thesis, Universiti Teknologi PETRONAS.

CO2 hydrogenation into value-added chemicals provides alternative approach to mitigate greenhouse effect and to reduce dependence on fossil feedstock. The objective of this work is to synthesize, characterize Cu-ZnO-based nanocatalyst on multi-walled carbon nanotubes (MWCNTs) support and study the performance of the nanocatalyst via CO2 hydrogenation to methanol and other oxygenates. Supported Cu/ZnO- based nanocatalysts have been formulated using impregnation method, due to its easy operation and controlling. In this work, synthesis parameters such as total metal loading, Cu:ZnO ratio, synthesis pH and type of support were fixed at 15wt%, 7:3, pH=7, and CNTs support, respectively, based on previous reported works by other researchers. Effects of the alkali promoters, that was demonstrated by several researchers to improve performance and catalytic characteristics such as manganese (Mn), zirconium (Zr), and niobium (Nb) in form of single, double, and tri-promoters on the physicochemical properties of the catalyst have been investigated. The physicochemical properties of the catalysts were studied using N2 physical adsorption, transmission electron microscopy (TEM), X-ray diffraction (XRD), X-ray photoelectron (XPS), temperature-programmed reduction and desorption (TPR/D) and N2O pulse chemisorption. The performance of the synthesized catalysts in CO2 hydrogenation to methanol was examined in a two-phase reaction system, which is a fixed-bed micro activity reactor, at various reaction conditions. The physicochemical properties of MWCNTs supported Cu/ZnO- catalyst was influenced by the type of alkali promoters added into the catalysts. Higher Cu surface area with better dispersion due to smaller particle size, which was more uniformly distributed was obtained at double promoted Mn-Nb-Cu/ZnO-CNTs (MN-CZC) catalyst under the same synthesized conditions. The MN-CZC catalyst had average particle size of 4 ±1.1 nm, as measured by TEM and resulted in CO2 conversion of 18.69% at default condition of 250oC, 2.25 MPa and 3H2/CO2 v/v ratio. The addition of promoters improved the reducibility, dispersion of Cu (highest SCu = 4.90 m2 /g, highest Cu dispersion of 7%), BET surface area (highest SBET = 177 m2 /g), and Cu surface areas up to 4.9 m2 /g. Compared to those with other promoters or combination of promoters, combination of Mn and Nb works as structural promoter by stabilizing viii more Cu nanoparticles on the outer surface of CNTs. The CO2 conversion trend correlated to the size of nanoparticles, Cu dispersion as well as Cu surface area where the results show that catalysts with average particle size of 5 nm yielded CO2 conversion > 18%. All studied catalysts exhibit the same pattern of product distribution, with methyl formate (MF) as the primary product. Simultaneously, higher reaction temperature has contributed to the formation of methane as the main product, as well as a decrease in the formation of methyl formate. Additionally, the kinetic parameters were estimated, assuming the reaction is second order, which resulted in activation energy value of 9.93 kJ/mol·K. Since methyl formate is one of the main building blocks in C1 chemistry and has been utilised extensively in the manufacture of more than 50 compounds, this may lead to a new approach in industries that can be applied in direct CO2 hydrogenation.

Abro, Ghulam E Mustafa (2023) *Evaluating SDF-based Robust Control Schemes with Observer Designs for an Underactuated QUAV under Unmodeled Dynamics.* Doctoral thesis, Universiti Teknologi PETRONAS.

For an underactuated Quadrotor Unmanned Aerial Vehicle (QUAV), a Newton Euler Dynamic model with a hyperbolic function and the manipulation of external disturbances has been chosen in this thesis. Additionally, one may be able to view the performance evaluation of single dimension fuzzy (SDF) based backstepping control (BSC) and sliding mode control (SMC) under the influence of unmodeled dynamic factors. It turns out that single dimension fuzzy-based SMC design produces better results than single dimension fuzzy-based BSC; as a result, various advancements in this type of control scheme have been made within thesis, including model-free single dimension fuzzy-based SMC (MFSDFSMC), dual loop single dimension fuzzy-based sliding mode control with linear extended state observer (DLSDFSMC with LESO), and last but not the least, dual loop single dimension fuzzy-based sliding mode control with positional estimator and disturbance observer (DLSDFSMC with PE and DO). This dissertation also discusses cutting-edge techniques, the majority of which are adaptive-robust control algorithms. By analyzing the limitations of earlier proposed solutions, the dissertation demonstrates that the sinusoidal functions of the roll, pitch, and yaw subsystems are the primary issue. In order to draw the conclusion that the outcomes of the suggested (DLSDFSMC with PE and DO) control method have been demonstrated to be superior for the improving the transient and steady state responses, Zeno effect, convergence rate and excessive time delays. Consequently, verified by an experimental setting. The Lyapunov stability proof for all proposed SDF-based control systems is also available.

Alpandi, Amni Haslinda (2023) *Inhibition Of Paraffin Wax And Scale Deposition From Penara Crude By Jatropha Oil With Silver Nanoparticles Through Wax Appearance Temperature And Pour Point Reduction.* Doctoral thesis, Universiti Teknologi PETRONAS.

Wax deposition is one of the main flow assurance problems at the production stage of the oil and gas industry. In conjunction with wax deposition, scale deposition can also interrupt the flowability of crude oil in pipelines. Common industrial chemical additives used to mitigate wax deposition, such as triethanolamine and poly ethylenecovinyl acetate, are found to pose safety problems when seepage or leakage occurs during transportation or operation. Furthermore, these additives are only solving one type of flow assurance problem at a time. Studies on dual inhibitor performance are found to be limited in literature, thus providing the motivation for this investigation. Hence, this study aims to investigate the effectiveness of a dual inhibitor from a natural plant source. One natural plant-based wax inhibitor was selected from jatropha seed oil (JSO), crude palm oil (CPO), and crude palm kernel oil (CPKO) based on their paraffin inhibition efficiency (PIE), and the experimental findings were supported by characterisation tests using gas chromatography/mass spectrometry (GC/MS) and Fourier transform infrared spectroscopy (FTIR). Then, a series of experiments was conducted using a Fann viscometer and a jar test. In order to enhance the understanding of the active components found in JSO, PVTsim software was used to simulate the effect of oleic acid on wax deposition and validate the experimental results. The results of this study revealed that 5% JSO gave the highest PIE, which is 86.30%. The major active component in Malaysian JSO is oleic acid (44.91%) with an ester fatty acid functional group. From the rheological and scale deposition tests, 1% JSO blended with 1% silver nanoparticles was found to be an effective jatropha-based dual inhibitor as it completely reduced the plastic viscosity, and the scale inhibition efficiency is 9.63% at 60 °C. The simulation results showed that as the concentration of oleic acid increased from 1% to 70%, the PIE of the additive also increased. The viscosity of the crude oil decreased continuously with increasing temperature from 55 to 80 °C. These simulation findings successfully validate the experimental results on the PIE of JSO and the viscosity of crude oil. The main contribution of this study is the development of a novel formulation of jatropha-based dual inhibitors to mitigate wax and scale deposition, thereby contributing towards the remediation of groundwater contamination and reduction of the operating costs of crude oil production

REHMAN, MASOOD (2023) *Innovative Hybrid Topology for Inductive Coupled Wireless Power Transfer with Robust Control Mechanism.* Doctoral thesis, Universiti Teknologi PETRONAS.

Inductive coupled wireless power transfer (ICWPT) has emerged as a promising solution for battery charging of electric vehicle (EV). Compensation topology is the most important aspect in the design of ICWPT system along with control mechanism. Significant work is done on the compensation topologies of ICWPT system to obtain load-independent constant current (CC) and constant voltage (CV) output. The load independent CC and CV output along with zero phase angle (ZPA) is essential for efficient ICWPT system, as it enhances power delivery of ICWPT system. Mostly, hybrid topologies were proposed in the literature to realize load-independent CC and CV output; however, they were complex without any control mechanism, also they needed communication link between the coils. Therefore, this thesis presents an innovative hybrid topology for wireless power transfer with robust control mechanism. The proposed topology uses series-series (SS) and inductor-capacitorcapacitor/series (LCC-S) topologies for obtaining load-independent CC and CV output along with ZPA. The proposed compensation uses primary side switching with only one capacitor from receiver side, thus minimizes the circuit elements at the receiver side. The switching control mechanism is provided along with the current estimation method. Thus, there is no need of communication link between transmitter (Tx) and receiver (Rx) coils to control the switches. The switching process can be controlled easily from the primary side by the estimated output voltage. Moreover, the coupling coefficient varies during charging process, as it is difficult to fully align Tx and Rx coils for EV charging process. During misalignment of Tx and Rx coils, the mutual inductance changes, thus coupling coefficient also changes, which affects the output constant voltage profile; consequently, the power delivery of the system is affected. Therefore, a PID based control system is designed for ICWPT system to regulate the voltage at constant level during misaligned conditions. The results of hybrid topology showed that, the maximum-load-efficiency of above 90% was achieved in CC and CV mode at an air gap of 130 mm. Moreover, the result of PID controller based ICWPT system provided above 90% efficiency, while maintaining the peak value of 240 V during misalignment of the coils. The maximum output current was set at 10 A.

Thulasiraman, Sundarajoo (2023) *Undoped And Ionic Liquid Doped Asphaltene As An Ambipolar Organic Semiconductor.* Doctoral thesis, Universiti Teknologi PETRONAS.

Solution-processed organic field effect transistors (OFETs) have received special attention, owing to their potential for simple and low-cost manufacturing. However, the lack of solution processable, the lack of flexibility in polarity conduction, and the lack of charge carrier density in organic semiconductors (OSCs) have prevented OFETs from being adopted as a viable technology. In this work, asphaltene, which is typically considered waste in the refinery, is investigated for potential use as an organic semiconductor (OSC) owing to its π-conjugated carbon arrangements. Prior to the asphaltene extraction, the crude oil tank bottom sludge (COTBS) was thermally treated at 100 ^{O}C in a muffle furnace. The extracted asphaltene sample was subjected to elemental analysis. The stock solution of asphaltene in toluene and ionic liquid (IL) in chloroform was prepared at concentrations of 0.4 g/l and 1.38 g/l, respectively. Based on the mass of the asphaltene in a 3 ml solution, the required IL to achieve the needed doping ratio was identified. The undoped and IL-doped asphaltene-based OFETs were fabricated by spin-coating the prepared undoped and IL-doped asphaltene solution on the electrodes, respectively. From the elemental analysis, carbon and hydrogen contents were 81.73 wt% and 8.91 wt%, respectively. Hence, it can be confirmed that asphaltene is successfully extracted. The doping of the IL in asphaltene improves the number of charge carriers by two orders of magnitudes i.e., from 106 cm-2 to 108 cm-2 . Eventually, the fabricated bottom gate bottom contact (BGBC) structured OFETs exhibit FET characteristics. Moreover, the device demonstrated ambipolar conduction with hole (μh) and electron (μe) mobilities of 10-4 cm2 /Vs and 10-8 cm2 /Vs, respectively. In this work, undoped and IL-doped asphaltene-based OFETs were demonstrated, which is the first of its kind.

Ali Algamili, Abdullah Saleh (2023) *Development Of Highly Sensitive Noninvasive Acetone Gas Detection Sensor Using Memsbased Polymumps Technology.* Doctoral thesis, Universiti Teknologi PETRONAS.

Being overweight, especially obesity, harms nearly every aspect of health, from sexual and pulmonary function to cognitive and mood. Thus, breath acetone detection is an ideal non-invasive, painless, cost-effective and portable method to detect and evaluate fat burning. Therefore, this research proposed to develop a MEMS device that can be utilized to attain this purpose due to its compact size and low power consumption. MEMS devices based on standard Polysilicon Multi-Users MEMS Process (PolyMUMPs) have been fabricated and characterized for the purpose of detecting breath acetone gas. A sensitive and selective material of titanium dioxide $TiO2$ has been deposited and coated on the sensing layer of the moving plate. When the sensor will be exposed to a human breath, the sensing material absorbs/adsorb the acetone gas and this interaction causes the sensor mass to increase, also the displacement of the device change. This change is measured and correlated to the concentration change of the acetone gas. Electrothermal actuation method has been used to drive the sensor in the dynamic mode and the output voltage has been measured using an MS3110 universal capacitive readout circuit that is used to readout the small change of the static capacitance when the device is actuated. The device's theoretical parameters are determined via analytically modelled equations, validated through simulation, and verified experimentally. Experimental results show that the PolyMUMPs device is capable of detecting acetone gas with concentrations ranging from a lower detection limit of 0.01 ppm to 4 ppm. The mass sensitivity of the device is found to be 3.8574 μHz/fg, while the detection limit indicates that the device can detect up to 44 ppb. The response time was found to be ~90 seconds, while the recovery time was found to be ~15 seconds. The output voltage change of the experimentally tested was found to linearly increase from 0.176 V to 0.295 V. The sensor is found to be more sensitive towards acetone gas compared to other VOCs gases.

Imran Gulcharan, Nurul Fauzana (2023) *A New Development Of Investigation Of Power System State Estimation For Dynamic Power Network.* Doctoral thesis, Universiti Teknologi PETRONAS.

With the current rapid energy storage and power electronic loads penetrating the power system, dynamic state estimation is playing a main role. The received measurements are sometimes insufficient and uncertainty from measurement noise, network model inaccuracies, or errors introduced in various stages of the communication path which leads to the challenges of unable to obtain faster system response or even insufficient protection functions. Detection of per measurements are not suitable for dynamic system as it will require a longer time for computation and thus leads to computation burden due to insufficient measurement. Statistical techniques such as normalized residuals and chi square tests are commonly used to detect and identify bad data problems, however, do not have the greatest capability for treating gross measurement errors. Thus, the objective of this research is to conduct a study on performance comparison towards the IEEE 14 bus system, IEEE 30 bus system, IEEE 57 bus system and IEEE 118 bus system in terms of stability, computational time, and system accuracy by using modified algorithms from the Weighted Least Square (WLS) estimator as well as to integrate the measurements from pre – estimated values. Each of the bus systems was tested under multiple stress conditions with multiple set measurements per bus system and conducted in 10 loops of simulation to obtain the average computational time. The outcome of the test has shown that the modified method could allow the system to converge even in multiple stress conditions. The technique implemented of MJ -WLS ensured the system stability and observability by providing adequate number of states and measurements, capable of reducing the computational time and burden by the selection of available measurements to assist real time state estimation. The pre – screening technique, ARM - JWLS applied allows the number of measurements to be higher than the states to ensure accuracy of the final estimate. The established performance in the applied techniques in real time measurement are crucial as it enables reliability, better security, and protection towards dynamic network in a distribution system.

Al-Hiyali, Mohammed Isam Naji (2023) *Principal Wavelet Coherence Of Dynamic Functional Connectivity For Diagnosis Of Autism Spectrum Disorder.* Doctoral thesis, Universiti Teknologi PETRONAS.

The study of functional connectivity (FC) of the brain using resting-state functional magnetic resonance imaging (rs-fMRI) has gained traction in uncovering FC patterns related to autism spectrum disorders (ASD). It is believed that the neurodynamic components of neuroimaging data enhance the measurement of the FC of brain nodes. Hence, methods based on linear correlation of rs-fMRI may not accurately represent the FC patterns of brain nodes in ASD patients. This study proposed a new biomarker for ASD detection based on wavelet coherence and singular value decomposition. In essence, the proposed method provides a new feature vector, which is extraction of the principal component of the neuronal dynamic FC patterns of rs-fMRI BOLD signals. The method known as principal wavelet coherence (PWC), is obtained by applying singular value decomposition (SVD) on the wavelet coherence (WC) and extracting the first principal component of the WC. The ASD biomarkers were selected by analysing the relationship between ASD severity scores and the averaging of wavelet coherence coefficients (WCC). The experimental data set, which included 505 ASD patients and 530 normal control subjects, was obtained from the publicly available Autism Brain Image Data Exchange (ABIDE) data set. This data was randomly divided into 90% for training and cross-validation and 10% unseen data to test the performance of the trained network. The ASD classification results show good performance with 95.2% accuracy compared to previous results based on the ABIDE database. In the same context, the average accuracy is 90.2% for PWC + 3LCNN in ASD subtype detection (ASD, PAD and PDD-NOS). The results of this study have illustrated the good potential of the PWC technique in representing the dynamics FC between brain nodes and open up possibilities for its clinical application in diagnosis of other neuropsychiatric disorders.

Hanif, Mehwish (2023) *Design And Optimization Of Thin Film Multilayer Structures For Acousto-Optic Devices.* Doctoral thesis, Universiti Teknologi PETRONAS.

Wearable applications featuring photonic on-chip sensors are on the rise. Among many ways of controlling and/or modulating, the acousto-optic technique is a popular technique. So far, the material used in fabricating an acousto-optic tunable filter is in bulk form, limiting its use in integrated optics. Therefore, new materials are needed to be explored, which can lead to the realization of CMOS compatible acousto-optic tunable filter. This work investigates different multilayer structures that can be fabricated for realizing an acousto-optic device, the objective being to obtain a high acousto-optic figure of merit (AOFM). The proposed structures are ZnO/SiO2/Si, LiNbO3/SiO2/Si and AlN/SiO2/Si. The selected materials (i.e., ZnO, LiNbO3, and AlN) possess both optic and piezoelectric properties, making them suitable for acousto-optic devices. An investigation of Sezawa and Rayleigh wave propagation modes, as well as the optimization of the film's thickness level, is conducted. Several properties are discussed by varying the thicknesses of the layers of these materials. The study shows that the multilayer thin film structure-based devices can give a high value of electromechanical coupling coefficient (k 2) and a high AOFM as compared to the bulk piezoelectric/optical materials. The study is conducted to find the optimal SAW mode and normalized thickness of the multilayer structures with a material possessing the best optical and piezoelectric properties for fabricating acousto-optic devices. Based on the simulations and studies of SAW propagation characteristics, such as the k 2 and phase velocity (v), the acousto-optic figure of merit is calculated. The maximum value of the acousto-optic figure of merit achieved is higher than the AOFM of all the individual materials used in these layer structures. The suggested SAW device has potential applications in wearable and small-footprint acousto-optic devices and gives better results than those made with bulk piezoelectric materials.

KARNA, VISHNU VARDHANA REDDY (2023) *Heart Disease Risk Prediction Using Hyperparameter Optimized Machine Learning With Principal Component Transformed Features.* Doctoral thesis, Universiti Teknologi PETRONAS.

Heart disease is one of the leading causes of sudden death for many individuals around the world. Early-stage prediction of heart disease risk can save lives by undergoing appropriate diagnosis steps or making necessary lifestyle changes. Recent studies have focused on using data mining and machine learning techniques to detect heart disease based on specific features. The previous research studies on heart disease risk prediction have limitations such as small datasets, irrelevant features, lacking hyperparameter tuning and less classification accuracy which varies between 78% and 94%. This study aims to develop a best predictive model using feature engineering and hyperparameter optimization for improving heart disease classification accuracy. The methodology that was deployed in this research involved data pre-processing where Cleveland and Statlog heart disease datasets were integrated to obtain a greater number of observations, feature engineering, hyperparameter optimization and classification. Feature engineering comprises of Principal Component Analysis and feature selection that includes Correlation-based Feature Selection, Chi-square, Gain Ratio, and Relief techniques which have been applied to select the significant original and transformed features of heart disease. Then, optimization was performed to determine the best hyperparameters by utilizing a Bayesian optimizer. Finally, classification using machine learning algorithms has been carried out using various single and ensemble classifiers such as Decision Tree, Naïve Baye, Logistic Regression, Support Vector Machines, K-Nearest Neighbors, Artificial Neural Networks, AdaBoost M1, Bagging, and Rotation Forest, on full and optimal sets of original and transformed features of heart disease. The outcome of this research clearly produced significant principal component transformed features based on Chi-square and Gain Ratio feature engineering techniques with the best classification accuracy of 98.80% and an AUC of 1.0 using optimized K-Nearest Neighbors (OKNN).

Ahmad, Isiyaka Hamza (2023) *Absorption Of Selected Herbicides By Mil-101 (Cr) And Mil-53 (Ai) Metal-Organic Frameworks: Optimization, Validation And Molecular Docking Simulations Studies.* Doctoral thesis, Universiti Teknologi PETRONAS.

Adsorption and modelling of the herbicides 3, 6- Dichloro-2-methoxybenzoic acid (dicamba; DCA),2-chloro-N-(2-ethyl-6-methyl-phnyl)-N-(1-methoxypropan-2-yl) acetamide (metolachlor;MET) and 4-chloro-2-methyphenoxyacetic acid (MCPA) from water using MIL-101 (cr) and MI:-53(AI) metal-organic frameworks (MOFs) were explored in this study. Previously reported adsorbents are faced with longer equilibration time in hours, incomplete removal efficiency with several experimental runs by trial and error, low adsorption capacity, poor regeneration, and reusability potentials as well as the lack of information on the binding interaction, affinity and binding position between the studied herbicides and the adsorbents. The study aims to apply alternative porous materials with high adsorbents. The study aims to appky alternative porous materials with high adsorption capacity, good water and thermal stability, shorter equilibrium time at optimized condition using minimum experimental runs, prediction and validation of the experimental adsorption, and understand the binding interaction at molecular level. The MOFs were hydrothermally synthesized and characterized by thermal gravimetric analysis (TGA), filed emission scanning electron microscopy (FESEM), X-ray diffraction (XRD), Fourier transformed infrared spectroscopy (FTIR) and nitrogen adsorption-desorption measurement. Experimental design, optimization, prediction, and validation of the adsorption capacity were determined using the central composite design response surface methodology (CCD-RSM) and multilayer-perceptron-feed-forward artificial neural network (MLP-FF-ANN). The batch adsorption process was investigated by varying the effects of contact time (5-60min), initial concentration (5-50 mg/L), MOFs dosage (5-50 mg), pH of the solution (2-12) and temperature (25-59 °C). the optimization of the process parameters revealed fast equilibration time within 25-30 minutes using 50 mg/L concentration, 10-20 mg MOF dosage, solution pH 4 and temperature of 40 °C with 44 runs. MET preferred to bind and absorbed at the outer pore of the MOFs. Prospect for the reusability potential of the MOFs were shown to have superiority for the removal of DCA, MET and MCPA from water in terms of shorter equilibrium time, reusability, higher adsorption capacity and efficiency. Hence, can be employed as adsorbent materials for the removal of herbicide contaminants from environmental waters.

Alakbari, Fahd Saeed (2023) *Development Of Critical Total Drawdown Pressure And Geomechanical Properties Models: A Data-Driven Approach.* Doctoral thesis, Universiti Teknologi PETRONAS.

Critical total drawdown (CTD) along with the sand production index method (based on static Young's modulus (Es) and static Poisson's Ratio (υs)) are commonly used to detect sand production. Some CTD, Es, and υs models are used in the literature. However, these published models have limitations: lack of accuracy, limited data ranges, and lack of proving the relationships between the inputs and outputs. Moreover, the previous Es and υs models which are used to determine the sand production prediction fail to detect the accurate sand onset tendency and rock's types. This study aims to apply data-driven approaches to accurately and reliably predict the CTD, Es, and υs for accurate evaluation of the sand rock consolidation and sand onset tendency. Different data-driven models, namely the Adaptive-Neuro-Fuzzy-Inference-System (ANFIS) and Gaussian-process-regression (GPR) were developed based on 23 wells from the Adriatic Sea for the CTD, 1853 and 1691 datasets from the United States, Malaysia, India, Saudi Arabia, and Venezuela for the Es and υs. The proposed models were evaluated using trend analysis to show the relationships between the inputs and outputs and an average-absolute-percentage-relative-error (AAPRE), to indicate the models' accuracy. Comparison of the developed data-driven models with the published models indicated that all the proposed models are more accurate and can more properly follow the actual trends. The developed CTD prediction models have AAPRE in the range of 4.293 to 12.703%, while the previous CTD prediction models have AAPRE of more than 20%. The effects of independent variables on the CTD, Es, and υs are evaluated using trend analyses. The First and second ranks models to determine the Es are the ANFIS and GPR with AAPRE of 5.10% and 5.41%. The Es published models have AAPRE of more than 10%. The Gated Recurrent Unit and GPR are the top υs rank models with AAPRE of 3.22% and 3.77%, compared to published models with 10.65%. Moreover, the previous models fail to accurately predict sand onset tendency and rock types based on Es and υs while the proposed models show the correct sand onset tendency and rock types based on Es and υs prediction.

Jagaba, Ahmad Hussaini (2023) *Treatment Of Pulp And Paper Industry Wastewater Using Combined Activated Sludge And Biosorption Treatment Systems.* Doctoral thesis, Universiti Teknologi PETRONAS.

Current conventional treatment systems are unable to reduce the negative impacts since they were not intended for effluents with high pollutants concentrations. The effectiveness of extended aeration system (EAS) and paddy straw activated carbon – extended aeration system (PSAC-EAS) in the treatment of pulp and paper industry wastewater (PPIW) was investigated in this study. The effect of various PPIW concentrations and the hydraulic retention time (HRT) were investigated to examine the performance of extended aeration system (EAS) bioreactor and sequential batch reactor (SBR) systems, in a continuous flow and batch modes respectively. The experiments were conducted using a 10 L and 5 L EAS and SBR bioreactors, respectively that operated at 1-3 days hydraulic retention times (HRT) with PPIW concentrations at 20-100%. The bioreactors were fed with real PPIW having initial COD, NH4 + -N and total phosphorus (TP) concentrations that varied between 1142-5617 mg/L, 11.74-59.02 mg/L and 31-161 mg/L respectively. EAS, Anoxic-SBR and SBR bioreactors were operated without a biosorbent whereas the PSAC-EAS and PSAC -SBR bioreactors were filled with biosorbent. The experiment was designed to investigate the effect of HRT and PPIW concentration on COD, NH4 + -N, and TP removal of PSAC-EAS and PSAC-SBR. The result revealed that the maximum COD, NH4 + -N, and TP removal by PSAC-EAS are 89.62%, 73.85%, and 62.73% respectively while PSAC-SBR achieved 96.17%, 92.84%, and 90.86% removals respectively at 48 hrs HRT with 60% PPIW. However, the TP removal was lesser as compared to NH4 + -N. Thus, it was evident that the PSAC-SBR performance was better than PSAC-EAS due to application of PSAC. The First and second order models and Modified Stover-Kincannon models were utilized to analyze substrate removal rates. The modified stover was found to be perfectly suited for the observed measurements with values R2 values of 0.9797 and 0.9853 attained for ammonia-N and TP respectively in EAS. The PSAC-EAS had 0.9977 and 0.9968 for ammonia-N and TP respectively.

Kolawole, Afolabi Haruna (2023) *Development Of Polyethylene/Polypropylene Fibrous Radiation Grafted Adsorbent Containing Glycidol Ligands For Boron Removal.* Doctoral thesis, Universiti Teknologi PETRONAS.

Boron compounds are widely utilized for various industrial processes which are anthropogenic sources of boron in the natural environment, this poses health concerns to humans and animals health when released to water bodies. Hydroxyl-enhanced materials are promising for boron removal due to their higher chelation properties resulting to esters formation. The objective of this study is to develop a new fibrous boron chelating adsorbent prepared by radiation induced grafting copolymerization (RIGC) of N-vinylformamide (NVF) onto polyethylene/polypropylene (PE/PP) nonwoven sheet followed by hydrolysis and functionalization with glycidol moiety. The best RIGC reaction parameters for achieving high degree of grafting (DG) was determined. The degree of hydrolysis and glycidol density loaded in the adsorbent was optimized via response surface methodology (RSM). The properties of the prepared adsorbent were evaluated using various characterization techniques. The performance of the adsorbent under various conditions for boron removal was tested in the batch and continuous adsorption modes. The grafted poly(N-vinylformamide) (PNVF) with DG of 120% was obtained at 20 vol% NVF concentration, 300 kGy absorbed dose, 70 °C temperature, and 3 h time. The PNVF was then completely hydrolysed to PVAm prior to glycidol functionalization at NaOH concentration, reaction temperature and time of 2.5 M, 79.3 °C, and 3.7 h respectively. A maximum glycidol density yield of 5.0 mmol/g was achieved when functionalized with 11.8 vol%, 78.9 °C and 109.4 min for glycidol concentration, reaction temperature and time, respectively. The boron adsorption was pH-dependent and attained a maximum adsorption capacity of 21.4 mg/g at a pH of 7 through the monolayer adsorption with pseudo second-order model. Under continuous conditions, an optimum breakthrough time of 351 min was achieved with a bed height of 14.6 mm, inlet flow rate of 16.4 h-1 , and initial boron concentration of 10.3 mg/L. The adsorbent behavior indicated that the breakthrough time is a function of both bed height and initial boron concentration, while the flow rate showed a marginal effect on the breakthrough time. The results from this finding suggest that the procedure of preparation adopted was effective and the new glycidol-containing adsorbent possess a high boron adsorption capacity and faster kinetics than the granular commercial resin. Thus, the adsorbent provides an alternative solution for removal of boron from aqueous solutions.

Nazar, Masooma (2023) *Development Of Green Oil Spill Dispersants Composed Of Ionic Liquids And Non-Ionic Surfactants.* Doctoral thesis, Universiti Teknologi PETRONAS.

The chemical dispersants have been used extensively for oil spill remediation in the marine environment. However, traditional chemical dispersants are necessary to be replaced with environmentally friendly oil spill dispersants due to their well-known toxicity and limited biodegradability. This research aimed to develop non-toxic and biodegradable formulation with higher dispersion effectiveness for crude oil spill remediation. The aggregation behaviour, dispersion effectiveness and particle size of the dispersed oil droplets of the binary mixtures containing non-ionic surfactants (e.g., Tween 80, Span 80) and surface-active ionic liquid (SAIL) 1-butyl-3-methylimidazolium lauroyl sarcosinate [Bmim][Lausar] were determined. The formulation composed of Tween 80, Span 80 and SAILs named ([Bmim][Lausar], and choline myristate [Cho][Mys]) was characterized by its emulsion stability, surface tension and interfacial tension (IFT). The toxicity experiments on zebra fish and the biodegradability of the formulations were assessed to ensure their safely used in the aquatic environment. The binary mixtures had non-ideal and synergistic interaction, and thermodynamically stable micelles were produced compared to the pure surfactants. The dispersants binary mixture efficiently dispersed the medium (Arab and Ratawi) and heavy (Doba) crude oils. At a dispersant to-oil ratio (DOR) of 1:25 (v/v) for Arab crude oil, dispersion effectiveness of 81.19% and 83.43% was achieved by using 40:60 (w/w) of Tween 80 + [Bmim][Lausar], and 70:30 (w/w) of Span 80 + [Bmim][Lausar]. A model was developed using response surface methodology (RSM) that effectively (R2 = 0.992) linked seawater salinity, temperature, and wave-mixing energy to dispersion efficacy for the binary mixtures. The formulation effectiveness for the dispersion of different crude oils ranged from 70.85% to 93.72%. The acute toxicity and biodegradability results showed that the formulation was practically non-toxic (LC50 = 450 mg L-1) readily biodegradable (73.26%). Overall, this research concluded that the newly developed formulations provide viable, environmentally friendly oil spill remediation and could potentially replace the use of toxic and non-biodegradable chemical dispersants.

Shokrollahiyancheshmeh, Fatemeh (2023) *Ultrasonic-Assisted Absorption Of Co2 Using Mdea-Based Solvent: Performance Evaluation And Sonochemical Study.* Doctoral thesis, Universiti Teknologi PETRONAS.

As the most matured natural gas sweetening process, absorption has been continuously improved to meet the separation requirement. Recently, Ultrasonic irradiation has been proposed as an alternative technique that can intensify the CO2 absorption process due to its sonophysical and sonochemical effects. Nevertheless, further studies are still needed to mature this technique, particularly by using slow kinetic absorbents having high inherent CO2 absorption capacity but low CO2 absorption rate. Hence, this study aims to evaluate the performance of the ultrasonic-assisted CO2 absorption reactor by elucidating the sonochemical effect. Initially, the CO2 absorption process using aqueous solutions of Methyldiethanolamine (MDEA) and Piperazine (PZ) promoted MDEA was investigated at various operating parameters. The optimized operating conditions were obtained at 12.36 W ultrasonic power, 50 wt% absorbent concentration, 5 wt% promoter concentration, 70 °C, and 11 bar CO2 partial pressure. Under the optimized conditions, CO2 absorption rates of 4.20 and 15.22 mol.hr-1 were achieved for unpromoted MDEA and PZ-promoted MDEA, respectively. The performance comparison was also performed under the optimized conditions to highlight the potential of the ultrasonic-assisted reactor. The results showed that the CO2 absorption rate in the ultrasonic-assisted reactor using unpromoted MDEA absorbent was 28 and 52 times higher than in conventional stirring and silent conditions, respectively. Subsequently, the sonochemical effect was quantitatively investigated using unpromoted MDEA. The investigation was performed via in vitro detection of hydroxyl ($\dot{OH}$) radicals generated under various reaction conditions and scavenged by Terephthalic Acid (TA). The generated $\dot{OH}$ radicals were analyzed by the highperformance liquid chromatography (HPLC) analytical technique. The parametric quantification showed that high power, high absorbent concentration, and high operating temperature could suppress the sonochemical effect. Whereas high operating pressure was found to be beneficial in inducing a higher sonochemical effect. Finally, the influence of the sonochemical effect on the reaction pathway during the CO2 viii absorption was assessed via the HPLC characterization of scavenged $\dot{OH}$ radicals under irradiated and silent conditions. The results proved that the sonochemical effect could not change the reaction pathway. Therefore, the origin of sonochemistry in aqueous solutions was considered to be water sonolysis, which could accelerate subsequent reactions

Anwer, Atif (2023) *Specular Highlight Mitigation Using Unsupervised Multi-Domain Adversarial Generation Of Specularity-Free Images Inferred From Polarimetric Data.* Doctoral thesis, Universiti Teknologi PETRONAS.

Specular reflection detection and removal is a fundamental yet non-trivial problem in the image processing domain, including applications for segmentation, object detection and decision-making systems. Most systems overlook the particular scenario and ignore input images with specular highlights instead of mitigating them in the pre-processing stage. This work presents techniques developed for accurately segmenting specular regions in real-world images and generating specularity-free images from a single image input without any additional guidance or parameters. For reliable specularity detection we developed an efficient Specularity Segmentation (SpecSeg) deep neural network based on the U-net architecture. SpecSeg has a fast inference time of 3.1ms and can be trained in only 40 minutes. We also develop a fast colour Weighted Median Inpainting (WMI) method to quickly inpaint large regions of affected specular regions with approximated colour. For specular mitigation, we developed a multi-domain Specular Highlight Mitigation Generative Adversarial Network (SHMGAN) trained using multiple polarimetric images, for synthesizing specularity-free images from a single image input. We take advantage of the inherently polarized nature of specular highlights and varying illumination information captured using polarizer filters. No external label or additional input is required for the removal of specularity as the SHMGAN network uses a dynamically generated self-attention mask for detecting specular regions. Both networks are trained and tested on self-acquired and publicly available datasets of real-world images. The images generated after specular mitigation are realistic and have minimal noise, distortions and aberrations compared to the existing state-of-the-art methods.

Manzoor, Bilal (2023) *Safety Management Framework For Mitigating Accidents At High-Rise Building Projects For Malaysian Construction Industry.* Doctoral thesis, Universiti Teknologi PETRONAS.

The Malaysian construction industry plays a vital role in the economic progress of country. On the other hand, the annual increase in the number of fatalities and accidents at high-rise building projects is a serious concern, and statistics are alarming. As a result, this research aims to provide a framework for safety management to mitigate construction accidents and improve safety measures in high-rise building projects for safer construction. To accomplish this aim, a comprehensive literature review was carried out to identify the safety factors, and a questionnaire survey was conducted with construction projects' stakeholders. The outcome of this study revealed that the top ten critical safety factors causing accidents in high-rise building projects are 'Fall from roofs/floor (working at height or open edges without using fall-protection systems)', 'Personal protective equipment (negligence to wear safety hat on)', 'Personal protective equipment (negligence in using safety belts in heights)', 'Fall from roofs/floor (working on unsafe scaffolding/ scaffolding failure)', 'Scaffolding & Ladder Failure (scaffolds are not fastened/tightened properly)', 'Safety sign (no warning signs)', 'Safety sign (no on-site monitoring system of workers)', 'Safety sign (no safety sign location plans)', 'Safety sign (no identification of potential safety hazards)' and 'Safety sign (no erection of signs as required)'. Furthermore, in order to reduce construction accidents, it is essential to present mitigation measures for safer construction. It was found that digital technologies including Building Information Modeling (BIM) have been acknowledged as effective instrument for improving construction productivity and efficiency. Interviews were employed to conduct qualitative research, and the results show that interviewees emphasized using photogrammetry and drone technology in high-rise building projects to improve safety. In conclusion, a safety management framework was developed by consolidating research findings that articulate measures and future needs of BIM integration with other digital technologies to mitigate construction accidents in high-rise building projects.

Mohamad, Mazlina (2023) *Development Of Seismic Microzonation Map Of Malay Basin For Offshore Facilities.* Doctoral thesis, Universiti Teknologi PETRONAS.

Soft soil in offshore regions may cause vibrations experienced by offshore structures, particularly the current fixed jacket platforms that were built without consideration for seismic in Malaysian waters. In order to develop a map of seismic microzonation, a map of soil amplification factors according to soil type, proposed designed horizontal response spectra and site coefficient values (Ca and Cv) for Malay basin, this study was created. For the ground response analysis of six selected seismic events with five return periods of 100, 200, 500, 1000, and 2500 years, a 1-Dimensional nonlinear analysis of layered soil (NERA) was utilised. Peak surface acceleration (PSa), the soil amplification factor, and the designed horizontal response spectral acceleration for the research area were all determined through analysis. The results demonstrate that the PSa value for soil type E is often greater than that for soil type D, and the PSa exhibits an increasing tendency when compared between a return time of 100 years and 2500 years. Higher PSa was observed by the near-field seismic event when compared to the far-field seismic event. From 100 years to a 2500-year return period, soil amplification factors for soil types D and E exhibit a decreasing tendency; however, in terms of values, soil type E has larger amplification. For soil types D and E, two designed horizontal response spectral accelerations were suggested, and comparisons with ISO 19901-2 were done under average and envelope conditions. The findings indicate that proposed spectrums were higher, particularly for soil type E. As a result, as compared to ISO 19901-2, the predicted site coefficients for soil types D and E were greater. Additionally, a comparison of the far-field and the near-field reveals that the far-field has a longer period of continuous acceleration. Since data showed that soil amplification occurred in soil types D and E at the Malay basin and present design might significantly underestimate the horizontal response spectrum, seismicity effect should be taken into consideration while developing the offshore industry.

Mohammed Al-Dhahebi, Adel Mohammed (2023) *Development Of Electrospun Mxene/Polyvinylidene Fluoride Nanofiber Composites Aptasensor For Efficient Determination Of Ochratoxin A.* Doctoral thesis, Universiti Teknologi PETRONAS.

Ochratoxin A (OTA) foodborne mycotoxin is an ongoing global concern with 25% of the world's harvested crops being contaminated each year, leading to wide toxicological effects to human and animal health while contributing to billions of dollars losses in agricultural and food-based industries. Current analytical methods used for the detection of food pollutants suffer from sophisticated instrumentation, complicated operations, poor sensitivity, and selectivity with time-consuming detection processes. In this thesis, a simple and ultrasensitive aptasensor electrode, viz. electrospun polyvinylidene fluoride (PVDF)/MXene (Ti3C2Tx) composite fiber, was developed for efficient detection of OTA. The MXene nanoflakes delaminated from the MAX phase (Ti3AlC2) using the minimally intensive layer delamination method (MILD) were dispersed in PVDF and developed as nanofibrous composites by electrospinning. The electrospun MXene/PVDF composites were then characterized for their morphology, crystal structures, functional groups, surface chemical structure, thermal properties, and mechanical properties. The electrodes for the electrochemical studies were developed by the layer-by-layer deposition method. The nanofibrous composites containing 13 wt.% MXene have improved the electroactive surface sites and acted as a suitable nano-environment for the surface functionalization and aptamer immobilization, thereby enhancing the electron diffusion kinetics of the aptasensor electrodes. The selection of this MXene based PVDF nanofiber composites aims at improving the major drawbacks of aptasensor platforms for OTA detection mainly the sensitivity, specificity, reproducibility, and stability. Under optimized conditions, the developed aptasensor demonstrated sensitive detection of OTA over the dynamic concentration range from 1 fg mL-1 to 1 ng mL-1 with a limit of detection of 2.15 fg mL1 and quantification limit of 6.52 fg mL-1 , with high selectivity. The proposed aptasensor demonstrated excellent selectivity in the presence of other mycotoxins, stability at room temperature, reproducibility and applicability to detect OTA in real viii grape samples with an LOD of 1 fg mL-1 . Overall, the implemented strategy provides an excellent mechanistic insight in designing and developing novel aptasensing framework through nanofabrication technique that could inspire efficient and economical methods to detect hazardous foodborne and environmental pollutants.

Noor, Azmatullah (2023) *Treatment Of Synthetic Wastewater With 3d Printed Bio-Carrier In Submerged Attached Growth System.* Doctoral thesis, Universiti Teknologi PETRONAS.

The conventional wastewater treatment plant is still struggling to meet ammonia and nitrate discharge limits in Malaysia. In this study comparison of synthetic domestic wastewater treatment (DWW) was established between conventional activated sludge (CAS) and submerged attached growth activated sludge (SAGAS) systems to find appropriate solution. The submerged attached growth bio–carrier (TAVID) was printed through vat polymerization of acrylate-based resin using stereo–lithography (SLA) technology to utilize as submerged attached growth bio–carrier. The specific surface area (SSA) of TAVID was 971 m2 ⁄m3 , with density, zeta potential and contact angle of 1.15±0.05 g/cm3 , -30.46 mV, and 43.6° ± 2.8° respectively, indicating high SSA and hydrophilic behaviour of bio–carrier. The effects of cycle time (CT) and filling ratio (FR) were studied in sequential batch mode. The removal efficiencies of 96.8 mg/L, 93.32 mg/L, and 88.89 mg/L obtained for COD, NH4 + –N, and TP removal respectively. The obtained optimal solution of CT and FR were 17.06 hrs and 12.38% respectively, with desirability of 98.7%. The effect of medium to high strength of wastewater (DWW) and the hydraulic retention time (HRT) were also investigated on the performance of continuous flow CAS and SAGAS systems with similar operating conditions. The obtained optimum value of FR of 12.38% (v/v %) was used in SAGAS. The result revealed that the maximum COD and NH4 +–N, and TP removal by CAS were 88.46%, 64.74%, and 51.84% respectively while SAGAS achieved 94.21%, 91.68%, and 89.08% removal efficienciesrespectively at 18 hours HRTwith 1.5 (SF) DWW. The obtained optimum value were 16.42 hrs and 1.52 (SF) for HRT and strength of DWW with desirability of 97%. The experimental data was validated through mathematical bio-kinetic models. The R2 values for COD, NH4 + –N, and TP removal were 99.93%, 99.88%, and 99.83% for modified Stover–Kincannon model while for Grau's second order model 99.85%, 99.82%, and 99.80% respectively. Thus, these models can be used in designing a SAGAS system and consequently predict the bioreactor behaviour.

Sanusi, Fasilat Aramide (2023) *The Nexus Of Internal Corporate Social Responsibility Practice And Employee Intention To Job Continuity: A Study Of Malaysian Medium Size Manufacturing Companies.* Doctoral thesis, Universiti Teknologi PETRONAS.

The lack of employee intention to job continuity is one of the biggest challenges facing organizations in the 21st century. According to the International Labor Organization, millions of employees are unhappy with their jobs but are there for the purpose of earning income to survive. Existing literature affirms that internal corporate social responsibility plays an important role in ensuring the continuity of employees in the organization. Recently, a number of reports have been issued regarding the insufficient provision of essential internal social benefits to employees in the manufacturing sector. However, the focus of internal corporate social responsibility practice has largely been on providing essential internal social benefits to the employees in their organizations to promote employee intention to job continuity. Additionally, the Malaysian government is set to be a developed country by 2030 (Vision 2030), which calls for an enabling environment that will increase the sustainability of manufacturing sectors through employees' interest on intention to job continuity. Unfortunately, medium-sized manufacturing companies are facing a high rate of voluntary employee turnover, which keeps increasing from 1.1% to 13.2% in 2014 and 14.3% in 2015. Between 2016 and 2019, the rate jumped from 27.2% to 31.6% according to the Malaysian Bureau of Labor Statistics report. The lack of effective internal corporate social responsibility practices is the primary cause of the sector's low rate of employee intention to job continuity, particularly among those not in positions of leadership. The current study investigates the impact of internal corporate social responsibility practice (compensation and benefits, wellbeing at workplace, social support, and employee recognition) on employee intention to job continuity among full-time employees in Malaysian medium-sized manufacturing companies. Based on Social Exchange Theory, the study also investigated the mediating role of work-life balance on the relationship between internal corporate social responsibility practice and employee intention to job continuity among the employees not in positions of leadership. Data was collected from the medium-sized manufacturing companies (n = 297). A Partial viii Least Squares-Structural Equation Modeling (PLS-SEM) technique was used to test the research model. The study findings revealed that internal corporate social responsibility practice (social support and employee recognition) have positive impact on employee intention to job continuity except for compensation and benefits and wellbeing at workplace which have no direct impact on employee intention to job continuity. Furthermore, work-life balance significantly mediated the relationships between compensation and practice, wellbeing at workplace, social support, and employee intention to job continuity. Except that work-life balance did not has a mediating effect on the relationship between employee recognition and employee intention to job continuity. Lastly, this study contributes to the existing studies by investigating the role of internal corporate social responsibility practice on employee intention to job continuity in the medium-sized manufacturing company and the mediating role of work-life balance on the dimensions of internal corporate social responsibility practice in relation to employee intention to job continuity.

Tackie-Otoo, Bennet Nii (2023) *Experimental Investigation Of The Oil Recovery Potentials Of Alternative Asp Formulations For Sandstone And Carbonate Reservoirs.* Doctoral thesis, Universiti Teknologi PETRONAS.

Despite the promising nature of alkali-surfactant-polymer (ASP) flooding, its application is limited by various technical issues and environmental concerns. The goal of mitigating the impact of these limitations has led to research into the oil recovery potential of alternative chemical agents. Nevertheless, there is limited deployment of these alternative chemical agents in field application due to high chemical cost. Therefore, this study focuses on investigating the potential of alternative ASP formulations composed of monoethanolamine (ETA), sodium cocoyl alaninate (SCA) / hexadecyl-3-methyl imidazolium bromide (C16mimBr) and Schizophyllan (SPG) for their enhanced oil recovery application in sandstone and carbonate reservoirs, respectively. Conventional ASP formulations are deployed for comparative purposes.
A comprehensive approach has been deployed to study the EOR potential of the proposed formulations. The approach included surface tension measurements, aqueous stability test, interfacial tension measurements, emulsification tests, surfactant adsorption, rheological measurements, core flood experiments, unit technical cost estimation and micromodel experiments. The alkali–surfactant (AS) combinations of the alternative chemical agents exhibited excellent oil recovery potential through high hardness tolerance, superior interfacial properties, desirable emulsification properties and favorable adsorption on rock surfaces. The combination of ETA and SPG alleviates the detrimental effect of inorganic alkalis on HPAM. Therefore, the alternative ASP formulations showed better rheological properties than their conventional counterparts both in bulk phase and porous media. The ETA–SCA–SPG formulation showed promising EOR potential achieving an additional oil recovery of ~22% after waterflooding, while the conventional counterpart achieved an additional recovery of ~18%. The ETA–C16mimBr–SPG formulation also exhibited excellent EOR potential by recovering ~27.05% additional oil, while the conventional counterpart also achieved additional oil recovery of ~19.24%. Based on results of the micromodel experiments, direct pore to pore displacement and emulsification are the main oil recovery viii mechanisms and their occurrence is dependent on prevailing reservoir conditions. Cost analysis showed that the proposed ASP formulations have higher chemical cost per incremental barrel of oil. Nevertheless, due to reduction in the mixing plant facility costs, they have comparable cost per incremental barrel of oil to their conventional counterpart. Therefore, this study reveals that a careful cost benefit analysis, development of low concentration chemical formulations and mass production of these chemical agents would facilitate their application in the field. The application of these alternative formulations will make compliance to environmental regulations and ASP flooding in harsh reservoir conditions feasible.

Waqas, Sharjeel (2023) *Development Of Membrane Rotating Biological Contactor For Wastewater Treatment.* Doctoral thesis, Universiti Teknologi PETRONAS.

Membrane technologies are highly reliable for water and wastewater treatment, especially biological wastewater treatment. However, the performance of the pressuredriven processes is highly restricted by membrane fouling. Variation of hydrodynamic conditions near the membrane surface can diminish membrane fouling. This study developed a novel membrane rotating biological contactor (MRBC), an integrated system embracing membrane filtration and a conventional rotating biological contactor (RBC) in one individual bioreactor by inserting a membrane panel inside the bioreactor. The MRBC is equipped with a unique feature in which the disk rotations are used to provide biological aeration and as an inherent mechanism for membrane fouling control by physically scouring off fouling materials and improving hydrodynamics near the membrane surface. Another MRBC (MRBC with wipers) configuration utilizes the unique feature of rotating wipers attached to the shaft to wipe the membrane surface to yield an efficient and compact system. Results show that high biological performances were achieved for most parameters irrespective of the membrane. The steady-state permeabilities of the membranes operated under MRBC configuration are 92.4% and 19.7% higher for the polyvinylidene fluoride and polysulfone membrane, respectively, compared to external membrane filtration system. As membrane-to-disk gap decreases from 2.4 to 0.5 cm, an increase of 14.3% and 11.6% in membrane permeability was observed for the polyvinylidene fluoride and polysulfone membrane, respectively. The MRBC with wipers configuration results show that the steady-state permeability is 231% higher in the MRBC compared to the conventional external membrane-based RBC. The increase of disk rotational speed from 30 to 80 rpm plays a positive role in fouling mitigation by improving the contact between rotating wipers and the membrane. As disk rotational speed increases from 30 to 80 rpm, an increase of 10.8% in membrane permeability was observed. This reduces cake layer formation at the membrane surface, leading to enhanced membrane permeability. The projected full-scale energy audit of viii the proposed system consumes only one-fourth of the energy (0.16 kWh/m3) as compared to referenced MBR, operated at a similar treatment capacity. This study provides a simple, feasible and proof of the concept strategy for the construction of novel MRBC which has the potential in solving membrane fouling problems with a more compact design.

Aawag, Aawag Mohsen Mohamed (2023) *Development of Framework for Implementing Total Quality Management in Industrialised Building System (IBS) Construction Projects in Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

The construction industry significantly impacts the global economy. In Industrialized Building System (IBS) projects, a lack of Total Quality Management (TQM) implementation leads to dissatisfaction with project shortcomings like cost and time overruns, low labour efficiency, poor design, and poor quality, all of which result in customer disappointment. This study provides a practical TQM framework for enhancing quality in construction organizations' products, services, and operations. Semi-structured interviews and a questionnaire gathered insights on TQM implementation, advantages, barriers, and impact on IBS project performance. Thirtyfive (35) TQM success factors were identified, and grouped into leadership, customer satisfaction, continuous improvement, process management, teamwork, and top management commitment. Next, the factors in each group were ranked utilizing the Relative Importance Index (RII). Overall, organisations ranked leadership as the most critical TQM practice, while top management commitment was placed lowest. Based on their experience with TQM procedures, the organisations have both comparable and diverse opinions on the challenges. Data analysis for a framework was carried out using Structural Equation Modeling (SEM) to depict and establish relationships between TQM success factors and IBS project performance. A proper deployment of conceptual framework can improve TQM's adoption in IBS projects. The framework was validated using semi-structured interviews with twenty (20) construction professionals and experts. Malaysian construction players are in the early stages of TQM implementation in IBS projects. This study partially fills the gap in empirical studies concerning the TQM process and provides a practical approach to its implementation via the framework. Malaysian construction organizations require a cultural shift regarding the TQM in IBS projects, which cannot be accomplished without a change in values, attitudes, and policymakers support.

Ajmal, Muhammad (2023) *Safety Management and Safety Compliance Effect on Occupational Safety and Health Performance in Downstream Oil and Gas Industry of Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

Organisations worldwide are struggling to sustain their occupational safety and health performance (OSHP). As employees encounter millions of occupational accidents and injuries annually based on the International Labour Organisation (ILO), OSHP must be optimised to mitigate safety costs, accidents, and injuries. Extensive safety management research has been performed in multiple global industries. For example, the Malaysian Occupational Safety and Health Master Plan (OSHMP) 2021- 2025 aims to alleviate fatality and occupational accidents and increase disease reporting with key performance indicators. This study examined the implications of safety management practices (safety training, safety promotion policies, workers' involvement, safety communication and feedback, and management commitment to safety and safety rules and procedures) on OSHP with safety compliance as a mediator in the Malaysian downstream oil and gas industry. The OSHP was measured based on occupational accidents and occupational injuries. The study data were collected from 280 operation and production department workers in local downstream oil and gas industries through snowball sampling. Structural equation modelling (SEM) was then employed for data analysis. Resultantly, assumptions on safety compliance as a mediator between (i) safety training, (ii) promotion policies, (iii) management commitment to safety and safety rules and procedures, and (iv) OSHP were supported as opposed to (v) safety communication and feedback and (vi) workers' involvement. This study provided significant theoretical and practical contributions with emphasis on OSHP and safety management practices. The empirical outcomes facilitate practitioners to enhance OSHP using safety management practices in the Malaysian oil and gas industry.

Al-Aidrous, Al-hussein Mohammed Hassan (2023) *Framework For The Implementation Of Industrialized Building System (IBS) In Low-Rise and Mid-Rise Residential Buildings.* Doctoral thesis, Universiti Teknologi PETRONAS.

Sustainable building development requires a balance between the increasing demand for construction and the efficient use of materials and resources. The use of industrialized building systems (IBS) as an optimum construction alternative is on the rise. In Malaysia, IBS is crucially needed to mitigate the industry dive shortage for labor, reduce time and cost overrun, increase productivity, offer higher quality control, and minimize construction waste. Therefore, it is expected that IBS would reduce construction time and offer a competitive long-term economic advantage. However, construction stakeholders, especially in developing countries, are facing wide range of challenges to implement IBS which require further investigation. This research aims to develop a framework for sustainable IBS implementation, especially for the low and mid-rise building sector. A mixed method is adopted in this study based on interview, questionnaire, and case study. The collected data were then used to develop a PLS-SEM model that analyzes the relationships between IBS Critical Success factors (CSFs) and sustainability criteria. The investigation of this research revealed that IBS implementation level is less than 3% of annual building projects. Several blocking factors caused this situation were identified, ranked, and categorized into four main components including financial concerns, design and management worries, stakeholders' reluctance, and limitation in government regulation. The top five blocking factors are high initial capital cost, high initial cost for customized design, transportation cost, higher overall cost, and obligation for financial upfront commitment. Then, this study offered the CSFs that would turn the blockage into success. This study resulted in twenty-six factors grouped into five CSFs comprising planning and control, roles and responsibilities, policies and incentives, industry maturity and technology advancement. The top five success factors are early planning to implement IBS system, extended training for local labor, effective communication among players from early phase, evaluate project location and accessibility and viii adopting standard dimensions and modular coordination. Afterwards, the impact of CSFs was measured based on sustainability criteria through the relationships between the components of CSFs and the sustainability criteria. As a result, this examination revealed that there are nine significant relationships between IBS CSFs and sustainability criteria mediated by technology advancement. The study framework can be used to guide policymakers and industry professionals to determine the essential factors for a successful and sustainable IBS implementation.

Ali, Manal Osman Mohamed (2023) *Bioretention Treatment Train with a Modified Saturated Zone for Enhanced Nutrient Removal of Agricultural Runoff.* Doctoral thesis, Universiti Teknologi PETRONAS.

Bioretention is a common water quality control practice; however, in conventional bioretention, nutrient removal is generally low. There is also a lack of modelling studies for predicting nutrient removal in bioretention systems. Besides, there are insufficient studies on the relationships between nutrient removal and the factors that influence it. Therefore, this study aims to develop an advanced bioretention system using a series of bioretention columns called Bioretention Treatment Train (BTT) retrofitted with vegetation and subsurface drainage cell (SDC). This system used a novel carbon source additive, oil palm empty fruit bunch (EFB), to improve nutrient removal. In addition, GIFMod was also used to predict nutrient removal in the system. The influences of some factors, such as the inflow concentration, flow rate, number of treatments, retention time, and carbon source percentage on BTT performance, were investigated using the Taguchi optimization method. The results demonstrated that BTT was an effective technique for enhancing nutrient removal from agricultural runoff. Incorporating vegetation and SDC has effectively enhanced nutrient removal. The findings supported the hypothesis that amending bioretention with oil palm EFB can enhance nutrient removal. Based on the short-term performance evaluations, BTT modified with SDC and 10% oil palm EFB could achieve the best performance, and most of the removal efficiencies of nitrogen and phosphorus compounds were more than 90%. The long-term performance evaluation has also shown that this system can still provide excellent nutrient removal over a long time. On the other hand, the modelbased analysis indicated the significance and potential of GIFMod as a reliable model for predicting nutrient removal in GI applications. The results further demonstrated that the Taguchi method is excellent for determining the significance of the influencing factors and their contributions.

Ali, Muhammad Asghar (2023) *Examining the Effect of Physical and Social Servicescape on Customer revisit intentions and word of mouth using SOR theory.* Doctoral thesis, Universiti Teknologi PETRONAS.

Although the Malaysian full service restaurant industry witnessed growth, however turbulent market situation (high prevailing competition and covid 19 outbreak) posing challenge to maintain their growth and profitability in the long run. Multiple studies during turbulent market situations evidenced that servicescape plays a central role for the long term survival of an organization in a hedonic consumption context. Studies confirmed customer satisfactory evaluation of servicescape and emotional bonding is inevitable to retaining existing customers through revisit intentions and acquiring new ones through word of mouth. However, this domain of research is still underresearched in the Malaysian full service restaurant context. Hence the present study aims to assess the effect of physical servicescape, employee servicescape and customer servicescape on customers' satisfaction and affection and subsequent influence on revisit intentions and word of mouth. Lastly, this study also investigates the moderating effect of perceived crowding on customer satisfaction and affection. The present study is done in full-service restaurants in Malaysia. This study followed the Stimulus-organism-response framework to develop a conceptual model stating perception of customer servicescape, employee servicescape and physical servicescape of full service restaurant (as stimulus: S) influences customer satisfaction and affectionate bonding (work as Organism) which in turn engender revisit intentions and word of mouth (R). This study used Smart PLS-SEM to validate and test the proposed conceptual framework developed based on S-O-R Model. To address the stated research questions, a web-based survey technique was used for data collection. Data from 370 respondents were collected and respondents were identified using a convenient sampling technique. The researcher used different online facebook platforms/groups to approach respondents conveniently available. Out of 370 sample data, 308 properly filled/useable responses were used to perform PLS-SEM analysis. The results confirmed customer servicescape, employee servicescape and physical servicescape are valid second-order constructs respectively.

Anwr, Albaghdadi (2023) *A Novel Balanced Double Crank-Rocker Mechanism for Vibration Suppression.* Doctoral thesis, Universiti Teknologi PETRONAS.

The crank-rocker mechanism is found in different equipment and has many synthesis options that are used in many industrial applications. However, many problems accompany the design and operations of these systems such as the lack of delivered output demands, and the presence of shaking forces and moments which lead to the increase in vibrations. Hence, the objective of this study is to introduce a methodology for synthesis, balancing and analysis of the crank-rocker mechanism, based on duplication of the linkage parts and by adding balancing counterweights. The purpose of using a double configuration of such a mechanism is meant to reduce the inertial forces caused by a single mechanism arrangement, and the counterweights are used to reduce the force in this system. This study presents different theoretical approaches used to design this configuration and to utilize synthesis optimization methods to identify different mechanism parameters. Also, different methods were adopted to enhance the optimization process by deriving the related mathematical equations which can be utilized to construct the balancing objective function. Then a proper dynamic analysis is performed to identify the required balancing variables. Different tools and software are utilized to perform the balancing process, system modelling and simulation. Moreover, a fabricated model was introduced for concept validation and to investigate the effectiveness of implementing such mechanism. The suggested methods were found to achieve better results in terms of shaking forces and moment reduction. A fabricated model was used to investigate this theory to verify the superiority of using a duplicated mechanism over a singular configuration. The overall vibrations were reduced by about 30% to 70% in the x and y-direction, respectively. Also, a comparison was conducted between simulation and test measurements, and it was found that the difference percentage was less than 14% in the waveform measurements and less than 9% in the spectrum measurements. In conclusion, this mechanism is recommended to be used and implemented in different industrial applications, such as the application of internal combustion engines, robotics and high-speed machines.

Ayandotun, Wasiu Babatunde (2023) *Performance Analysis of a Free-Piston Linear Generator (FPLG) Engine using Compressed Natural Gas (CNG) and Compressed Natural Gas-Carbon Dioxide (CNG-CO2) as Fuels.* Doctoral thesis, Universiti Teknologi PETRONAS.

A free piston linear generator (FPLG) engine is a device that converts chemical energy from different types of fuels into electrical energy through a conversion process. Despite the advantages of the FPLG engine to operate with variable compression ratios that allow for combustion of different types of fuel and operating conditions, there are downsides and technical challenges that hinder the engine's continuous operation and stability. Poor mixture quality and in-cylinder pressure fluctuation are identified as barriers to achieving continuous operation and stability and can be improved by accurate engine operating parameters and effective air-fuel mixture preparation and scavenging, which leads to good combustion. Hence, there is a need to investigate the engine operating parameters experimentally on a single piston spark ignition direct injection FPLG engine fuelled with CNG-CO2 mixture at different injection positions, ignition velocities, and lambda ratios. The comparative performance analysis of the mixture (CNG-CO2) and the base fuel (CNG) on the engine's performance was examined under different operating conditions and under their optimum conditions. The operating parameters are optimized to better understand their influence on engine performance and emissions using the response surface methodology (RSM) technique. The results reveal that when using the CNG-CO2, the engine exhibits good stability, with a 7.46% coefficient of variation in achieving peak pressure and generates output power (root-mean-square) of 24.49 bar and 239.8 W, respectively, which is 9.63% and 17.1% lower than the output of the CNG fuel under optimal conditions. The optimized combination of variables suggested by RSM for the CNG-CO2 are -19.97 mm injection position, 0.996 m/s ignition velocity, and 0.8 lambda. The models' validation confirmation for the mixture is less than 10% error. In conclusion, the FPLG is able to run stably with a CNG-CO2 mixture and generate electricity with better efficiency (59.5%) than CNG fuel.

Ayub, Saba (2023) *Electromagnetic Shielding Effectiveness Of Magnetite-Modified Graphene-Polymer Composites at Broadband Frequency Ranges.* Doctoral thesis, Universiti Teknologi PETRONAS.

Electromagnetic inferences (EMI) have been increasing over time and the demand for EMI shielding materials is intensifying in response to the rising sensitivity of electromagnetic (EM) pollution. Hence, this research aims to synthesize magnetitemodified graphene (MMG) polymer composite to enhance the EM shielding properties at broadband frequency ranges. The synthesis of MMG with optimum magnetite on the modified graphene (MG) was made by using the solvothermal method where graphene modification was made with nitric acid at different molarities and at 3 M, higher functional groups were achieved. Besides, in magnetite preparation by hydrothermal method, less than 30 nm particle size was attained for better permeability. Moreover, at 3 hrs. ultrasonication time, an optimum amount of magnetite was achieved on MG. The EM characteristics of MMG were studied by varying magnetite concentration and examining its dielectric, magnetic, and electrical properties with various polymers (PMMA, PVDF, PDMS, PVA), where the PVDF showed remarkable outcomes for electrical, dielectric, and magnetic properties and was selected for further assessment. To study the EMI shielding properties in X (8-12 GHz) and Ku (12-18 GHz) bands, MMG filler at various proportions (2%, 4%, 6%, 8%, and 10%) was synthesized with PVDF polymer by hydrothermal and ultrasonication methods to form PVDF@MMG composites. It was observed that in X-band, the total shielding effectiveness of 53.04 dB was obtained at a thickness of 3 mm in sample PVDF@MMG10, while in the Kuband frequency range, it was 51.74 dB at a 3 mm thickness. Moreover, the EMI shielding absorbing ability of the composite was remarkable in Ku-band as compared to the X-band at different thicknesses with lower filler concentrations. Hence, there is a potential in this composite at broadband frequency range to make high-efficiency EMI shielding devices to overcome EMI pollution.

Azeem, Mohammad (2023) *Experimental and numerical investigation of interply fiber hybridization and stacking in Type -IV pressure vessels under low-velocity impact.* Doctoral thesis, Universiti Teknologi PETRONAS.

In CNG-powered automobiles, filament-wound Type IV pressure vessels (Type IV PVs) are often utilized for gas storage due to their lightweight, greater fatigue, and anti-corrosion characteristics. These vessels are usually made of carbon fiber-reinforced polymers, which have low impact resistance, damage tolerance, and toughness. LVI can damage the inner structure (subsurface) of these PVs, which is barely visible and can decrease the residual strength of the structure. Furthermore, the inner plastic liner makes Type IV PVs more sensitive to impact loading. Impact resistance in Type IV PVs has been identified as a substantial uncertainty in estimating their consistency during their design lifetime. The potential of hybrid composites with proper stacking for Type IV PVs was investigated to overcome the above difficulties and achieve high safety. The filament winding technique was employed to construct the hybrid cylindrical specimen with multiangle winding at various stacking sequences. Carbon fiber (T700) as the base fiber and glass fiber (E-glass) as the hybridizing fiber are used with epoxy resin. The micromechanical and hoop properties of prepared specimens with a variable amount of interlayer hybridization comprising mixed (polar, helical, and hoop) windings and variable stacking were investigated. The standard static and dynamic tests were conducted on the specimens. Split-disk tests were performed to find the hoop tensile strength, which corresponds to the burst strength for pressure loads. The LVI tests were evaluated at different energy levels (40J and 20J) to evaluate the impact response. The 12-liter PVs were also fabricated and tested for impact, and the residual burst strength was found. Various ply-wise failure modes are witnessed through a 3D numerical modeling effort. The Hashin damage model is used to capture failure modes. The results show that the sample CA exhibits liner damage, which is not seen in hybrid samples. The sample hybrid B (HB) with 10% hybridization at the outer side has the higher force peak values in F-t curves, while that with 10% inside hybridization (HD) has a lower value. The sample with 20% glass layers (HE) has shown the most insufficient effect compared to the other two. The ring test results concluded that replacing the carbon fiber layers with low-modulus fiber decreases the hoop strength. However, adding glass fiber layers to the carbon fiber-based CPVs would reduce the impact of energy absorption. In addition, using combined layers of the polar, hoop, and helical winding patterns in diverse stacking configurations of hybrid composites is one of the innovative research methods for the study of filament-wound pipes and cylinders. Both the experimental and ply-wise numerical analysis of the hybrid composite systems and the mixed winding angle for CPV manufacturing were original additions to the literature.

Babikir, Ismailalwali Alobaid Magzoub (2023) *Improving Seismic Facies Classification through Attribute Selection and Sample Size Analysis: Examples from Malay and Sabah Basins, Offshore Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

In recent years, machine learning (ML) technology has gained significant traction in various industries, including geophysics. However, the widespread application of supervised ML in seismic data analysis faces obstacles such as irrelevance, excessiveness, and a lack of data. Seismic facies classification (SFC), an essential application in this field, also encounters challenges such as attribute dimensionality and a scarcity of annotated training data. Many seismic attributes used as input for SFC are often redundant and irrelevant. Moreover, the lack of annotated training data is common due to the labor-intensive labeling process. These limitations lead to the building of inefficient complex ML models and prolonging computational time. The current research developed a multiattribute SFC workflow to address these limitations, encompassing attribute extraction, manual interpretation, dimensionality reduction, labeling, feature selection, sample size analysis, ML model building, and deployment. The study utilized two datasets of varying geological and classification complexities from the Angsi Field (AF) and the Dangerous Grounds (DG) region offshore Malaysia. Several attribute selection techniques were evaluated, with most of them yielding perfect attribute subsets for the AF dataset. However, only the wrapper and embedded methods could produce optimal subsets for the more complex DG dataset. Attributes such as amplitude, gray-level co-occurrence matrix (GLCM), and spectral seismic attributes proved to be significant in distinguishing the targeted seismic facies in both datasets, while geometric attributes were generally considered irrelevant. Spectral magnitude components (SMCs) played a more significant role in classifying the DG broadband data. The analysis of the training sample size revealed that a larger training subset improved classification performance for the DG dataset, which has a heterogeneous geology and more classes. Conversely, for the simpler classification vii scenario of the AF, the classifiers reached a performance plateau with a smaller sample size. While filter and embedded selection methods yielded similar attribute subsets for different sample sizes of the DG dataset, the wrapper technique generated different attribute subsets, with the optimal one obtained using the largest sample size. The study demonstrated the importance of attribute selection and training sample analysis. It established workflows and identified significant attributes that could enhance SFC in Malaysian basins and similar geologic settings.

Barambu, Umar Nafiu (2023) *Development of Antifouling Membrane Via Vapor-induced Phase Separation/Wavy Flow Channel for Produced Water Filtration.* Doctoral thesis, Universiti Teknologi PETRONAS.

The fundamental problem for the development of antifouling membranes is still the leaching of the polyethylene glycol (PEG) additive to the nonsolvent (water) bath during membrane formation. For improved antifouling membrane development, this work employed the vapor-nonsolvent induced phase separation (V-NIPS) technique to preserve substantial PEG additives within the polysulfone (PSF) membrane matrix. The V-NIPS technique is attractive due to its influence on the PSF cast film kinetics posed by the dense top layer formed during the humid air exposure period. The PSF/PEG membranes fabricated by setting the cast film humid air exposure time at 0, 30, 60, and 90 seconds were assessed based on their physicochemical properties and performance during produced water (PW) filtration. The physicochemical characterization results show that by adjusting the cast film humid air exposure time, substantial PEG chains were preserved within the PSF membrane matrix with the M60 membrane (fabricated by 60 seconds of humid air exposure period) as the best performing membrane. The M60 membrane demonstrated an enhanced hydraulic, energy-saving, and oil rejection performance of up to 209 %, 68 %, and 16 % respectively compared to the baseline M0 membrane. Moreover, the performance of the M60 membrane was further improved by patterning its surface via a wavy flow channel approach that induced the feed turbulence flow visualized through the computational fluid dynamic (CFD) model. The wavy patterned M60 membrane had up to 58 % and 36 % enhanced hydraulic and energy-saving performance against its linear M60 membrane counterpart. Hence, the results obtained in this study demonstrate the potential of the V-NIPS technique and wavy flow channel system for the development of an antifouling membrane for PW filtration.

Faisal, Masood (2023) *Performance Evaluation of Optimized Compound Parabolic Concentrator Based Photovoltaic System Using Nanofluids.* Doctoral thesis, Universiti Teknologi PETRONAS.

The CPC collectors have emerged as the best low-concentration collectors for PV applications. However, they cause non-uniform solar flux distribution on the PV surface and increments in the temperature of PV cells. The performance of CPC-PV collectors can be potentially enhanced by employing optimized CPC geometry together with the placement of PV receiver at a location of more uniform solar flux. Moreover, the nanoparticles-based heat transfer fluids, due to their superior heat transfer properties, have the potential to limit the temperature rise of PV cells, thereby increasing their electrical efficiency. This research aims at enhancing the optical and electrical performance of a CPC-PV collector using the above-mentioned techniques. A multiphase methodology was devised to accomplish this goal. An analytical model was first developed and solved using MATLAB for generating reflectors' profiles of 2D CPC, followed by detailed parametric analysis and multi-objective design optimization using the response surface modeling approach. A 3D CAD model was then developed using Solidworks software, optical performance was evaluated using Monte Carlo raytracing simulations, and the best receiver location was determined. The nanofluids were synthesized using different weight fractions of CuO and MWCNT nanoparticles, and their significant thermophysical properties were evaluated at different weight fractions and temperatures. A prototype of an optimized CPC-PV collector was fabricated, and the electrical performance parameters were evaluated using water and water-based nanofluids. Using optimized geometry, CPC height decreased by 26.5%. The best receiver location, in terms of solar flux uniformity, was found to be 25 mm below the exit aperture, which caused an increment of 7% in the optical efficiency of the CPC collector. Electrical efficiency was improved by approximately 6.68%, 7.49%, and 9.33% due to cooling by water, CuO/water, and MWCNT/water, respectively. In conclusion, the electrical performance parameters are improved by using nanofluids for the cooling of the PV receiver in the CPC-PV collector.

Fudzin, Ahmad Fauzi Bin (2023) *Integrated Multi-Tier Modularity And Outsourcing For Module And Vendor Selection In Automotive Industry.* Doctoral thesis, Universiti Teknologi PETRONAS.

The automotive industry in Malaysia has expanded extensively over the years, requiring more local content to support the local industries. This has led to growth of the local auto part manufacturing industry. It is noted that modularity and outsourcing approach have been adopted by the industry in order to support localization. Due to the automotive companies constantly introduces new product, a newly developed standardization of selection methods in modularity and outsourcing is essential in order to achieve accelerated time to market. This research introduces a multi-tier modularity and outsourcing assessment of Body-in-White (BIW) in welding assembly processes. The concept adopted is segregating components into several modular assembly tierlevels for outsourcing. However, the segregation of modules into several tier-levels has not been captured by previous studies concerning the modularity of BIW in the automotive industry. The research methodology framework starts with modular assessment, which was adopted from the concept of product hierarchy and process hierarchy in Design for Manufacturing and Assembly (DFMA). It is achieved using time elements which incorporate complexity interface index and process lead-time computation. The approach adopted the Analytical Hierarchy Process (AHP) of vendor selection. The model and algorithm established with support from CATIA V5 and Visual Basic Application (VBA). The main idea of this research is to examine the multi-tier modularity and outsourcing for modular and vendor selection. By performing case study using empirical data in the automotive industry in Malaysia, this research investigates the implication of multi-tier modularity assembly in BIW structure for outsourcing. The finding demonstrates that modularity and outsourcing can be achieved by incorporating multi-tier modular selection and vendor selection. To conclude the result in product hierarchy for module A-1 and A-2-3 is 33.3% and 32.3% respectively, while in process hierarchy for both model is 48.3% and 34.4% respectively. The selected module was finalized to be outsourced to vendor. Vendor A has the highest score of 0.35206. Whereas vendor B is 0.239, vendor C is 0.126, vendor D is 0.146 and vendor E 0.135. The results demonstrate the effectiveness of the proposed model and have achieved the objective of the research. The model could standardize the process and assist industrialists making a proposal on multi-tier modularity and finally, policy makers are able to justify the outsourcing of modular in Malaysia automotive industry

Gupta, Monika (2023) *Functionalized Graphene/Copper Oxide/Chitosan Nanocomposite Based Thin Film Transistor For Co2 Sensor.* Doctoral thesis, Universiti Teknologi PETRONAS.

Carbon dioxide detection (CO2) level is crucial for indoor and outdoor air quality monitoring. For CO2 gas detection, metal oxide (MOS) sensors are commercially being used. However, MOS sensors have limitation to be used at room temperature (RT). Recently, research on MOS alternatives has been very active and graphene has emerged as a viable contender for RT operation, owing to its outstanding electronic and surface properties. However, graphene sensors suffer from the problems of slow recovery, even though sometimes, recovery is not achieved at all, because graphene tends to agglomerate due to reduced concentration of oxygen functional groups (OFGs). Hence, in this research work, a nanocomposite of functionalized graphene (FG), copper oxide nanoparticles (CuO NPs), and chitosan (CS) is proposed as a potential active sensing layer for RT gas detection. It is hypothesized that the incorporation of CuO NPs and CS will provide better dispersion to the graphene and avoid agglomeration. Moreover, CuO NPs not only enhance the electrical properties but also improve the adsorption and desorption of CO2 gas molecules, leading to fast recovery. FG/CuO/CS nanocomposite is synthesized by reducing the graphene oxide using green reducing agent ascorbic acid in the presence of CuO NPs and CS. The material characterizations exhibit a well-interlinked, highly stable, and well-dispersed ternary nanocomposite with an enhanced amount of OFGs and lower sheet resistance (RS ~45 kΩ/□). To demonstrate the functionality of as-developed nanocomposite, the FG/CuO/CS is integrated as a sensing layer in a thin film transistor (TFT) in order to fabricate the CO2 sensor. The fabricated TFT- sensor with FG/CuO/CS sensing layer (channel) is exposed to CO2 gas for the concentration range of 10 – 1000 parts per million at RT. The FG/CuO/CS TFT CO2 sensor shows ~35% enhancement in the sensing response with a 3-fold reduction in recovery time (Trec) and high repeatability as compared to FG-based sensor. The response and Trec of developed CO2 sensor are found to be 32% and 4 s at RT (25°C). The developed sensor is also found to be selective for CO2. The developed FG/CuO/CS TFT-based CO2 sensor is not only suitable for gas sensing but also future electronic biosensing applications.

Hamad, Salaheldin Mohsen Salaheldin Mohamed (2023) *Examining the Impact of Integrated Reporting on Financial and Sustainable Development Goals Performance in Malaysia: The Moderating Role of Board Attributes.* Doctoral thesis, Universiti Teknologi PETRONAS.

Integrated reporting (IR) is a relatively new reporting paradigm that aims to improve the quality of information and create sustainable value by incorporating integrated thinking into corporate strategy. In 2017, the Malaysian Code on Corporate Governance (MCCG 2017) and Bursa Malaysia encouraged large companies to adopt IR. However, research on the potential financial and sustainable benefits of IR adoption, particularly in the voluntary context of developing countries, is still limited. Herein, drawing on the stakeholder theory and the lens of a multi-theoretical perspective, this thesis aims to examine the impact of IR quality on corporate financial and sustainable development goals (SDGs) performance. Additionally, it seeks to investigate how specific attributes of the board of directors moderate the intertwined relationship. This study adopted a quantitative approach and developed an IR disclosure index to collect secondary data through the manual content analysis technique from the top 100 Malaysian public listed companies (PLCs). To test the research hypotheses, both univariate statistics (t-test and ANOVA) and multivariate regression analysis (fixed and random effects models) were applied to panel data from 2015 to 2020 on 358 firm-year observations. The study found that Malaysian PLCs have demonstrated a continued upward trend and improvement in their IR quality level and SDGs performance. The study also found that IR practices have a positive impact on the market value of companies, as measured by Tobin's Q, but a negative impact on financial performance, as measured by return on assets and return on equity. This suggests that Malaysian PLCs are still in the early stages of IR adoption, incurring significant costs to commit to integrated thinking and reporting. Furthermore, the result showed that companies with higher IR quality levels are more likely to have superior SDGs performance. Moreover, the impact of IR quality level on corporate financial and SDGs performance is more pronounced for companies with a higher proportion of female directors on their boards. The study is among the first to comprehensively examine the impact of IR quality on corporate performance while highlighting the role of board attributes. It provides valuable insights for policymakers, investors, and management on the vital role of businesses in achieving the SDGs and how IR and the board attributes can serve as a turning point in corporate performance and achieving the SDGs' agenda.

Haron, Gamal Abdalla Suliman (2023) *Ionic Liquid-Assisted Nanocellulose Preparation From Microcrystalline Cellulosefor For 3D Nanocomposite Filament Fabrication.* Doctoral thesis, Universiti Teknologi PETRONAS.

Nanocellulose (NC) is a nano-scale size of cellulose that has been used extensively in a variety of demanding applications due to its excellent features including biocompatibility, light weight, tunable surface properties, and improved environmental footprint. However, the sustainable production of NC is still confronted with bottlenecks due to poor solubility and hard processability of biopolymers using conventional hazardous solvents and reagents including concentrated sulfuric acid. The use of ionic liquids (ILs) as powerful "green" solvents for biopolymer processing have induced a great deal of interest in recent years. In this study, we investigated NC production for nanocomposite filament fabrication using various ILs as a reaction medium. Firstly, the prediction of microcrystalline cellulose (MCC) solubility in 300 ILs (15 cations and 20 anions) was obtained by deploying the conductor-like screening model for real solvents (COSMO-RS). Secondly, the effect of a binary mixture consisted of IL and DMSO as NC processing media was examined by atomic force microscopy (AFM), field emission scanning electron microscopy (FESEM), Fourier transform infrared spectroscopy (FTIR), thermogravimetry analysis (TGA), and x-ray diffractometry (XRD). Third, the effect of parameters on NC yield was investigated and optimized using response surface methodology (RSM). Moreover, the 3D printability of the developed composite filament was also tested. There was a negative correlation between cellulose solubility and experimental NC yield obtained. 1-hexly-3-methylimmdazolum hydrogen sulfate [Hmim][HSO4] IL showed the highest nanocellulose yield (64%) due to a relatively weaker Hydrogen-bonding ability with cellulose. It was observed that the average diameter of cellulose nanocrystals (CNCs) obtained with IL-cosolvent (C-CNCs), and pure IL (P-CNCs) were 50 nm and 0.77 µm, respectively, whereas the length of C-CNCs and P-CNCs were found to be 757 nm and 2.11 µm, respectively. Under the optimized conditions the NC yield of 68% was obtained with experimental error

Hashlamon, Ibrahim (2023) *Dynamic Responses Of Instrumented Test Vehicle In Stationary State For Indirect Bridge Health Monitoring.* Doctoral thesis, Universiti Teknologi PETRONAS.

Indirect bridge health monitoring using a scanning vehicle has attracted attention of researchers due to its mobility, practicality, and cost efficiency. This research is focused on the dynamic responses of the vehicle when it is in stationary state. Bridge frequency visibility is assessed for the vehicle in moving and stationary states by analytical closed-form solutions and finite element (FE) simulations, employing vehicle to bridge amplitude ratio. Analytically, novel closed-form formulations are derived for stationary vehicle response on a bridge exited by another moving load. The derived equations are successfully validated with FE simulations conducted by LS-DYNA program. The analytical solutions are conducted in MATLAB. Moreover, the derived equations of the stationary vehicle are compared with those of the moving vehicle which is already provided in the literature. FE simulations are employed to incorporate more parameters such as road roughness and vehicle damping. In these simulations, the stationary vehicle shows higher visibility of bridge frequency than that of the moving vehicle. Transmissibility of the stationary vehicle and its contact-point response (CPR) is investigated using undamped vehicle. However, to consider more realistic approach, this study develops new formulations to include CPR of damped vehicle. The transmissibility of the vehicle and its CPR are investigated in the time and frequency domains. The transmissibility of the CPR of damped and undamped vehicle shows good agreement with that of the bridge (reference). Frequency-free vehicle is designed for laboratory experiment and its transmissibility performance is investigated. Modal properties such as frequency, damping ratio and mode shapes are generated from the vehicle and direct measurements. The vehicle doesn’t show its frequency when it is parked on the beam while excited by impact hammer test. This shows the vehicle response is free from its own frequency. Also, modal properties identified from vehicle and bridge measurements have shown good agreement. Finally, signal processing techniques are proposed to for damage detection by processing the stationary vehicle response. Advanced signal processing techniques such as variational mode decomposition and Hilbert transform are used to identify bridge damages. The damage is detected and is shown as a peak in the processed response.

Hassan, Farrukh (2023) *An Improved Particle Swarm Optimization Based Threshold Selection Approach For Noise Reduction Inacoustic Emission Signals.* Doctoral thesis, Universiti Teknologi PETRONAS.

Acoustic emission (AE) is one of the Non-Destructive Testing techniques used for structural health monitoring. AE signals are often contaminated with various kind of noises that make many traditional machine learning algorithms ineffective for prediction. Wavelet transform (WT) have been used for denoising acoustic emission because it can effectively display the coarser low-frequency features and gather the information about a signal in time and frequent domains simultaneously. Furthermore, WT distinguishes and prevents noise elements effectively. Noise threshold estimation is an estimation techniques perform poorly if the noise is widely dispersed in high-frequency bands. With advancement in the field of Artificial intelligence, several heuristic optimization algorithm, Artificial Bee Colony, Genetic Algorithm, and Fruit Fly Optimization have been adopted for the estimation of noise threshold. However, PSO just like other fundamental heuristic algorithms are affected by locals extremes. This study aims to suggest a noise threshold based on hybrid HPSI for wavelet threshold denoising. The proposed technique provides the global best values generated by PSO to a local search algorithm. Since only the global best values generated by PSO to a local search algorithm. Since only the global best is utilized, local search algorithm can accelerate their search around eligible solutions while still only affecting other particles as they approach the global best. AE data was acquired from 500 meters long steel pipeline. It has been shown that proposed method outperforms existing denoising approaches in term of Root Mean Square Error (RMSE) and Signal to Noise Ratio (SNR). The SNR of the proposed method is 36.84% higher than the highest SNR among traditional denoising methods, while RMSE decreased by 34.39%.

Hassan, Yarima Mudassir (2023) *Study Of Stability And Effect Of Silica-Based Metal Oxide Nanocomposite For Electromagnetic-Assisted Enhanced Oil Recovery.* Doctoral thesis, Universiti Teknologi PETRONAS.

Various nanoparticles (NPs) have been discovered as innovative agents for improving reservoir oil productivity. However, NPs are continuously trapped in the rock pores due to the persistent aggregation of the NPs caused by the high temperature of the reservoir. Recently, the electromagnetic (EM)-Assisted enhanced oil recovery (EOR) approach revealed success in this regard despite the persistent problems of the NP's entrapment. The present study is designed to prepare smart nanofluids that incorporate magnetic and dielectric attributes to enhance energy absorption of the fluids for the attainment of oil displacement. Hence, silica-based metal oxide NPs of Fe2O3- SiO2, ZnO-SiO2, and ZnO-Fe2O3-SiO2 were synthesized using the sol-gel method. A visual test complemented by a zeta potential analyzer was used to determine the stability of the fluids. A goniometer was used for interfacial tension (IFT) and wettability analysis while a sandpack flooding method was used for the EOR experiment at 100 ℃. The results have shown that the crystalline phases and purity of the composite NPs were improved when annealed at different temperatures. The synergistic behavior of nanocomposites has shown remarkable outcomes for improving stability, IFT, wettability, and EOR above their constituents. Thus, composite NPs enhanced the stability by 79 %, while IFT and wettability were improved by 99 and 56 % respectively. The oil recovered during the composite nano-flooding experiment was found to be 9.72, 8.71, and 8.37 % for ZnO-Fe2O3-SiO2, ZnO-SiO2, and Fe2O3-SiO2 respectively. However, during EM-Assisted nanocomposite flooding of ZnO-Fe2O3-SiO2, ZnO-SiO2, and Fe2O3-SiO2, oil recovery was respectively observed to be 14.10, 13.65, and 23.26 %. The present study has proven that the energy propagated to the silica-based composite nanofluids via EM waves has energized the magnetorheological and electrorheological properties of the nanofluids. Hence, an additional disturbance was generated at oil to water interface which reduced IFT and wettability alteration and consequently enhanced the transportation of the fluids in a porous media.

Hong, Leong Wai (2023) *Sequential Flow Baffled Photobioreactor Designed For Synergistic Microalgal-Bacterial Interactions To Produce Biodiesel From Nitrogen-Rich Wastewater.* Doctoral thesis, Universiti Teknologi PETRONAS.

Microalgae are regarded as potential feedstock for biofuel production while being able to sequester carbon dioxide into valuable bio-products. However, the challenges associated with microalgal cultivation are the high input costs coupled with infeasible integration into wastewater treatment. As such, a novel sequential flow baffled microalgal-bacterial (SFB-AlgalBac) photobioreactor was developed to exploit the synergistic microalgal-bacterial associations for enhancing microalgal biomass production while bioremediating nutrient-rich wastewater. The initial performance of photobioreactor was found to be optimum at the 5.0 L/d influent flow rate with records of the highest microalgal nitrogen assimilation rate (0.0271 /d) and biomass productivity (1350 mg/d). Further increase of flow rate had resulted in poor culture vitality evidenced by the 10% reduction in biomass productivity due to excessive cell washout and hydraulic stress from the continuous flow operation. A dual nutrient heterogeneity mode exploiting the nitrogen transformation and valorization mechanisms was subsequently introduced, resulting in total nitrogen removal efficiency up to 96.38% with maximum microalgal biomass production up to 792 mg/L under a balanced NH4 + -N (60 mg/d) and NO3 - -N (58 mg/d) loadings. The microalgal lipid extracted via the Bligh and Dyer solvent extraction method using 1:2 (v/v) chloroform/methanol ratio was subsequently transesterified into biodiesel obtaining 228 to 281 mg/mg of biomass. The microalgal biodiesel constituted 97 - 100% in C16 to C18 fatty acid methyl ester (FAME) species thus, conforming to the requirements for quality biodiesel application. The FAME compositions which leaned towards higher unsaturated fatty acid (USFA) fractions lowered the biodiesel pour point, catering for the applications in cold climate regions. Energy feasibility studies revealed highly positive net energy ratio (NER) value (8.38) for producing microalgal biomass. However, the NER value dropped to a low value (0.23) for microalgal-to-biodiesel system, stemming from the high energy inputs incurred in the downstream processes for converting biomass into lipid and biodiesel. Nevertheless, the SFB-AlgalBac photobioreactor was anticipated to exploit the low-cost nitrogen sources from nutrientrich wastewaters via bioconversion into valuable microalgal biomass while fulfilling the requirements of sustainable wastewater treatment technologies.

Imran, Qazi Sohail (2023) *High Resolution Reservoir Modelling Constrained by Rock Physics and Stochastic Inversion In a Clastic Environment.* Doctoral thesis, Universiti Teknologi PETRONAS.

The ever-increasing demand for fossil fuels has pushed the petroleum industry to explore the hydrocarbon in ever challenging areas, which are often characterized by very complex sand distributions due to variety of depositional environments. Hence, characterizing a reservoir based on conventional seismic and well-log stratigraphic analysis often leads to uncertainties. Malay basin in Malaysian offshore is no exception; therefore, this research work aims to map the structural framework and the subsurface heterogeneity (away from the wells), to evaluate the available solutions to integrate and propose improved approaches to enhance the quality of the results. To address the challenges, a cross-disciplinary methodology uses the attributes from well log and 3D seismic data analyses and integrates the petrophysical, rock physics and geostatistical seismic inversion inputs within a comprehensive reservoir modeling framework. It also takes into account the strengths and shortcomings of the methods used, to improve the results. Petrophysical and rock physics evaluations laid a solid foundation and deduced that the study area has gas and oil filled fine sand reservoirs interbedded with shale and coal. To delineate the structural framework shrouded in gas cloud, an advanced workflow based on 3D fault-oriented semblance is used to auto detect and extract the structural elements. 6 horizons between 1200 – 1800 ms interval and 8 faults which cut through all horizons, were extracted with unprecedented clarity. The structural elements form an asymmetrical E-W trending elongated anticline with four-way dip closure having horst graben geometry at the center. Simultaneous and stochastic inversions provided the elastic volumes of AI, Density and Vp/Vs. The 3D reservoir models constrained by stochastic inversion provided the higher resolution results due to incorporation of structural and geological trends in the process. Multiple sizeable prospective sand bodies in D35, D50 and D60 reservoirs have been identified around 1400- 1600 ms interval. The sand beds as thin as 5 meters were captured, and the results were validated using the facies logs. The high-resolution 3D property models were generated by using the variogram inputs and acoustic impedance volumes as constrained. The property models show that the study area has distributary channel complexes and prograding mouthbars with 15% to 25%, that is fair to very good porosity distribution. The volumetric ranking as P50 mid case and P10 as high case, shows a value (STOIIP) of 500 MM bbls and 700 MM bbl respectively, which shows that the study area has significant hydrocarbon reserves. The study demonstrated that how the link between seismic and reservoir properties is established using the improved approach which led to more powerful results. The study is expected to improve the understanding of the subsurface and to have significant implications for future exploration in Malay Basin as well as similar basins around the world.

Kamal, Nur Liyana Mohd (2023) *Study On The Potential Application Of Treated Coal Bottom Ash For Sustainable Cement Replacement.* Doctoral thesis, Universiti Teknologi PETRONAS.

For last few years conventional concrete faced many concerns due to sustainability and depletion of natural resources point of view. For those reasons many industrial byproducts such as fly ash has been introduced in concrete. However, its continuous supply to meet the demand is much questioned. This study explored the potential application of coal bottom ash (CBA) in the concrete industry due to its prevalent physical and mechanical properties and from the same source as fly ash. The main focus of the study was to explore the performance of CBA as replacement to cement content. For enhancing the properties of CBA as cement substitute, it was treated (by grinding and chemical treatment) to reduce heavy metal elements. Ground coal bottom ash which is known as GCBA was produced from grinding process. From the result, it shows that the optimum size was 45µm and optimum replacement was at 10% which demonstrate high compressive strength at early age. However, GCBA 75µm with 10% replacement is comparable with normal concrete. Therefore, this study decided to proceed the investigation with chemical treatment on 75µm GCBA. The chemical process was carried out in this study by using citric acid. The chemical treatment has the capacity to reduce metallic components in CBA at an ideal solution temperature of 40°C and at 4 percent acid concentration over a 60-minute reaction period, according to the results. For characterization, XRF examines the chemical components on CBA which was labelled GCBA (ground CBA) and TCBA (treated CBA). Apart from that, the samples underwent the Blaine’s air permeability test and specific gravity test. It’s shows that, the finer the CBA, the more Si2O contents were observed. It was believed that the increment on specific surface area was led to the reactive Si2O. In conclusion, the TCBA has improved the properties of concrete in terms of compressive strength, tensile strength, and durability. From optimization analysis and leaching study, it showed that with the established chemical treatment, TCBA showed its viability equivalent to fly ash effects in concrete.

Khan, Dodo (2023) *A Scalable Proof-Of-Review Consensus Model For Permissionless Blockchain Network.* Doctoral thesis, Universiti Teknologi PETRONAS.

Blockchain is a distributed ledger with immutable records that allows transactions across various participating nodes after these nodes achieved a mutual consensus. Blockchain's scalability problem has become crucial with the widespread use of Blockchain technology. The scalability issue arises with the increasing number of nodes and transactions in blockchain networks. The research community revealed that inefficient consensus models are the main cause of scalability. And it is associated with various interdependent parameters, transaction throughput, latency, and the number of nodes. To solve this scalability problem, this research proposes a novel consensus model called Proof-of-Review (PoRv) to establish an efficient and scalable Blockchain. The “review” in the proposed protocol refers to the community's (the blockchain nodes) trust on a node, which depends entirely on the node’s historical behavior within the blockchain network. In the proposed consensus model, there are four modules to process transactions and produce high throughput in blockchain applications efficiently. The first module identifies the leader node, the second module allows the leader node to propose the block, and the third module verifies the block. Finally, the last module allows deciding on the block. The proposed consensus model has a 2-chain architecture where these chains are cryptographically linked. The first chain stores the transaction, and the second chain stores the reviews. This proposed PoRv consensus model was evaluated using the scalability evaluation criteria identified in this research. The proposed PoRv model was also compared with benchmarking consensus models based on throughput, latency, number of nodes, and transactions for validation. The validation was done in 3 scenarios, i) with a high workload and same network size, ii) high network size and same workload, and iii) high network size and high workload. The results presented in this thesis show that the proposed model possesses better scalability in terms of throughput and latency than existing benchmarking models. However, this study's scope didn’t include Blockchain's security, privacy, and reliability. The main limitation throughout the experiment was the lack of high- viii performance machines to generate a high volume of transactions to evaluate the throughput and latency exhaustively. As such, this impacted the expansion of the Blockchain network, the number of nodes, and the overall volume of transactions.

Khan, Farhat Ullah (2023) *A Dynamic Compact Deep Learning Architecture For Pattern Recognition.* Doctoral thesis, Universiti Teknologi PETRONAS.

Dynamic deep learning networks are a class of neural network architectures that are able to adapt their structure and parameters during training or inference. This allows the network to better handle changing input data, improve performance on tasks with non-stationary data distributions, and learn more efficiently by only using the necessary number of neurons and connections. Examples of dynamic deep learning networks include networks that incorporate attention mechanisms, architectures that use gating mechanisms to control the flow of information, and networks that can add or prune neurons and connections during training. These architectures have been applied to a variety of pattern recognition tasks such as image classification, natural language processing and speech recognition. With the ability to adapt to the changing input data and optimize the network structure, dynamic deep learning networks have the potential to improve the performance of neural networks and make them more practical for real-world applications. In this research, architecture of a dynamic deep learning, called PrimeNet is proposed. PrimeNet relaxes the static declaration constraint by allowing dynamic layer configuration relay. Dynamic layer configuration relay (DLCR) is a method used to train deep neural networks. DLCR allows for the dynamic modification of the network architecture during training, which can lead to more efficient and effective training compared to traditional methods where the architecture is fixed. The proposed PrimeNet is an enhanced architecture aimed to dynamically identify and encourage the quality visual indicators from the input to be used by the subsequent deep network layers and increase the gradient signals in the lower stages of the training pipeline. The MNIST, FMNIST, CIFAR-10, STL-10 and SVHN datasets have been used to validate the proposed research. PrimeNet has obtained state-of-the-art results on these image datasets, attaining the combined purpose of compact dynamic deep neural structure that is computationally inexpensive. Classification performance is evaluated in terms of F1 score. viii The floating point operations (FLOPS), number of parameters and memory requirement metrics is used to demonstrate the computational complexity evaluation results. The proposed research also naively attempts to discuss the involved computational complexities in the proposed advanced deep neural structure.

Khan, Hanana (2023) *Examining the Impact of Fiscal Deficit on Macroeconomic Performance: Current Account Deficit and Inflation in ASEAN.* Doctoral thesis, Universiti Teknologi PETRONAS.

This study aimed to investigate the fiscal deficit and its alarming consequences from the perspective of the current account deficit and inflation of ASEAN and its sub-groups. This study considers the panel data collected over the last three decades (1990-2020) for ten member nations of ASEAN. The panel methodology includes panel unit root, panel Auto Regressive Distributed Lag (PARDL), Cointegration regression (Fully Modified and Dynamic Ordinary Least squares), and Panel Dumitrescu & Hurlin (DH) Granger causality test. The results show that the fiscal synchronization hypothesis and government expenditures contribute strongly toward long-run sustainable economic growth in ASEAN. The fiscal deficit influences the current account deficit in the long run, while in the short run, the current account deficit causes the fiscal deficit, which supports the current Account Targeting Hypothesis (CATH). The fiscal deficit significantly generates inflation, while political stability plays a significant role in ASEAN. The Debt outstanding is a high inflationary source of financing the fiscal deficit in ASEAN. Moreover, the fiscal synchronization hypothesis and current account targeting hypothesis are supported in the lower-middle-income group. The upper-middle-income group confirms expenditure dominance and the Ricardian equivalence hypothesis, and the higher-income group confirms revenue dominance and current account targeting hypotheses. In conclusion, the fiscal deficit of ASEAN is alarming mainly on the grounds of current account balance, inflation, political stability, government revenues, and debt outstanding. Efficient utilization of resources to attain sustainable economic growth, following fiscal synchronization, considering interest and exchange rate stability in the current account and fiscal balance, and utilizing the domestic sources of deficit financing, are the study's implications.

Khursheed, Shahzad (2023) *QUATRID: A Low Computational Coding-Efficient Distributed Residual Video Codec With Quantized Transform Decision Mode.* Doctoral thesis, Universiti Teknologi PETRONAS.

Video coding standards are continuously evolving according to application scenarios. A significant decrease in bit rate while maintaining low computational complexity is considered a rule of thumb. The latest video coding standards have high encoder computational complexity due to motion compensation and prediction process and are suitable for downstream applications only. Alternate encoding options like distributed video coding (DVC) are worthwhile, whereby motion compensation and prediction process are removed from the encoder. DVC focuses on keeping encoder sufficiently lightweight to suit resource-constrained encoder of upstream (uplink) applications like wireless video sensor networks (WVSN) for medical monitoring. This novel video coding paradigm separates encoding of correlated sources and offers lower encoding computational complexity but at the expense of high coding delay and channel coding computational complexity and substantially lags in coding performance. Even though several DVC techniques have been employed, it remains challenging to achieve coding efficiency while limiting the high decoding delay and ensuring a trade-off between the computational complexity of the encoding and decoding process. Mainly the channel coding with excessive feedback channel requests and inaccurate online correlation noise model (CNM) contribute to mentioned performance gaps. This thesis proposed QUAntized Transform ResIdual Decision (QUATRID) scheme with a main contribution of designing and integrating novel QUantized TrAnsform Decision Mode (QUAM) method into distributed residual video coding that effectively reduces the channel coding and feedback channel requests. Further, the designed online CNM and reconstruction method contribute to achieving high coding efficiency with limited feedback channel requests and high-quality reconstructed frames. The thorough profiling of the QUATRID with experimental results demonstrates a significant gain in coding efficiency and a substantial reduction in computational complexity. Bjøntegaard delta analysis shows that QUATRID successfully achieved 5.4% to 10.48% coding efficiency and 0.06 dB to 0.32 dB PSNR gains while reducing channel coding computational complexity, bit planes reduction percentage, and feedback requests reduction ratio by 4.8 to 34 folds, 84% to 97%, and 2.8 to 4 folds, respectively, in comparison to DISCOVER.

Khurshid, Hifsa (2023) *Synthesis of Advanced Nanocomposites for Treatment of Polycyclic Aromatic Hydrocarbons in Produced Water.* Doctoral thesis, Universiti Teknologi PETRONAS.

The dissolved fractions of polycyclic aromatic hydrocarbons (PAHs) in wastewater have many adverse effects on humans, animals, and water species. Agricultural waste and advanced nanocomposite materials are underutilized for wastewater PAH removal, despite interest in their development. This study synthesizes advanced PAH-removing compounds for synthetic wastewater and produced water (PW). Therefore, the oil palm leaves (OPL) waste activated carbon modified by ZnCl2 (OPLAC-ZC), was synthesized at OPL:ZnCl2 = 1:1. The M-OPLAC-1, M-OPLAC-2, and M-OPLAC-3 are nanocomposites of OPLAC-ZC and MXene using three synthesis methods. The OPLAC-ZC nanocomposites with NZVI were also synthesized at Fe:OPLAC-ZC = 1:1 (N-OPLAC-1) and 1:2 (N-OPLAC-2). For PAH elimination, NZVI and MXene nanocomposites were produced at Fe:MXene = 1:1, 1:2, and 2:1. In batch testing, the materials degraded naphthalene (NAP), fluorene (FLU), and phenanthrene (PHE) in synthetic wastewater at different pH, dosages, contact times, and PAH concentrations. Adsorption isotherm and kinetic modeling was applied for the identification of removal mechanism. The adsorption parameters were optimized using RSM in DE software. The PAHs' removal efficiency was evaluated in PW at optimized parameters. Results showed that the OPLAC-ZC, M-OPLAC-2, N-OPLAC-2, and N-MXene-3 had surface areas of 331.15 m2 /g, 259.35 m2 /g, 258.39 m2 /g, and 55.69 m2 /g, respectively. The removal of NAP, FLU and PHE was heterogenous, favorable, and involved chemisorption proved by Freundlich isotherm and pseudo-second-order kinetic model. The optimum parameters were as follows: pH of 3, dosage and contact time of 2197 mg/L and 72 min for OPLAC-ZC, 1493 mg/L and 67 min for M-OPLAC-2, 122 mg/L and 49 min for N-OPAC-2, and 101.5 mg/L and 40.5 min for N-MXene-3. M-OPLAC-2 was the most efficient, stable, and expensive synthesized material for PAH removal in PW. This study developed advanced materials that removed over 90% of three PAHs (NAP, FLU, and PHE) from synthetic wastewater and PW.

Krishnan, Vijendren (2023) *A Study on Cultivation Conditions and Its Impact Towards Biodiesel Production of Marine Microalgae.* Doctoral thesis, Universiti Teknologi PETRONAS.

Microalgae absorb CO2 efficiently by photosynthesis to grow and produce various biochemical substances such as lipid which can be transesterified for fatty acid methyl ester (FAME) production. Marine microalgae have been reported to have potential for high FAME production. However, high CO2 concentration can cause poor growth for marine species for reasons that are still unclear. There are also limited studies that look into changes of FAME composition during the cultivation period, which is crucial to determine extraction of high-quality FAME. Also, an appropriate growth kinetic model needs to be determined to predict the microalgae growth accurately. In this study, two pure marine strains namely Nannochloropsis oculata, and Tetraselmis chuii were cultivated to determine its growth trend, lipid productivity, cultivation period and FAME production due to the effect of vitamins, minerals, CO2 and nitrogen concentration. The microalgae were cultivated and aerated, and biomass concentrations were measured on daily basis. While at each growth phase, lipid extraction was conducted according to Bligh and Dyer method and transesterified by alkali transesterification method. Findings show that, N. oculata and T. chuii cultivated in various CO2 concentrations has a similar growth pattern. However, N. oculata produced the highest productivity (0.0563 g/L.d) in medium augmented with 3% CO2 concentration whereas; T. chuii produces highest productivity of 0.499 g/L.d. However, the N. oculata growth was inhibited at 7% CO2 concentration (0.0288 g/L.d), due to high acidic condition that inhibited the nutrient uptake and growth. T. chuii has recorded the highest FAME yield as much as 0.0711 g/L in 1% CO2 concentration on day 14. Whereas, N. oculata exhibited the highest FAME yield (0.0798 g/L) in 1% CO2 concentration on day 12, which also produced FAME composition with a balanced proportion of saturated fatty acid and unsaturated fatty acids for high quality biodiesel. The four major fatty acid produced were C16:0 palmitate, C16:1 palmitoleate, C18:1 oleate and C20:5 cis-5,8,11,14,17 eicosapentaenoate. Highest FAME content by N. oculata (69.272%) recorded in 37.5 viii mg/L nitrate concentration on day 14 was deemed suitable for ideal FAME production due to its proportionate FAME composition and high FAME content. Overall, these findings corroborate N. oculata as the potential candidate for high biomass production and high-quality FAME production. Among all the non-linear growth kinetic models, logistic with lag and modified Gompertz model shows the best fitting to the growth pattern. However, the linear regression exhibited the most accurate prediction.

Kumalasari, Intan (2023) *Effect Of Microencapsulated Phase Change Material On Temperature And Mechanical Performance Of Bituminous Mixture.* Doctoral thesis, Universiti Teknologi PETRONAS.

A pavement that can resist rutting and regulate pavement surface temperature is needed. Among the techniques to regulate pavement surface temperature, phase change material (PCM) pavement has the potential due to its latent heat storage property. Therefore, the main objective of this study is to reveal the effect of microencapsulated PCM (MPCM) on the thermal and mechanical performance of bituminous pavement. As a proof of concept, a 100% MPCM bituminous mixture was tested and proven to reduce the surface temperature. In the following phase, various concentrations of MPCM (0%, 25%, 50% and 75% of total weight of conventional filler) were incorporated into bituminous mastics. Their rheological performances were evaluated using two type analyses using a rheometer. Using these data, a neural network (NN) model was developed for sensitivity analysis to evaluate and confirm the maximum limit of MPCM concentration based on the rheological tests. Then, MPCM bituminous mixtures were made at lower concentrations than the maximum MPCM concentration found in the rheological test. Wheel tracking (WT) and indirect tensile fatigue (ITF) tests were conducted to examine the rutting and fatigue failures of the MPCM bituminous mixtures. Lastly, surface temperature measurements of these mixtures were performed. The results showed that the 100% MPCM bituminous mixture could reduce surface temperature around 2℃. Results from the rheological performance tests showed that 50% MPCM in the filler is the maximum limit in the mastic. The developed NN model shows that at typical Malaysian surface temperature of 60℃–65℃, up to 50% MPCM in the mastic is predicted to still have a good rutting performance. However, the MPCM bituminous mixtures did not pass the WT and ITF tests, even at the lowest concentration of 10%. Their surface temperature measurements also did not show significant temperature reduction. In conclusion, the use of MPCM in bituminous mixtures at the current state does not satisfy the required rutting and fatigue resistances. Therefore, these detrimental suggest that solid-solid form of PCM is required to be considered when development of PCM pavement.

Malik, Khurshid (2023) *A Novel Approach For Enhancement Of Mechanical Performance Of Natural Fiber Reinforced Epoxy Composites For Structural Applications.* Doctoral thesis, Universiti Teknologi PETRONAS.

Natural fiber-reinforced epoxy composites are attractive in the automotive industry due to their high strength to weight ratio; however, weak interface bonding between fiber and matrix restricts their structural applications. This study adapted three techniques (graphene nanoplatelets (GNPs) toughening, fiber chemical treatment, and hybridization) to improve the mechanical performance of the composites. The physical and mechanical properties were tested according to ASTM standards. The rheology analysis showed an increment in viscosity for GNPs modified epoxy, and dispersion was verified by SEM. The uniformly dispersed GNPs (0.1-0.2 wt.%) acted as additional reinforcement, which provided mechanical strength and excellent interlocking between fiber and epoxy in the composites. Flax/GNPs/epoxy composite with 0.1 wt.% of GNPs showed the highest enhancement in the tensile (19%), flexural (20%), shear strength (51%), fracture toughness (49%), water resistance (27%) properties. 0.2 wt.% of GNPs resulted in the highest improvement in kenaf/GNPs/epoxy composite properties. Sodium lauryl sulfate (SLS) at 2.5-5.0 wt.% for 5 hours achieved the desired roughness on the fiber surface, as revealed by SEM. The fiber surface roughness improved bonding between fiber and epoxy and showed tensile, flexural, shear strength, fracture toughness, and water resistance by 11, 97, 59, 78, and 20% in SLS-treated flax/epoxy composites. Similarly, treated kenaf/epoxy composites showed enhancement in their properties. The composite developed by uniformly dispersed GNPs, and chemically treated fiber showed increased composite properties. These composites have potential in automotive interior parts such as bumpers, tailgates, door panels, and roof panels. Hybridization of kenaf and flax with carbon and glass fiber increased the density of composites. The stacking sequence and increase in carbon fiber volume fraction in kenaf/carbon hybrid composite, hybrid [C/K/C/K/C/K/C] showed the highest increase in tensile performance (402%) compared to pure kenaf/epoxy composite. The change in the stacking sequence of viii kenaf/carbon composite, hybrid [C2/K3/C2], showed the highest increase in flexural strength (300%), shear strength (281%), and water resistance (46%). The hybrid [C/K2/C2/K2/C] displayed a 79% increment in fracture toughness among all hybrid composites studied. A similar design of kenaf/glass, flax/carbon, and flax/glass showed improved mechanical properties compared to pure flax/epoxy and kenaf/epoxy. These hybrid composites have potential automotive applications in structural components such as seat support components, beams, hoods, side frames, chassis, and leaf springs.

Mazhar, Muhammad (2023) *Unveiling Service Failure and Service Recovery in Online Shopping: Impact of Servpology on Post-Purchase Behaviour.* Doctoral thesis, Universiti Teknologi PETRONAS.

> The proliferation of the Internet and its unwavering accessibility has instigated customers to use online channels for shopping by posing rising expectations from online businesses, particularly webstores. The challenges of online shopping through webstores were further compounded in the wake of the pandemic in that the webstores were not adequately equipped to match the jaw-dropping online boom. Consequently, the webstores encountered massive complaints due to service failure and developed customers' grudges. In this vein, customer retention is unequivocally considered a critical factor for the success of any business. In pursuit of it, Webstores rendered service recovery to the complaining customers for retention purposes. Therefore, the service recovery mediates the relationship between complaining behaviour and switching/repurchase intention. However, service recovery might not always retain angry customers due to its inefficiency. Angry customers might switch to other webstores because of grudge-holding. Therefore, webstores need to revisit their service recovery strategies to reduce the grudge-holding. The current study proposes that servpology might be an effective service recovery strategy to minimise the grudgeholding. For this purpose, the current research investigates the moderating effect of servpology to reduce grudge-holding that will ultimately increase the repurchase intention. To validate the proposed hypotheses, an empirical study was conducted to investigate the customers' post-purchase behavioural intentions after service failure and recovery using the lens of the expectation-disconfirmation theory. Data was collected from 437 online shopping customers using exponential discriminative snowball sampling through an online questionnaire. SPSS and SmartPLS 4.0 were used for descriptive and inferential statistical analysis. Results revealed that service failure leads to increased customers' complaining behaviour and grudge-holding. In addition, service recovery increases the repurchase intention, but surprisingly service recovery has no significant effect on decreasing switching intention. Furthermore, grudgeholding increases the switching intention and decreases the repurchase intention ix relationship. However, servpology, as a moderator, can reduce the effect of grudgeholding. Under the paradigm of expectation-disconfirmation theory, the findings contributed theoretically to the literature on service recovery and consumer complaint behaviour. Moreover, it rewarded practitioners by suggesting strategically effective service recovery. Finally, it concluded that customers' complaints should be resolved in time and service recovery should be offered as per customers' expectations.

Mehreen, Mehreen (2023) *Developing a Sustainable Bankruptcy Forecasting Model: Evidence from the Market-Leading Islamic Banking Countries.* Doctoral thesis, Universiti Teknologi PETRONAS.

Every business sector, including the banking industry, is facing multi-layered business risks such as sustainability risks, governance risks, market risks, and above all, bankruptcy risks. The Islamic banking industry is still in its growth stage as compared to the giant conventional banking industry, hence the risk of default is also higher for Islamic banking. Moreover, the bankruptcy forecasting model used for conventional banks is also applied to Islamic banks even though Islamic banks have some specific Shariah regulations which are different from conventional banks. Additionally, the previous bankruptcy forecasting models are only based on financial ratios. However, the changing dynamics of businesses nowadays made it compulsory to extend the scope of the current bankruptcy forecasting models for more accurate bankruptcy precision. The objective of the study is to propose a novel Sustainable bankruptcy forecasting model, and to extend the scope of the bankruptcy forecasting model from one dimension (financial ratios) towards a Sustainable bankruptcy forecasting model. This study introduced two new dimensions (corporate governance (CG) and corporate sustainability (CS)) to be included in the bankruptcy forecasting models. This study collected panel data from 23 Islamic banks from the market-leading Islamic banking countries for the decade of 2010 to 2019. Fuzzy Logic, Ordered Logit Regression, and ANOVA tests were applied on a balanced panel using the MATLAB, SPSS, and STATA softwares. The results of ordered logit regression showed a significant impact of financial ratios, Islamic CG, and CS on the bankruptcy condition of Islamic banks. It affirmed the argument of this study about including these multi-factors in the new bankruptcy forecasting model for providing superior surveillance. The results of the ANOVA test revealed the differences among Islamic banks on their financial attributes, which leads to appropriate policy insights. This study extended the scope of the financial ratios theory by introducing a moderating role of industry-specific measurements and opened up a new line of inquiry to agency theory by extending the scope of traditional CG to Islamic corporate governance. This study also claims novelty for extending the instrumental approach of the stakeholders' theory through the addition of sustainability items aimed at reducing the chances of bankruptcy. This study insights policymakers towards incorporating the non-financial attributes of Islamic banks into the bankruptcy forecasting model and to adopt a standardized shariah governance model for Islamic banks. The study also viii urges practitioners to adopt uniform standards for sustainability disclosure to assure the sustainability of Islamic banks.

Mohamed, Mohamed Ibrahim Beer (2023) *A Reference Security Architecture For Service-Oriented Enterprise Computing.* Doctoral thesis, Universiti Teknologi PETRONAS.

Enterprise computing is an information technology-driven business operational model, where the business applications are interconnected through integration technologies such as Service Oriented Architecture (SOA). The SOA facilitates application integration even beyond organizational boundaries that operate on standalone software components, called web services. However, SOA is challenged by different implementation factors and security is the topmost as the web service is prone to attacks as the open web is the medium of communication. The Open Web Application Security Project (OWASP) is a well-known community that publishes security vulnerability reports on web-based integrations periodically. Both the available products in the market and the existing research prototypes address a few specific areas in these listed OWASP vulnerabilities, however, yet to have a comprehensive security solution in the tailorable way forward. As part of the conducted research, a security reference architecture for service-oriented enterprise computing is proposed. This reference architecture is primarily aimed at addressing the latest OWASP 2021 security vulnerabilities on interoperable web services. Typically, reference architecture includes common architecture principles, patterns, building blocks, and standards that are used as constraints for constructing more concrete architectural elements. The implementation of this proposed reference architecture can be experienced as a whole solution for addressing OWASP 2021 vulnerabilities and can be tailored according to the needs of underlying enterprises. A mathematical model is developed for measuring security risk in the SOA environment. Finally, the practicality and correctness of the proposed security reference architecture are studied and validated based on a realistic SOA case study. From the performed proof-of-concept, it is observed that the proposed security reference architecture outperforms the chosen leading security products in the market and existing research prototypes by recording a 12.05% of higher security protection rate on average.

Musa, Suleiman Gani (2023) *Synthesis And Optimization Study Of POM@MOF Composites Toward CO2 Conversion Into Cyclic Organic Carbonate With Epoxide Organic Carbonate With Epoxide.* Doctoral thesis, Universiti Teknologi PETRONAS.

The safety of human health and the environment is being threatened by environmental risks brought on by CO2 emissions. Under the influence of special catalysts and certain conditions, CO2 reacts with epoxides by cycloaddition reaction to give cyclic carbonates which are value-added chemicals for pharmaceutical and industrial applications. However, there is a need to develop a more robust catalyst that can perform at ambient condition for industrial application as most of the previous catalyst have a short life cycle and requires high temperature and pressure. The coupling of metal-organic frameworks (MOFs) with other functional materials such as polyoxometalates (POMs) has shown a remarkable increase in their stability and catalytic property. Two MOF materials, MIL-101(Cr) and HKUST-1 were impregnated with transition metal substituted POMs to obtain POM@MIL-101(Cr) and POM@HKUST-1 composites respectively. The composites were characterized using Fourier transformed infrared spectroscopy (FTIR), X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), thermal gravimetric analysis (TGA), X-ray photoelectron spectroscopy (XPS), and nitrogen adsorption-desorption measurements. The TGA results for the composites showed significant improvement in their stability having 550 ˚C and 390 ˚C for POM@MIL-101(Cr) and POM@HKUST-1 composites, respectively as compared to their pristine MOFs. The CO2 uptake was remarkably increased to 27 and 58 cm3 /g with isosteric heat of 35.3 and 38.4 KJ/mol for POM@MIL-101(Cr) and POM@HKUST-1, respectively. Central composite design (CCD) was employed to design the experiment for CO2 and epichlorohydrin conversion into cyclic carbonate. The optimization studies for the interaction of reaction parameters for MnPW@MIL-101(Cr) and MnPW@HKUST-1 catalysts were evaluated using response surface methodology (RSM). The prediction and modeling of the data were compared using an artificial neural network (ANN). The optimum condition for the CCD-RSM studies was obtained at catalyst amount;12.5 mg, co-catalyst amount; 0.055 mmol, temperature; 100 ºC, and time;24 h. A conversion of 95.9% and 98.5% were attained by ix MnPW@MIL-101(Cr) and MnPW@HKUST-1, respectively. The study revealed that HKUST-1-based composites have higher gas adsorption and conversion ability than MIL-101(Cr)-based composites. In addition, TM-substituted POM-based composites show higher activities than the Keggin-type POM group with MnPW@HKUST-1 having the highest CO2 adsorption and epichlorohydrin conversion of 98.5%. The MIL-101(Cr)-based composites however have better reusability than HKUST-1- based composites by having six consecutive cycles without any deformity. According to the study, TM-substituted POM@MOF composites can act as a potential catalyst for the conversion of CO2 and epoxide into organic carbonates for industrial application.

Patel, Mahesh Chandra (2023) *Performance evaluation of surfactant-based viscoelastic fluid For shale fracturing at elevated shear rate and temperature.* Doctoral thesis, Universiti Teknologi PETRONAS.

Water entrapment is a serious issue during hydraulic fracturing operations in unconventional shale rock formations. This study investigates all possible reasons for water entrapments identifying sections of a fractured formation where the water may entrap considering natural and induced issues. Nonpolymeric surfactant-based viscoelastic (SBVE) fluid systems of cetyltrimethylammonium bromide (CTAB) and Sodium Nitrate (NaNO3) (with and without 1wt% ZnO nanoparticles (NPs)) have been proposed to mitigate the water entrapment problem during fracturing in shale rock formations. The main objective of this study is to develop SBVE fluid/nanofluid systems using CTAB, NaNO3, and ZnO NPs and test their rheological characteristics under elevated shear rate and temperature (ESRT) conditions by comparing them with traditional guar gum gel fluid. The SBVE fluids/nanofluids prepared are categorized into groups 1 and 2, having constant low and high surfactant concentrations of 0.1M and 0.2M and varying salt reagent concentrations at a difference of 0.2M. The group 1 fluids were further divided into type 1 and type 2 fluids and nanofluids respectively, and group 2 fluids into type 3 and type 4 fluids and nanofluids respectively. The rheological analysis was performed for a range of shear rates 0.1 to 500 sec-1 at different temperatures from 25°C to 75°C. The optimum fluid estimated in each SBVE fluids/nanofluids category based on their ability to maintain rheology under ESRT conditions. In group 1, optimum SBVE nanofluid of type 2 showed better rheology than the optimum fluid of type 1 but not better than the guar gum gel fluid. In contrast, in group 2, the optimum fluid of type 3 showed better rheology than the optimum nanofluid of type 4 and guar gum gel fluid. Further, the study focuses on validating the mono-alcoholic breaker system and proposing fluid flow and prediction models. The mono alcohol ethanol can break the proppant slurries of optimum fluid and nanofluid in 40 minutes. Most of the SBVE fluids and nanofluids follow Herschel Bulkley's fluid models. The decision tree model was the best-generalized prediction model depending on the train and test score and performance metrics estimated.

Qureshi, Abdul Hannan (2023) *Automated Progress Monitoring Of Steel Reinforcement for Construction Projects Using Photogrammetry.* Doctoral thesis, Universiti Teknologi PETRONAS.

Current steel reinforcement (SR) inspection practices in construction projects are manual in nature; hence, they are time-consuming. SR drawings are technical; therefore, inspection outcomes' accuracy depends on the inspector's (supervisor or engineer) experience. Moreover, manual inspection practices outcomes are sometimes prone to error. In contrast, with the emerging of the fourth industrial revolution, the construction industry has also adopted a few technological solutions for SR progress monitoring. However, most prevalent construction progress monitoring technologies, such as laser scanners, are costly and mainly detect qualitative aspects and quantitative aspects are not covered. This study aims to develop a photogrammetry-based automated smart solution for evaluating on-site SR quality (SR spacing, SR diameter) and quantity (number of SR bars, SR length). This study has three objectives. The first objective is to identify the factors affecting the operational quality of automated progress monitoring technologies for SR. The second objective is to evaluate the photogrammetry tools to select the most suitable option. The final objective is to devise a unique methodology for scaling up the 3D point cloud model to ground truth dimensions, and to develop Python and MATLAB based three smart modules, 'A', 'B', and 'C', to interpret the 3D model for SR quality and quantity parameters; the devised system is named as "Smart SR Evaluation Model (SSREM)". The SSREM has the capability to evaluate on-site SR with the help of images with an accuracy of more than 99% for SR length, number of SR bars, 97% for SR spacing, and accuracy of more than 91% for SR diameter. The SSREM offers an economical, effective, and efficient solution with minimum human involvement. It provides site safety, especially for highrise buildings, remote progress monitoring to far projects, minimising CO2 emission by controlling unnecessary site visits, and most importantly, it is an IoT-supported model.

Raksasat, Ratchaprapa (2023) *Enrichment of Sewage Sludge for Black Soldier Fly Larvae Bioconversion into Biodiesel.* Doctoral thesis, Universiti Teknologi PETRONAS.

Black soldier fly larvae (BSFL) have been proved their potential for valorizing of sewage sludge and transform into valuable biomass. In this study, sewage sludge palatability was successfully enhanced by either blending with palm kernel expeller (PKE) or anaerobically pre-treatment. The correlation study was also achieved through mathematical model as well as artificial neural network to improve larvalbased biodiesel quality. Lastly, the distribution of environmental impact was as well accomplished through life cycle assessment. Firstly, the optimum ratio of sewage sludge blending with PKE had been determined at 2:3, giving rise to the highest BSFL weight of 46.99 mg/larva. Furthermore, lipid yields from larvae fed with blended feed at optimum ratio were boost up 97.44%. Further increment of PKE had contributed to the inhibiting of BSFL growth and resulting in the decrease of larval biochemicals. As the nutrients in sewage sludge are entrapped within extracellular polymeric substances (EPS), the enrichment of sewage sludge by breaking down the EPS was subsequently studied via anaerobic pre-treatment. The optimal condition was attained at pH3 after 8 days of pre-treatment, releasing the nutrients of 14.13±8.47 mg soluble carbohydrate and 15.61±0.60 mg soluble protein for 1 g of sewage sludge. The larval weight was increased to 7.34±0.97 mg/larva, while lipid content was raised up 14.7 times. Further investigation of FAMEs profile revealed the presence of significant amount of saturated fatty acids (81.48% for blended sewage sludge and 53.14% for anaerobically sewage sludge) was corresponded with commercial biodiesel. The values of R2 in correlation study obtained were approaching 1, while MSE values were insignificant. Lastly, anaerobically pre-treated sewage sludge had demonstrated higher damage than blended sewage sludge by 13.5% of overall midpoint impact per 1 kg of biodiesel production as the chemicals used for transesterification was higher due to lower biodiesel conversion in anaerobically sewage sludge (39.02%) as opposed to blended sewage sludge (87.05%).

Rawindran, Hemamalini (2023) *Enhancing attached microalgal growth onto palm kernel expeller in producing biodiesel.* Doctoral thesis, Universiti Teknologi PETRONAS.

The conventional cultivation system relied on an inert solid surface supplemented with inorganic or liquid extract organic carbon sources for microalgal attachment. As this approach is costly and labor-intensive, current study explored a novel application of palm kernel expeller (PKE) as both medium for attachment and nutritional supplement in promoting microalgal growth. By employing response surface methodology (RSM), PKE dosage of 5.67 g/L, light intensity of 197 µmol/m2 s and photoperiod of 8:16 light:dark hours/cycle, provided maximum microalgal density and lipid productivity of 9.87 ± 0.05 g/g and 29.6 mg/L day, respectively. Thereafter, optimization of pH yielded best performance at pH 5 and pH 7 with microalgal density of 10.94 ± 0.83 g/g and 10.28 ± 0.31 g/g, respectively with lipid productivity of 26.05 mg/L day and 28.54 mg/L day. The attached microalgae from pH 3 medium produced the best crude biodiesel property, followed by pH 5 and pH 7 mediums with low oxidative property yet highly applicable for diesel blending purposes. The attachment of microalgae onto PKE was found to be proffered by the increase in hydrophobic traits. This study established another novel finding in the form of the work of attachment (Wcs) analysis, which demonstrates that cell attachments at all pH mediums were thermodynamically favorable, with Wcs-PKE>0. pH 7 exhibited the greatest Wcs, followed by pH 5 where the microalgae preferred to attach onto surfaces with low dispersive and polar surface free energies. The mechanism of microalgal-PKE complex attachment was elaborated using physical intermolecular interactions and EPS activity, while their detachment was induced by chloroform and methanol. Life cycle analysis (LCA) revealed that harvesting and lipid production exhibited the highest environmental impact. However, the overall global warming potential was much lower (5.2 x 10- 4 kg CO2 eq) compared to previous studies. The energy analysis showed a NER of 0.52, indicating that the energy produced was less than the energy invested. Although not ideal for energy sustainability, the NER value exceeded that of conventional petroleum diesel and most previous microalgal technologies.

Rehman, Amirun Nissa (2023) *Kinetics And Stability Studies Of Co2 Hydrate In Quartz Sand And Amino Acids For Co2 Storage.* Doctoral thesis, Universiti Teknologi PETRONAS.

CO2 storage as hydrate in porous media is a promising method to store carbon dioxide (CO2). However, the prolonged formation kinetic behavior of hydrate hinders its application and has prompted urgent research attention to improve the CO2 hydrate storage capacity. The objective of this study was to evaluate the effect of quartz sand properties and amino acids L-methionine (L-meth), L-isoleucine (L-iso) and Lthreonine (L-threo) on CO2 hydrate formation and dissociation kinetics in three quartz sand particles QS-1 (<0.6 mm), QS-2 (0.6-0.8 mm), and QS-3 (0.8-2.0 mm). The hydrate formation experiments were conducted in a high-pressure hydrate reactor with and without brine (3.3 wt.% NaCl) at 4 MPa and a temperature of 274.15 K in 100% water saturation. The hydrate dissociation kinetics was studied at a temperature of 277.15 K. The results showed that hydrates form faster in deionized water (DI) than brine solution. The presence of brine decreased hydrate stability and reduced the CO2 storage capacity by 30% compared with DI. Further, the quartz sand with lowest porosity (38%) showed the highest CO2 storage capacity recording about 55% gas-tohydrate conversion ratio and showed the fastest onset hydrate formation time of 6 hr. However, the CO2 hydrates in the sand particles with low porosity were less stable compared to the systems with high porosity. In quartz sand L-meth exhibited the highest CO2 hydrate storage capacity at 0.2 wt.% recording about 93% gas-to-hydrate conversion ratio among the studied systems. Also, L-meth enhanced CO2 hydrate stability with the lowest hydrate dissociation rate compared to L-iso and L-threo systems in quartz sand. Comparatively, L-meth enhanced the storage capacity by 36% and reduced the induction time by 50% than conventional promoter SDS in quartz sand with brine suggesting it favorable for CO2 storage applications. CO2 hydrate nucleation time was predicted in quartz sand with and without the best studied amino acid L-meth system with high prediction accuracy and an absolute average deviation of 2.4 hours. The findings in this study provide high CO2 storage capacity in sediments as hydrate.

Rozaini, Muhammad Nur' Hafiz Bin (2023) *The development of sample preparation techniques for the analysis of endocrine disruptor compounds in water samples.* Doctoral thesis, Universiti Teknologi PETRONAS.

The presence of endocrine disruptor compounds (EDCs) at trace level in environmental waters has made the sample preparation for qualitative and quantitative analyses becoming more challenging. Therefore, this research primarily aimed to develop alternative sample preparation techniques for the high-performance liquid chromatographic determination of selected EDCs: bisphenol A, 2-phenylphenol, 4-tertoctylphenol, triclosan, triclocarban and methyltriclosan laden in water samples. Firstly, salting-out-based liquid-liquid microextraction technique was developed. Under the optimum conditions, the developed method displayed good linearity over the concentration range of 0.18 to 1000 µg L-1 , high coefficient of determination (R2 > 0.9899), and good detection limits ranging from 0.05 – 0.2 µg L-1. Next, a solid-based microextraction technique, known as membrane-protected microextraction was developed. MXene and beta-cyclodextrin – crosslinked citric acid (BCD-CA) were selected as potential adsorbents. The adsorbents were characterized to determine the chemical and physical properties using fourier transform infrared spectroscopy (FTIR), brunauer - emmett teller (BET), particle size distribution (PSD), thermogravimetric analysis (TGA) and field emission scanning electron microscopy (FESEM). Under the optimum extraction conditions, both techniques demonstrate good coefficient of determination R2 > 0.9902 (MXene) and R2 > 0.9807 (BCD-CA) within the concentration range of 0.5 – 500 µg L-1. Both techniques have been successfully applied in several types of water samples, namely, wastewater, river, lake and water bottle, and manifested good recoveries ranging from 81.0 ± 1.2 - 105.5 ± 7.4 % (MXene) and 80.2 ± 4.0 - 99.9 ± 2.9 % (BCD-CA). Interestingly, BCD-CA possessed a better selectivity property as opposed to MXene. Hence, three EDCs compounds were chosen as the model compounds to evaluate the adsorption process and selectivity property of BCDCA toward these compounds. Kinetics, isotherms and thermodynamics of the adsorption process were also investigated. The adsorption process between EDCs and viii BCD-CA was dominated by pseudo-second order and Freundlich model. Besides, it also was found that BCD-CA had the highest adsorption capacity towards 4-tertoctylphenol (49.8677 mg g-1) as compared with the other EDCs.

Saafan, Muhammad Ezzat Ibrahim (2023) *Predicting Two-Phase Capillary Pressure Curves in Low-Permeability Sandstone using 2D Images and Resistivity Measurements.* Doctoral thesis, Universiti Teknologi PETRONAS.

Laboratory capillary pressure measurements are costly and challenging, especially for low-permeability samples. Consequently, many approaches tried obtaining capillary pressure curves from fractal models utilizing rock images and resistivity measurements. However, the existing fractal models simplified the actual pore shapes with cylinders, which do not allow any residual wetting phase to remain in the invaded pores. This thesis presents a novel approach to infer drainage and spontaneous imbibition capillary pressure curves from rock images and obtain drainage curves from resistivity data. First, using image-extracted information, the pore structure is adequately represented as bundles of tortuous square and triangular capillaries with sinusoidally varying radii. After that, the drainage and SI processes are simulated to derive innovative fractal capillary pressure models. Also, an electrical resistivity model is derived for partially saturated porous media. Additionally, the genetic algorithm is utilized to match laboratory-measured resistivity data and obtain the resistivity model's parameters. Then, the matched parameters are adopted in the drainage capillary pressure model to generate the drainage capillary pressure curves. The developed models are validated using laboratory data from low-permeability sandstone samples. Results of five samples with 2D images indicate that the majority of predicted versus laboratory-measured drainage and SI water saturation falls within one standard deviation error of $\pm$ 0.06 and $\pm$ 0.03. Moreover, the mean absolute percentage error (MAPE) of the image-extracted maximum pore area is roughly decreased by 50% when two slices are used instead of one slice. On the other hand, using resistivity data of eighteen core samples, the MAPE of the calculated water saturation ranges between 2.4% and 39.4%, with a median and mean MAPE of 11.3% and 13.3%. Moreover, compared with literature models, the proposed method of obtaining drainage capillary pressure from resistivity measurements is superior for samples with permeability lower than 5 md.

Sattar, Mohsin (2023) *Creep Crack Growth Prediction Model for the Life Assessment of Stainless-Steel.* Doctoral thesis, Universiti Teknologi PETRONAS.

Advance development in material research tends to look at the behavior of the materials subjected to mechanical and operational loadings over extended periods. The complexity of the applied thermo-mechanical boundary conditions makes it critically important to consider creep and creep-related failures. The most established and current creep models like Norton-Bailey, MPC Omega, Sine-hyperbolic, Theta projection, and KachanovRabotnov are used in the FEA industry and research but may have several limitations. Each model has proved to be accurate for specific materials under certain stress and temperature conditions, but neither single model can predict near accurate creep deformation curves for a wide variety of alloys nor meet the analysts' expectations. Therefore, the research is designed to evaluate the established creep prediction models, concerning their deficiencies and limitations for creep predictions. An improved material model for creep damage, covering primary, secondary, and tertiary stages in the form of mathematical formulation, based on creep power laws and existing model limitations is introduced. The new model is developed by combining and integrating Norton Bailey and Kachanov-Rabotnov models. Curve fitting and sub-routine scripting are the two methods adapted in the research for integrating the new model in ABAQUS. Results were compared with the experimental data as well as from other established models, for model validation. The comparison of the new model with the experimental creep data has indicated accuracy between 90.69% and 93.92% for testing at 336 hours and 1000 hours at 600 0C and 700 0C. In addition, the new model's accuracy was computed at 88.5% as compared to 84.3% for the Theta projection model applied to 2.25Cr-1Mo steel for creep prediction at 754 0C. Similarly, the new model's accuracy was 92% as compared to the 72% accuracy of the sine hyperbolic model applied to 2.25Cr-1Mo steel at 750 0C. In comparison with the Omega model, the creep prediction accuracy of the new model was found to be 77.8%, then 72.4% for SA-455 steel at 720 0C. The K-R model's accuracy was 92% as compared to the 94% precision of the new model applied to the super alloy at 700 0C. Subsequently, sensitivity studies were conducted using RSM and ANOVA to measure the significant contribution of the input factors: stress, stress exponent, creep parameter and damage parameter on the target response creep strain rate. Sensitivity studies of creep models' comparative results and the case studies comparisons of published experimental work with the new model, prove the significance of the new creep model as an alternative to the established creep models.

Seng, Liew Chin (2023) *Thermally Pre-Treated Sewage Sludge As A Feed For Black Soldier Fly Larvae To Produce Biodiesel.* Doctoral thesis, Universiti Teknologi PETRONAS.

Waste activated sludge (WAS) is a by-product of the wastewater treatment process. In recent years, the generation of WAS has been increasing due to rapid urbanization. While the common approach is to landfill the WAS, the scarcity of land has prompted the need of a new solution. Black soldier fly larvae (BSFL), which can valorize organic waste is a potential solution for reducing WAS and subsequently, generating lipid for biodiesel production. Nonetheless, the low biodegradability of WAS has retarded BSFL growth. Therefore, the low temperature thermal pre-treatment was conducted prior to larval feeding. Accordingly, 75oC was found to be the threshold temperature for producing a palatable WAS, while 90oC was vindicated could improve the nutrient availability in WAS. Thereafter, BSFL fed with pre-treated WAS had shown enhanced growth. BSFL with the highest weight gained (2.16 mg/larva) was attained when fed with WAS pre-treated at 90oC for 16 hours, which was 292.3% higher than the control. The BSFL growth was found to be correlated well with WAS's soluble chemical oxygen demand (SCOD). This hints that there is a threshold SCOD where BSFL need to maintain their metabolism activities. Feeding on samples pre-treated at higher temperature decreased the BSFL lipid content from 25 to 21 wt%. Nonetheless, after accounting for the BSFL weight, 90oC BSFL biomass still produced the highest lipid yield (0.6 mg/larva). Subsequently, 90% – 94% of the BSFL lipid was successfully converted into biodiesel. BSFL biodiesel constituted >80 wt% of saturated fatty acid methyl esters, making it highly oxidative stable. Its characteristics also met the standard of EN 14214 and ASTM D6751, proving its viability as a biofuel. Lastly, the life cycle assessment showed that, in terms of global warming potential, the approach of producing biodiesel from pre-treated WAS fed BSFL only generated 1% of what was expected from landfilling of WAS. It also registered lower environmental impacts as compared with the production of other common biodiesels since no land clearing or fertilizing was involved. While thermal pre-treatment had proven viable in improving viii WAS palatability for enhanced BSFL growth and biodiesel production, future work should focus on reducing the energy consumption involved.

Siddique, Junaid (2023) *Customer Engagement Valence And Service Co-Creation In Multi Actor Service Networks Of Online Businesses.* Doctoral thesis, Universiti Teknologi PETRONAS.

Organizations business models are evolving to leverage customer networks to orchestrate service creation called co-creation to grow the competitive scale, reduce cost and increase revenue growth. More and more webstores are using customers' interaction with other actors (stakeholders) for service creation. These platforms are transforming the divide traditionally present between customers and actors in a webstore to engage customers in the process of co-creation. However, not always the customer's engagement might predict positive outcomes such as service co-creation. The customers might also engage negatively with the webstore that is a strong prediction of negative outcomes such as service co-destruction. Service co-creation and service co-destruction occurs based on the direction of customer's engagement (positive vs negative), known as customer engagement valence. This empirical research attempts to investigate the antecedents and outcomes customer engagement valence in a multi-actor network such as webstore. Further, this study develops a measurement instrument to gauge service co-creation for empirical research. This study applies quantitative technique to investigate the relationship among key constructs. The data was collected from 737 respondents using purposive sampling. The Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to test the hypothesized model. The results revealed that customer's perception is a strong predictor of customer engagement valence. Customer's positive engagement leads to service co-creation that is a driver of brand loyalty and customer's negative engagement generates service co-destruction that is a predictor of brand avoidance. Customers' engagement includes both consciousness and unconsciousness. To investigate customer engagement valence by capturing customer's unconsciousness an experimental study was performed using neuromarketing technique. The data was collected using electroencephalogram (EEG) from 50 volunteer respondents during the ix experiment. Multigroup analyses was performed to re-investigate the outcome of customer engagement valence. The results confirmed that customer engagement leads to service co-creation (when engagement is positive) and service co-destruction (when engagement is negative). This study contributes the existing knowledge by presenting a clearer view of customer engagement, as it was investigated by capture customer's consciousness and unconsciousness. Secondly, the measurement scale of service co-creation will attract the attention of research to understand the service co-creation empirically. Overall, the study provides substantial theoretical, methodological, and practical contribution to enhance the understanding of customer engagement valence.

Talpur, Noureen (2023) *A Deep Neuro Fuzzy Classifier With Rule-Base Optimization For Classification Problems.* Doctoral thesis, Universiti Teknologi PETRONAS.

Deep Neuro-Fuzzy System (DNFS) is a widely used approach for improving classification accuracy in real-world problems with nonlinear behavior. However, the model suffers from two issues: (i) more features in classification data result in a larger fuzzy rule-base, (ii) optimizing the DNFS' rule-base using standard Gradient Descent (GD) approach can lead to a local minima problem, resulting in poor classification accuracy for DNFS model. The literature has developed numerous cutting-edge optimization algorithms, including Particle Swarm Optimization (PSO), Grey Wolf Optimizer (GWO), Ant Colony Optimization (ACO), and Arithmetic Optimization Algorithm (AOA). AOA has shown remarkable performance but suffers from imbalanced exploration and exploitation search, as well as poor convergence for highdimensional problems. Hence, this study focuses on improving the DNFS' classification accuracy by proposing an enhanced version of the AOA algorithm as a novel Bitwise Arithmetic Optimization Algorithm (BAOA). The novel BAOA outperformed AOA in efficacy when compared using fifteen test functions. Hence, the BAOA algorithm is used to address the first problem of a huge rule-base in the DNFS model by using it as a feature selection approach. Besides, the optimization of the fuzzy rule-base using the proposed BAOA algorithm avoids the second problem of local minima. For the stage of feature selection, BAOA selected 14.50 features from benchmark classification datasets with an average classification accuracy of 95.53% and a computational cost of 2.45 seconds. The DNFS model with a BAOA-optimized rule-base achieved the highest classification accuracy on benchmark datasets, with average training and testing accuracy of 96.56%, surpassing other DNFS models. Lastly, the Wilcoxon rank test confirms a significant difference between the proposed BAOA algorithm and other comparative optimization algorithms.

Zaman, Humaira Gul (2023) *Development of Chitosan-Metal Organic Framework Composite for the Adsorption of Pb(II) and Cd(II).* Doctoral thesis, Universiti Teknologi PETRONAS.

Metal pollution has increased over the globe, causing significant environmental issues owing to direct and indirect releases into water bodies. In this study, a microwave-assisted method was used to synthesize Zr-based MOF functionalized with Glycidyl Methacrylate (UiO-66-GMA) and then a chitosan-MOF composite was developed. The surface area and total pore volume of the MOF and composite are 1142 m2 /g, 967m2 /g, and 0.48 cm3 /g, 0.51 cm3 /g respectively. The performance was evaluated by investigating the impact of pH (2-10), contact time (0-200 min), initial metal ions concentration (100-1000mg/L), temperature (25-55°C), and adsorbent dosage (0.5-3g/L) on Pb(II) and Cd(II) percentage removal. Following an analysis of the adsorption isotherms, kinetics, and thermodynamics, the Langmuir model showed an excellent fit with the adsorption data. The adsorption process was a spontaneous endothermic reaction and kinetically followed the pseudo-second-order kinetics model. The reaction conditions of operating parameters were optimized via central composite design (CCD) based on response surface methodology (RSM) for the maximum adsorption of (Pb(II)) and Cd(II)). A statistically significant model was developed through regression analysis (R2= 0.99). The highest predicted value of Pb(II) and Cd(II) removal at optimal conditions was 92.45% and 95.56% respectively. The Pb(II) and Cd(II) maximum adsorption values were under the following conditions; an adsorbent dose of 0.6 g/L, 5.5 pH, 27.4 °C of temperature, and 55 minutes of contact time. The reusability of MOF and chitosan-MOF composite in the five consecutive adsorptiondesorption cycles retained 83.18% and 85.56% of its removal effectiveness, demonstrating it as a sustainable adsorbent for metal recovery.

Ahmad Wazir, Norhidayah (2022) *Synthesis And Characterization Of Oleic Amido Propyl Betaine For Formulation Of Ultra- Low Ift- Foaming Surfactant.* Doctoral thesis, Universiti Teknologi PETRONAS.

Surfactant is used as a foaming agent in enhanced water alternating gas (EWAG) method to reduce the mobility of gas. The surfactant used in this method typically has a good foam strength but does not have low enough interfacial tension (IFT) to provide excellent oil sweep efficiency. In recent years, a new technique combining the strength of surfactant as an IFT-lowering surfactant and foam generator into a hybrid formulation was introduced to improve the displacement and sweep efficiency at the same time. In this research, a focus was emphasized on the synthesis of ultra-low IFT surfactant as one of the components in the hybrid formulation. A modified two-step betaine synthesis procedure was used to synthesize the surfactant, oleic amido propyl betaine. Qualitative characterization of the as-synthesized surfactant was carried out through HPLC, FTIR, NMR, TGA, and FESEM-EDAX. The improvement of the surfactant was also performed using a mixture of diethylene glycol monobutyl ether (DGME) and ethylene glycol monobutyl ether (EGME), and the surfactant was named as CBH. It was then tested in Guntong seawater condition, comprising the solubility, surface tension, IFT, phase behavior, and thermal stability tests. An optimization process of as-synthesized surfactant was also carried out. However, the results revealed that the surfactant had a higher IFT value in the magnitude of 10−2mN/m than CBH. Hence, it was not qualified for the feasibility test. The CBH was preferred for the feasibility study as a component in the hybrid formulation as it had an improved solubility in the seawater, reduced the IFT to ultra-low level, had microemulsion Winsor type III behavior, and was thermally stable under the Guntong seawater condition. In the hybrid surfactant feasibility study, the CBH surfactant was combined with a foaming surfactant (IVF) and exhibited good foaming performance of at an ultra-low level. The effect of non-ionic polymer to the performance of the hybrid surfactant was also studied, and the findings are discussed in detail in the thesis.

Abbasi, Amin (2022) *Glucamine functionalized sulfur-based polymer for boron removal from aqueous solutions.* Doctoral thesis, Universiti Teknologi PETRONAS.

Boron is a pollutant that its concentration is increasing, particularly in wastewater, as a result of industrial discharge causing serious problems for nature and humans. The most common boron removal technique is using commercial resins which are hydrocarbonbased and not only expensive but also have environmental problems due to their dependency on the petroleum industry, non-degradability, and unsustainability. As such, a non-hydrocarbon replacement for the petroleum-based backbones of the commercial boron adsorbents can offer a new adsorbent with reduced dependency on the petroleum industry. Besides, if this non-hydrocarbon-based adsorbent is biodegradable, it can also suggest a solution to the environmental problems of the conventional boron adsorbents especially when it comes to their waste management and recycling. On the other hand, elemental sulfur, a byproduct in gas and petroleum refineries, can be polymerized with a vinyl monomer(s) using the inverse vulcanization method to produce cheap sulfur-based polymers, suggesting a new way to make value of the cheap and readily available material, while also reducing the environmental concerns regarding its open storage in vast amounts. The main objective of this research is to develop a sulfur-based boron selective adsorbent as a replacement for conventional hydrocarbon-based ones and to evaluate their properties and test their performance. To conduct this, response surface methodology (RSM) using central composite design (CCD) was initially utilized to optimize the copolymerization of sulfur with 4- vinylbenzyl chloride (VBC) employing the inverse vulcanization method. Consequently, a temperature of 154 °C, a reaction time of 120 minutes, and an initial sulfur load of 53 wt% were selected as the optimized reaction conditions. The properties of the copolymer produced under optimized reaction conditions were evaluated using different techniques. The full conversion of the comonomers and the formation of the polymer were confirmed. The polymer demonstrated a uniform morphology with a smooth surface and an amorphous structure with a relatively low glass transition temperature of 3.7 °C but high thermal stability up to 205 °C and considerable stability viii against depolymerization over time.

Tanimowo, Aliu Oluwaseyi (2022) *Nanofluids Influenced Convective Heat Transfer And Mass Dispersion In Porous Media With The Lattice Boltzmann Method.* Doctoral thesis, Universiti Teknologi PETRONAS.

To examine natural convective heat transfer in a porous medium that is fully saturated with Zn/Cu/CuO/Al2O3-H2O nanofluids, a two-phase Lattice Boltzmann model (LB-Model) capturing nanoparticles (NP) Brownian and thermophoretic forces for nanofluid (NF) flow in a porous medium is developed and proven. The goal is to use it to investigate the heat enhancement, augmentation, and dispersion of nanoparticles during NF transport at different Rayleigh numbers (Ra) and varying nanoparticle volume fractions (NVF). For a porous cavity, the equations of flow (velocity), temperature (energy), and NVF fields are numerically solved (LBM). The impact of changing the physical parameters of Rayleigh number, NVF, and Darcy number (Da) on flow patterns (streamlines), temperature distribution (isotherms), and NP spread (dispersion) are investigated. To understand the link between Ra, Da, and NVF, the Nusselt number is determined. The results reveal that as Ra and Da numbers rise, the Nusselt number rises, allowing for increased convective heat transport. With a greater temperature gradient at Ra = 105 ; Da = 10-2 NP dispersion is enhanced, resulting in good suspension stability for optimum NP performance, as opposed to Da = 10-4 , when NP sedimentation is noticeable. Similarly, increasing NVF matches the increasing Nusselt number until a specific optimum is reached. For NP type optimality, the study shows a good blend of nanoparticles' physical properties as the hierarchy of percentage enhancement performance is not determined solely by a factor (especially thermal conductivity, as vastly thought); with Al2O3 having the highest average Nusselt number of 15.27%, Zn follows with 12.76%, CuO has 12.22% and Cu has 10.54%. A proposed model on magnetohydrodynamics investigation accounts for the underestimation of nanofluid influence during natural convection. Lorentz force intensity is inversely related to fluid flow and heat transfer augmentation, although the inclusion of nanoparticles incurred some improvements. The heterogeneity of a porous ix enclosure is ascertained by extending the initial model via the inclusion of a nonconstant permeability layered matrix. The average Nusselt number is calculated under same condition at varying Ra and results turn out differently as the homogenous porous domain has higher Nusselt values than the heterogenous porous enclosure, at varying NVF thereby affirming heterogeneity as a significant parameter in flow analysis. This research uses LBM to gain a better understanding of nanoparticle dynamics and heat transfer enhancement behavior in porous media.

Usman, Aliyu (2022) *Performance Evaluation Of Regular And Gamma-Irradiated Waste Polyethylene Terephthalate Modified Asphalt Mixtures.* Doctoral thesis, Universiti Teknologi PETRONAS.

The exponential rise in waste polyethylene terephthalate (WPET) production is a major source of pollution globally, and recycling used items for economic and environmental reasons is a common problem that society is currently addressing. Research to enhance the mechanical performance of bituminous mixtures using WPET as sustainable material continues because of its potential as a recycling alternative for WPET. Nevertheless, previous studies have reported inconsistent performance properties due to incorporating WPET in asphalt mixes. For this reason, in this research, the WPET particles were exposed to 100kGy ionizing gamma rays to enhance the WPET properties as a component in asphalt mixes. This study investigates and compares the volumetric and Marshall characteristics as well as the performance properties of asphalt mixes containing regular (RWPET) and irradiated (IWPET) WPET granules. Additionally, the study also aims to develop an RSM coupled ANN-based optimization for IWPET modified mixes. The impact of gamma irradiation on the WPET was checked using analytical characterization. The findings from volumetric properties show that OAC reduces with increasing WPET content for both WPET modified mixtures relative to the reference mix. The Marshall stability values were increased for IWPET modified mixes and reduced for RWPET modified mixtures. The performance properties of both WPET modified mixes were improved compared to the reference mix. For instance, the lowest rut depth of 3.713mm and 3.121mm were obtained at 60°C for 20% RWPET and 40% IWPET, respectively, while the reference mix had a rut depth of 4.734mm. Furthermore, the resistance to fatigue of the modified mixtures containing 30% WPET was enhanced by 35.36% and 49.05%, respectively for RWPET and IWPET modified mixtures at 250kPa. The stiffness and moisture resistance were boosted for the modified mixes relative to the reference mix, however, IWPET modified mixes show superior performance. The RSM-based ANN optimization shows that both techniques were excellent with high R2 values greater than 0.9. However, the ANN method showed superior prediction ability compared to the RSM method with lower RMSE, MRE, and higher R2 values.

Ali, Imtiaz (2022) *Experimental Investigation On Improvement Of Mechanical Properties Of Dp590 Steel Joint Using Double Pulse Resistance Spot Welding.* Doctoral thesis, Universiti Teknologi PETRONAS.

Dual phase (DP) steel is commonly used for safety parts in car body. Poor weldability during resistance spot welding (RSW) is the key factor limiting its wide applicability in automotive body structure. The main challenge associated with RSW of DP steel is formation of very hard martensite in fusion zone (FZ) and heat affected zone (HAZ), which impair the load bearing and energy absorption capability and promote interfacial failure of the weld. In situ rapid tempering of martensite via applying a second pulse current after the first melting pulse current presents a new pathway to improve the mechanical properties of weld. Based on this notion, this study investigates the effect of double pulsing on microstructure-property relationship of the DP590 steel RSW weld. Double pulse RSW of DP590 steel was carried out in lap and cross tension configuration according to suitable Taguchi orthogonal array at various second pulse welding currents, welding times and cooling times. Macrostructure analysis showed that FZ size of double welds increased due to nugget edge remelting resulted in enhanced bond area. Microstructure analysis revealed the formation of tempered martensite in the FZ and HAZ featured by precipitation of nano-sized cementite precipitates which resulted in improved fracture toughness of the welds. XRD and elemental analysis further confirms formation of cementite precipitates. Texture analysis revealed the formation of randomly orientated grains with high fraction of high angle boundaries resulted in improved resistance to crack propagation. Mechanical performance analysis showed remarkable improvement in load bearing and energy absorption capability of the double pulse welds (DPWs) under cross tension and lap tensile shear loading. Moreover, DPWs also showed better fatigue performance compared to conventional single pulse welds. Taguchi S/N ratios analysis showed that optimum second pulse parameters to obtain maximum peak load and failure energy under various loading conditions are second pulse welding current of 7.5 kA, welding time of 560 ms and cooling time of 400 ms. Statistical models were formulated using multiple regression method to predict the peak load and failure energy of double pulse welds for given set of parameters. Regression analysis showed R2 of 96.79 % and 98.10 % of cross tension peak load and failure energy models respectively, whereas R2 of 90.57 % and 97.10 % of low dynamic tensile shear peak load and failure energy models, respectively which indicates that developed models are statistically significant.

Ibrahim Jibril, Zainab (2022) *Development Of Ce-Zr/Al-Mcm-41 Catalyst For Biodiesel Production From Date Seed Oil.* Doctoral thesis, Universiti Teknologi PETRONAS.

In this research, Ce-Zr/Al-MCM-41 monometallic and bimetallic catalysts were prepared by impregnation and sonication methods for biodiesel production. The catalytic properties were studied using N2 adsorption-desorption isotherms, X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), NH3-TPD, and CO2-TPD (Temperature Programmed Desorption). The result shows that CeO2 and ZrO2 particles were dispersed on the support. Biodiesel was produced from date seed oil that was extracted after roasting and soaking pre-treatment methods. Response surface methodology based on the central composite design (RSM-CCD) was used for the optimization of biodiesel yield. The result shows a good model fitting with an R2 value of ~0.92%, from the analysis of variance. The optimum conditions were reaction temperature of 60.5 °C, reaction time of 3.8 h, catalyst loading of 4 wt.%, and methanol to oil molar ratio of 6.2:1 mol/mol for 93.83% biodiesel yield. Kinetics was studied at a reaction temperature range of 55 – 60 °C and reaction time 1 – 4 h. Pseudo-first order was the best-fitted model with activation energy (Ea) of 57.51 KJmol-1 and the preexponential factor (A) of 1.00x109 min-1 . Thermodynamic studies show positive Gibbs free energy of activation (ΔG‡) and enthalpy of activation (ΔH‡), and a negative entropy of activation (ΔS‡). The catalyst was reusable for 5 cycles with no significant difference in the FAME yield. The quality of the FAME produced was within the values reported in studies, ASTM D6751, and EN14214 standards. In conclusion, Ce-Zr/Al-MCM-41 catalyst has a high potential for biodiesel production due to high activity and stability. The ratio of CeO2 and ZrO2 particles has a significant influence on the catalytic properties and performance. Therefore, the bimetallic catalyst performed better. Also, the sonication method improved the dispersion of CeO2 and ZrO2 particles. The synthesis of Ce-Zr/Al-MCM-41 bimetallic catalyst with various equal ratios of the active metal oxides is recommended.

Jamaludin, Siti Nur Fathiyah (2022) *Cenozoic tectonic evolution and succession of carbonate growth in development of Luconia-Balingian Provinces, Sarawak, Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

The Luconia and Balingian basins in Sarawak formed during the Eocene. The area underwent various tectonic deformations including extension and compression. It was infilled by thick sedimentary sequences, including widespread limestone. The basins also exerted a strong control of the pre-existing basement inhomogeneities reflected by structural variation in the basins. However, the degree of structural preservations within the thick sedimentary sequences is uncertain. Thus. this study aims to produce a comprehensive geological model that incorporates tectonic deformation and limestone growth as a regional marker. This was done by conducting seismic interpretation over 3025.7 km seismic lines, assisted with lithological interpretation from deep-seated wells. The depth tensor from airborne gravity and aeromagnetic data were evaluated to assess deep and shallow sub-surface structures. Results from seismic and well interpretation were combined to calculate the amount of total and tectonic subsidence. A chronological-based geological model was developed to demonstrate the effects of tectonic deformations at three different time ranges. The model is supported by the amount of tectonic subsidence since 37 Ma. The basins experienced an increase in tectonic subsidence from 37 to 18 Ma. Then, delay in tectonic subsidence from 15.5 to 11.8 Ma and increase in tectonic subsidence from 11.8 Ma. This area was formed partly by crustal extension at the beginning before it formed as a foreland basin. The insight into subsurface structures revealed NW-SE orientations at shallow depth and E-W to NWW-SEE directions in deeper depth. The E-W anomalies are postulated to represent the remnants of the crystalline basement. The findings of this study proved the existence of the "Basement Rule" in controlling the basin development and revealed the orientation of potential crystalline basement of Luconia continental block. The model had elevated the regional understanding of prolong tectonic and sedimentation history in the area. It could be an advantage in determining the potential hydrocarbon reserves, particularly in Eocene-Oligocene successions.

Abd Rashid, Ahmad Shukri (2022) *Geo-Mechanical Correlation of Surface Settlement Induced By Tunnel Excavation For Kuala Lumpur Valley Mass Rapid Transit (KVMRT).* Doctoral thesis, Universiti Teknologi PETRONAS.

Tunnelling construction is an inevitable cause of ground settlement in the built environment. Predicting the surface ground settlement in tunnelling remains a challenge especially to geotechnical engineers and predominantly the application of twin tunnel boring machine. This thesis investigates the surface ground settlement induced by the Earth Pressure Balance (EPB) twin tunnel boring machine in Kenny Hill Formation (KHF) for Klang Valley Mass Rapid Transit (MRT) Line 1: Sungai Buluh-Kajang (SBK) tunnel underground works. The fundamental of ground settlement by the empirical Gaussian distributions used the actual ground settlement data from this project and was back-analyzed by author's self-coded MATLAB algorithm. Each settlement data was iterated and fitted to parallel configuration of the twin tunnel alignments at six greenfield sections by superimposing two Gaussian distribution curves. The best fit curves resulted in twin tunnel parameters, namely settlement trough coefficient, K with averaged value of 0.25 for both tunnels and tunnel volume loss, VL of 0.45 %. Each individual tunnel shows this within the clayed soil type; however, iteration by both tunnels shows K coefficient was lower than the typical design value of 0.5, resulting in steeper settlement profile; whereas lower tunnel volume loss was expected considering the application of advanced EPB machine that controls well of ground pressure and deformation. Live data of twin tunnel EPB machine comprised of 21 parameters from major (Earth Pressure, Total Grouting, Soil Conditioning, Thrust Speed, Foam Injection, Tail Sealing, Soil Conditioning and Cutterhead) to minor geomechanical (Cutter Head: Rotation-Torque-Pressure, Screw Conveyor: RotationTorque, Tail Sealing and Sealing Grease Injection, Foam Injection: Foam AddictiveWater/Ring, Solution/ Ring and Average Foam, Soil Conditioning: Bentonite/Ring and Cutter Head Flushing Water/ Ring) were collected and analyzed together with manually logged tunnel shift reports. The tunnel machine interaction to ground settlement is studied by Artificial Neural Network (ANN) to identify which twin EPB tunnel parameters affected the ground settlement the most. The three main domain of geomechanical deformation (Loss of Face, Shield, and Tail) were tested in the ANN architecture which contributes to the sequential surface settlement and tunnel volume viii loss. Each tunnel section produced 21 sets of results based on the selected parameters for training, validation, and test within the Root Mean Square (RMSE) result, which lowest RMSE forecasting the regression analysis from prediction errors. Within the geo-mechanical parameters tested and the lowest RMSE, it proves Tail Sealing, Sealing Grease Injection and Foam Injection were the lowest three factors compared to the remaining geo-mechanical parameters. The overall RMSE results were lowest between 0.055 and 0.075 compared to highest RMSE of Face Loss of 0.426. On the other hand, the RMSE results for twin tunnel volume loss (VL) was quite low between 0.008 and 0.0183, which depends on actual tunnel volume loss of 0.45 %. The analysis also shows differences in geo-mechanical contributor relationship of ground surface settlement and tunnel volume loss with percentages of 87 % and 55 % of RMSE result respectively, within twin tunnel EPB.

Abdulkadir, Isyaka (2022) *Development of High-Performance Engineered Cementitious Composite with Enhanced Resistance to Elevated Temperatures Using Crumb Rubber and Graphene Oxide.* Doctoral thesis, Universiti Teknologi PETRONAS.

Despite its outstanding ductility and strain hardening behavior, one of the downsides of engineered cementitious composite (ECC) is the explosive spalling problem when exposed to elevated temperatures, in addition to its low modulus of elasticity and excessive drying shrinkage. This study aims to develop an ECC with enhanced performance at elevated temperatures and improved mechanical, durability, deformation, and microstructural properties by modifying it with crumb rubber (CR) and graphene oxide (GO). The aim of the research was achieved by developing three different GO-modified rubberized ECC mixes with the view to getting the most suitable CR and GO enhancement technique through a four-stage process. In the first stage, using response surface methodology (RSM), the optimum high-volume fly ash (HVFA) replacement of cement and PVA fiber volume fraction was obtained to develop a standard ECC-M45 with self-compacting (SC) properties satisfying EFNARC 2005 requirements. Subsequently, the three GO-modified rubberized ECC mixes were developed in stages two to four by firstly using GO (addition of 0.02 to 0.08%wt. of cement) and CR (1-5% replacement by volume of fine aggregate), followed by using only GO-modified CR (with GO concentrations of 0.25 – 1.0 mg/ml), and lastly using combined GO, CR, and GOCR as variables in the mixes, respectively. The fresh (SC), mechanical, deformation, durability, microstructural, and elevated temperature (200°C – 1000°C) properties were assessed as the responses. Also, response predictive models were developed and analyzed using ANOVA, and multi-objective optimizations of the variables and responses were performed. The results show that GO significantly decreased the flowability of the mixes in a fresh state while significantly enhancing the mechanical strengths, modulus of elasticity, and elevated temperature resistance. Conversely, CR reduces the mechanical strengths while enhancing the ductility and explosive spalling resistance. The two materials' synergetic effect significantly enhanced the developed mixes' overall performance. All the developed response models were experimentally validated with less than a 10% margin of error.

Ahmad, Aqeel (2022) *Development Of Polyetheretherketone/Multiwalled Carbon Nanotubes Nanocomposites With Different Ionic Liquids For Human Bone Transplantation.* Doctoral thesis, Universiti Teknologi PETRONAS.

Polyetheretherketone (PEEK) is a high-performance semicrystalline thermoplastic polymer with excellent chemical and thermal stability that has been widely used in the biomedical field as a substitute for human cortical bone. However, low bioactivity and weak mechanical properties restrict the use of PEEK in orthopedic implants. Reinforcement of PEEK by nanoparticles such as hydroxyapatite (HA) and multiwalled carbon nanotubes (MWCNTs), is a technique that has the potential to prepare PEEK composites with enhanced properties. Nevertheless, the homogenous dispersion of MWCNTs in the polymer matrix is a primary processing challenge. The present study reports an environmentally friendly approach for homogeneous MWCNTs dispersion in PEEK composites by using ionic liquids (ILs) with different loadings via melt-blending and compression molding techniques. To examine the effect of ILs on PEEK composites, optical microscope, FESEM, DSC, TGA, nanoindenter and UTM analysis were performed. Moreover, the effect of HA on biological properties, and thermal degradation kinetics of PEEK composites were also explained. ILs provoked a uniform MWCNTs dispersion in PEEK, as confirmed by FESEM and optical micrographs. The thermal properties including decomposition temperature and percentage crystallinity of PEEK composites with the employed ILs were enhanced. PEEK composites containing 1 wt% of 1- butyl-3-methylimidazolium hydrogen sulphate ([BMIM]HSO4) exhibited 37 % and 6.33 % increase in elastic modulus and tensile strength, respectively. The Alamar blue assay investigation confirmed that inclusion of HA to PEEK composites improved the cells viability (more than 80 %). Also, the effectiveness of PEEK composites with and without ILs was modelled using Coats-Redfern, Broido and Horowitz-Metzger models, and it was discovered that a 3-8 % rise in the activation energy of ILs treated composites was found. The considerable improvements indicated that ILs-based approaches could be a novel, green, and promising processing method for uniform MWCNTs dispersion in PEEK for prospective biological applications.

Al-Mekhlafi, Al-Baraa Abdulrahman Ahmed Hamood (2022) *The Effect Of Nature Of Work Factors And Driving Fatigue On Driving Performance Among Malaysian Oil And Gas Tanker Drivers.* Doctoral thesis, Universiti Teknologi PETRONAS.

Safety culture enhances the prevention actions and manages the most significant risks associated with the organization's activities. Research on safety culture has received attention among scholars, particularly in the field. However, the discussion about this issue in the oil and gas transportation sector is still limited, particularly in Malaysia. Therefore,this study aimed to examine the effect of the nature of work factors (work schedule, work activities, and work condition) and driving fatigue on driving performance. This study also investigated the moderating role of safety culture on the relationship between the nature of work factors and driving performance. The study employed a survey involving 357 oil and gas tanker drivers and fatigue assessment test involving 58 oil and gas tanker drivers working in the Malaysian oil and gas transportation industry. The Partial Least Squares (PLS-SEM) software was used in the survey to analyze the data and test the research hypotheses. The results indicated that there is no significant effect of work activities on driving performance. However, the work schedule has a bearing on driving performance.Additionally, there is a significant influence of work condition and safety culture on driving performance. The results further revealed that safety culture intervention moderated the relationship between the nature of work factors and driving performance. In the fatigue assessment test, both React and SPSS software were used to analyze the data. Based on the results, there was a significant difference between the tests. Also, driving fatigue negatively impacts driving performance based on drivers' accumulated effort, especially those who work in shifts. The outcomes of this study have important theoretical and practical implications for the Malaysian oil and gas transportation industry. The study suggests that managers in the Malaysian oil and gas transportation industry can adopt the strategy for enhancing the safety culture of the oil and gas tanker drivers to maintain a high level of driving performance. As a result, it will improve the effectiveness of drivers duties and reduce fatal road accidents to the nearest minimum.

Al-Salman, Husam (2022) *Evaluation of Novel Microwave-Current Assisted Sintering of Pure Beta-Silicon Carbide Nanopowder Based on the Optimization of Sintering Parameters.* Doctoral thesis, Universiti Teknologi PETRONAS.

Sintering of pure SiC ceramic with homogeneous nanostructure and fully dense body is a big challenge without using an external pressure and sintering additives because of a high melting temperature, low-self diffusion coefficients and high percentage of covalent bonds. The focus of the current study was to objectively evaluate an alternative to current assisted sintering techniques used for the monolithic ultra-high temperature pure SiC nanoceramic. For achieving the main objective of this research project, orthogonal array method was used as a statistic tool for designing the experiments and optimizing the parameters. The ranges of temperature, pressure and microwave power parameters were 1600-1900 °C, 20-80 MPa and 200-800 W, respectively. FESEM, EDS and XRD were performed to characterize the microstructure and elements composition. Besides, Vickers hardness test were performed to measure the microhardness of sintered SiC sample. Analysis of Variance was performed to evaluate the significance of parameters and the fitting of experimental data to the driven models. The regression model was driven using Analysis of Variance. The microwave contribution percentages of relative density and average hardness improvements were 9.07% and 25.29%, respectively. The optimal sintering parameters of relative density were 1900 °C, 80 MPa and 600 W of the temperature, pressure and microwave power, respectively. Then, the confirmation tests were carried out based on the optimal parameters of relative density. The best achievements of relative density and average hardness were 99.2% and 32.2 GPa, respectively, where the sintering parameters of the temperature, pressure and microwave power were 1950 °C, 80 MPa and 600 W, respectively. The saving of electrical power was 13.7%, when microwavecurrent assisted sintering technique was used for sintering pure SiC. In conclusion, the proposed microwave-current assisted sintering technique was an efficient for enhancing the densification, homogeneity and mechanical properties of monolithic SiC with nanostructure, as well as saving the energy

Ali, Shahid Muhammad (2022) *Design and Evaluation of Sensor Antenna Systems for On-Body Monitoring Activity in Healthcare Applications.* Doctoral thesis, Universiti Teknologi PETRONAS.

This research proposes sensor antennas for 802.11b/g/n standards in wireless body area networks (WBAN). The wearable devices to work on the human body are extremely challenging due to the interaction between the sensor antennas and the human body coupling effects. The proposed work describes the development of a flexible sensing meander line monopole sensor antenna (MMSA) and a rigid wirelessbased platform in detail, with a particular focus on the design of a new wireless button sensor antenna (BSA) that can be integrated into a wristband such as a hand watch. By combining a button antenna and a wireless sensor module that is designed on a printed circuit board (PCB), a mechanically robust system is realized, and its performance is validated by examining it as a wireless sensor antenna. The simulated and measured results showed good agreement in both designs. The BSA offers a wide range of omnidirectional radiation patterns (ORP) in free space, with a reflection coefficient (S11) of −29.30 (−30.97) dB, a maximum gain of 1.75 (5.65) dBi, and radiation efficiency of 71.91(92.51) % in lower (upper) bands. The S11 reaches −23.07 (−27.07) dB and −30.76 (−31.12) dB, with a gain of 2.09 (6.7) dBi and 2.16 (5.67) dBi, and radiation efficiency of 65.12 (81.63) % and 75 (85.0) %, for lower (upper) bands on the human chest and arm locations. Experimental assessments of the read range for indoor and outdoor scenarios confirm the results of a coverage range of up to 40 m. Similarly, the MMSA offers ORP, with a wide impedance bandwidth (BW) of 1282.4 (450.5) MHz, with a gain of 3.03 dBi (4.85 dBi) for lower (upper) bands in free-space. The impedance BW could reach up to 688.9 MHz (500.9 MHz) and 1261.7 MHz (524.2 MHz), with a gain of 3.80 dBi (4.67 dBi) and 3.00 dBi (4.55 dBi), on the human chest and arm, respectively. A measured shift of 0.5 and 100 MHz in impedance matching and resonance frequency was observed in both bands. The calculated Specific Absorption Rate (SAR) values are below the regulatory limitations for both 1-gram and 10-gram tissues standards for an input power of 0.1- 0.5 Watts.

Ali, Syed Emad Azhar (2022) *Long-run Effect of Information Security Breaches on Investors' Confidence: The Moderating Role of Intellectual Capital.* Doctoral thesis, Universiti Teknologi PETRONAS.

The COVID-19 pandemic has expedited digital revolutions across all industries, increasing businesses' usage of digital technologies for operational and strategic goals. However, with the widespread use of digital technology and the evolving nature of digital assets comes an increase in cyberattacks and information security (infosec) breaches, placing businesses at risk, particularly in the nine countries of Asia Pacific Economic Corporation (APEC-9). Infosec breaches can have a long-lasting effect on publicly traded companies' financial performance and, hence, on confidence in stock investors. Past research has focused exclusively on the short-run effect of infosec breaches on investor confidence despite its significance. Along with today's knowledge economy, the lack of efficient intellectual capital (IC) that results in effective infosec risk mitigation practices in the event of infosec breaches exacerbates the loss of investor confidence. Thus, this study evaluates the long-run effect of infosec breaches on investors' confidence in breached firms with the moderating effect of Intellectual Capital. The theoretical framework is founded on 'signaling theory' and 'knowledgebased theory' principles. This research examines the effect of 276 infosec breaches at publicly traded APEC-9 firms from 2009 to 2018 on investor confidence as measured by long-run abnormal returns and long-run equity risk. Using a one-to-one matching approach, each firm's performance is analyzed with its control firm for three years, from one year before to two years after the breach. The findings indicate that breached firms experience a significant negative abnormal return ranging from 7% to 20%. Equity risk increased by 11% within a similar period. The examination of infosec breach factors on investor confidence through quantile regression (QR) indicates that the long-run losses in investor confidence would be higher if the breach a) involves the compromise of confidential information, b) is a repeat breach to the same firm, and c) occurs at a non-US firm. Furthermore, our findings from the QR and Marginal Effect x Curve Method indicate that investor confidence losses could be mitigated for breached firms with a higher level of intellectual capital (IC).The study intends to be a valuable resource for investors, managers, and researchers seeking to better understand the longterm relationship between information security breaches and investor confidence. Also, a sophisticated insight is expected to be provided to managers by which they can develop and disclose their firms' IC to investors to portray effective infosec-risk management and resiliency practices.

Aslam, Mubeen (2022) *Domain Specific Modelling Language for the support of migration of PIM of an OSSS towards Infrastructure Cloud Service Model.* Doctoral thesis, Universiti Teknologi PETRONAS.

Nowadays in the global business market, Computational Fluid Dynamics-Open Source Simulation software(s) CFD-OSSS(s) are utilized more as compared to general OSSS. Complex simulation tasks are performed by CFD-OSSS in industries like automotive, turbomachinery, aerospace, health care, manufacturing, oil & petroleum, or civil engineering. Organizations prefer to work on their legacy CFD-OSSS rather than adapting new CFD-OSSS(s) since the whole organizational environment is set according to their specific business functionalities. With the dynamic growth in daily requirements and to avail benefits of a cloud environment, the organizations prefer to migrate their legacy CFD-OSSS to the cloud. While this cloud migration, organizations face problems in updating and maintaining the key business logic, elasticity, scalability, multiple users working at geographical distances, and control of cloud services. To overcome these critical issues being faced by the industrial community, this study proposes a novel Domain-Specific Modeling Language (DSML) which has the features of preserving and modernizing the business logic, data, dictionary, and library files of a legacy CFD-OSSS, load balancing for scalability, adding/release of on-demand resources for elasticity, a multi-user environment, a zone feature for geographical distances works, and service control of the infrastructure layer of the cloud. Thus, the main objective of this DSML is to transfer the legacy CFD-OSSS Platform Independent Model (PIM) to the target CFD-OSSS-PIM for the Infrastructure layer of the cloud. This DSML works for the middle layer of the Architecture Driven Modernization (ADM) framework that supports the preservation of the business functionalities of a system. For the evaluation of requirements required for the development of the proposed DSML, a novel Requirement Quality Evaluation (RQE) matrix is proposed. The main goal of RQE is to ensure that the requirements are complete, correct, consistent, feasible, verifiable, traceable, and modifiable. An extensive evaluation of the proposed DSML is done on benchmark CFD-OSSS(s) and is validated with a stateof-the-art Framework for Qualitative Assessment of DSLs (FQAD) and the Eclipse tool. Lastly, for the verification of system features and refinement towards viii implementation, the proposed DSML was verified with Object-Z formal specifications. Correctness and Consistency of Object-Z specifications are checked with the Eclipse tool. In comparison to the existing DSML(s), this study has shown promising results in terms of the transformation of legacy CFD-OSSS-PIM to the target CFD-OSSS-PIM for the infrastructure layer of the cloud.

Buniya, Mohanad Kamil (2022) *Developing Framework For Safety Program Implementation In Iraq Construction Projects.* Doctoral thesis, Universiti Teknologi PETRONAS.

The construction industry has always been considered one of the most hazardous industries globally. The construction industry's unsafe conditions require an effort to improve its safety performance to prevent and reduce accident rates. Iraq is a country that has been very active in construction activities over the last ten years and is continuing at a rapid rate. Despite the rapid growth in the construction industry, the workers are still working in poor safety conditions. Hence, there is a need to provide a safe working environment and reduce the accident rate through a safety program implementation in a proactive manner. This research investigates the effects of safety program implementation on safety performance and develops a framework by examining the influence of safety program implementation on overall project success (OPS). This study applied a mixed-methods approach. First, an interview with sixteen experts in the Iraqi construction industry was conducted to assess factors influencing safety program implementation. An Exploratory Factor Analysis (EFA) was conducted to validate the interview results. Finally, a questionnaire survey was utilized to obtain feedback from 196 respondents from the building projects using Partial Least Square Structural Equation Modelling (PLS-SEM). The framework was developed using the PLS-SEM to determine the impact of safety program implementation on OPS. Firstly, the result provides evidence of the interactions between the safety program factors. Secondly, the PLS-SEM shows that the safety program implementation contributes about 69.5% of construction projects' success. After using the critical success factors (CSFs) as a moderator, the empirical study shows a positive impact of CSFs on OPS. Thirdly, the findings are expected to be a steppingstone to facilitate the needed improvements in the Iraqi construction industry's safety performance. Lastly, the study's findings will also assist construction practitioners, and policymakers develop a reliable guideline for a successful safety program implementation in the construction industry

Chun, Ung Wei (2022) *FNIRS Adaptive Cognitive Training System (FACTS): Personalizing Cognitive Training With Neurophysiological Workload-Driven Dynamic Difficulty Adjustment.* Doctoral thesis, Universiti Teknologi PETRONAS.

Not only mismatch between mental workload and working memory capacity can cause mental underload or overload, such mismatch in cognitive training is also hard to detect. As a possible solution, functional near-infrared spectroscopy adaptive cognitive training system (FACTS), a novel neurophysiological workload-driven dynamic difficulty adjustment system to personalize cognitive training, has been proposed. The engineering contribution lies in the designing and implementation of the system. It adopts the Yerkes–Dodson law as the framework whereby the mental workload shall never exceed an individual's capacity, to prevent those unintended situations. It works by monitoring mental workload neurophysiologically in real time and performing dynamic difficulty adjustment accordingly, thereby reducing the effects of intra- and inter-subject variability. Study 1 involved 37 healthy participants undergoing mental arithmetic task with and without FACTS. Without FACTS, the participants not only showed higher perceived workload scores but also poorer task performance and a significant drop in activation towards the end of the task, signifying more severe mental overload. Conversely, they continued to exhibit manifestation of productive learning with FACTS despite showing early signs of mental overload. The study results demonstrated that it is feasible to implement the concept of FACTS and warranted Study 2, which involved only six patients with mild cognitive impairment and mild Alzheimer's disease. They all underwent 30-min mental arithmetic training incorporated with FACTS twice a week for twelve weeks, plus pre-, mid-, post-training and follow-up assessment along the course of the training. Albeit not statistically significant, signs of training and maintenance effect were found in relevant outcome measures up to a certain difficulty level while control test results deteriorated. The study results showed that mental arithmetic training with FACTS is effective in vii boosting the gains. As evidenced in both studies, dynamically administrating mental workload whose amount is constantly tailored to one's current mental state indeed helps to reduce the effects of intra- and inter-subject variability.

Farooq, Muhammad Umer (2022) *Motion Shape Image based divergence behaviour detection and localization at high-density crowds.* Doctoral thesis, Universiti Teknologi PETRONAS.

This research primarily focuses on divergence detection and localization at the high-density crowd. A new concept of crowd motion shape is proposed in which the motion of a high-density crowd is captured in the form of motion-shape images (MSI) that act as low-level features feed to a classifier. Initially, the motion of the high-density crowd is estimated through the Finite-Time Lyapunov Exponent (FTLE) and Lagrangian Coherent Structure (LCS) in the FTLE field provide ridges at crowd boundaries. LCS ridges in the FTLE field are extracted through a scheme called FTLE field-strength adaptive thresholding (FFSAT) and grey-scale MSI's are produced. A new high-density dataset called HIGH_DENSE is created containing synthetic and real videos of high-density divergence behaviour. MSI's obtained from HIGH-DENSE are trained with a convolution neural network (CNN) to classify any unseen video images as normal or divergent. Thorough qualitative and quantitative experimentations proved that the proposed MSI approach outperforms state-of-the-art anomaly detection methods in terms of accuracy and 18% to 32% higher accuracy is achieved compared to existing art for divergence detection at high-crowd densities. The second major contribution of this research is to localize high-density crowd divergence and introduce new localization features that make anomaly localization practically a useful tool to deploy rescue at the exact location of an anomaly. New localization features include start/source point detection at high-density, crowd density estimate at localization region, angle of divergence and continuous updates of divergence anomaly size/shape. Detailed divergence localization evaluations (both qualitative and quantitative) at highdensity crowds shows that existing art whose focus was on low-density localization fails to localize divergence at the high-density crowded scenes.

Farooqi, Ahmad Salam (2022) *Development of Ni-Sr Bimetallic Catalyst for Syngas Production via Combined Steam and CO2 Reforming of Methane.* Doctoral thesis, Universiti Teknologi PETRONAS.

> Combined steam and CO2 reforming of methane (CSCRM) is gaining an increased interest due to the critical requirements to mitigate global warming and provide alternative energy resources. The main limitations of CSCRM are the catalyst deactivation due to coke deposition on the catalyst surface and sintering of Ni metal. Therefore, in this study Ni-based catalysts supported on MgO-xZrO2 (x = 0, 5, 10, 15, 20 wt.%) mixed oxides were prepared by co-precipitation method and subsequently impregnated with 10 wt.% Ni metal. The characterization of the freshly prepared catalysts using N2 physisorption analysis, XRD, FESEM, H2-TPR, CO2-TPD, XPS and TEM techniques revealed suitable physiochemical properties for the CSCRM reaction. The best catalytic performance was obtained using the Ni/MgO-15%ZrO2 for the CSCRM reaction carried out in tabular fixed bed reactor at 4, H2O, CO2ratio of 3:2:1, respectively. The effect of the Sr addition (2-10 wt.%) on optimum Ni/15%MgO-ZrO2 catalyst was further investigated. The addition of Sr resulted in decreased catalyst acidity resulting in a more favorable reaction pathway during the CSCRM reaction. A superior catalytic performance was shown by Ni-Sr bimetallic catalyst with 6wt.% Sr loading (CH4 conversion = 96.2%, and CO2 conversion = 82.3 %) followed by 2wt.%>4wt.%>8wt.%>10wt.% Sr loading. The activity of the monometallic Ni catalyst declined due to the formation of amorphous carbon nanosheets which shrouded the active sites of catalyst, whereas Ni-Sr catalyst remained active due to the formation of filamentous carbon. The kinetics of CSCRM process over Ni-6%Sr/MgO-ZrO2 was investigated at a temperature range of 700- and the partial pressures of reactants (CH4, CO2 and H2O) ranged from 5-50 kPa. The experimental results obtained were then fitted with power law and Langmuir Hinshelwood kinetic models and the results are in good agreement with R2 value of 0.86-0.91. The apparent activation energy values for the consumption of CH4 and CO2 viii were found to be 20.94 kJ/mol and 27.53 kJ/mol respectively. The results revealed that the employment of MgO-ZrO2 mixed support and incorporation of Sr effectively boosted the Ni performance in CSCRM reaction along with suppressing the deposition of carbon on the catalyst surface.

Ghali, Abdulrahman Aminu (2022) *Energy Usage Efficiency Approach (E-Leach) For Mitigating Dos/Ddos In Internet Of Things (IoT) Environment.* Doctoral thesis, Universiti Teknologi PETRONAS.

Internet of Things (IoT) has gained remarkable acceptance with vast applications in industries, hospitals, schools, homes, sports, oil and gas, automobile, to mention a few. However, due to the unbounded connection of the IoT devices and the huge network communications, security concerns such as Denial of Service (DoS), Distributed Denial of Service (DDoS) attacks have posed real challenges in the IoT environment leading to the excessive draining of sensor battery energy. In particular, the research study has focused on improving battery energy usage efficiency and thereby mitigating the impacts of the DoS and DDoS attacks in the IoT perception layer. Recent studies have recommended the need to mitigate the DoS and DDoS attacks to safeguard the communication between the nodes and the Cluster Head (CH). For this reason, this study focuses on improving the existing protocol low energy adaptive clustering hierarchy (LEACH) by developing a robust approach named enhance low energy adaptive clustering hierarchy (E-LEACH). The proposed approach is based on a security mechanism that uses random keys to mitigate the impacts of DoS and DDoS attacks in the IoT perception layer and the approach was developed using MATLAB and tested with the Canadian Institute for Cybersecurity (CIC) dataset. The experimental results showed that the proposed E-LEACH can mitigate the DoS and DDoS attacks by 94.81% accuracy, and FAR by 0.02%, and with the average improvements for node lifetime, energy consumption, and throughput by 0.47%, 2.77%, and 3.98%, respectively which outperform the existing LEACH protocols such as LEACH, MS-LEACH, BLC-SDN, MOACO, GENETIC Algorithm, and Hybrid LEACH. The results suggest that the proposed approach has the potential in mitigating the DoS and DDoS attacks in the perception layer with overwhelming results. On this basis, the concept of mitigating DoS and DDoS attacks using the proposed approach may be considered when designing a framework to mitigate the attacks.

Hamidi, Rashidah Mohamed (2022) *Mechanical Activated Fly Ash Based Geopolymer As Coating Material For Urea Fertiliser.* Doctoral thesis, Universiti Teknologi PETRONAS.

Rapid and massive nutrient loss from urea fertiliser due to its high solubility characteristic had led to the invention of controlled release urea (CRU). Majority of the CRU produced from a non-biodegradable, toxic and expensive synthetic polymer. Fly ash based geopolymer, a green material was introduced as a potential coating material. However, the presence of less reactive fly ash particle resulted in porous geopolymer microstructure with low strength properties and consequently led to a poor release characteristic. In this work, fly ash was pre-treated via mechanical activation and the effect towards the properties of geopolymer coated urea with its urea release performance were investigated. Mechanical activation by high energy planetary ball mill with varied milling time, milling speed and ball to powder ratio was performed. Reactivity of fly ash wasimproved by reduction of particlesize from 15.331µm (original size) to 8.588µm which has led to the increment of the surface area (0.6998 to 2.7697 m2 /g). Geopolymer synthesis parameters were optimised using response surface methodology (RSM) obtaining mixing speed of 492 rpm, mixing time of 10min, NaOH concentrationof 12M, curing time of 1 day and curing temperature of 80oC as the optimum values producing geopolymer with highest flexural strength. Subsequently, geopolymer coating solution were prepared from original (OFA) and mechanically activated (MFA)fly ash with varied solid to liquid ratio and subjected to chemical, physical, morphology and mechanical analysis. Nutrient release rate of uncoated urea in water was rapid with 80% release within ~8 min compared to geopolymer coated urea (GCU) which transpired in ~30 min. The release was further delayed when urea coated with MFA based geopolymer with 80% release in ~90 min. Similar pattern was observed for urea release in soil where 80% of urea released in ~2 days (uncoated urea), ~6 days (OFA based GCU) and ~9 days (MFA based GCU). Production of GCU is highly beneficial in agriculture industry as it may improve the plant nutrient uptake, mitigates pollution due to nitrate leaching and ammonia volatilization and more cost efficient as no frequent fertilization involved.

Junejo, Aisha Zahid (2022) *Privacy Preserving Framework for Blockchain Networks.* Doctoral thesis, Universiti Teknologi PETRONAS.

With the widespread of blockchain technology, preserving the privacy (anonymity and confidentiality) of transactions have become crucial. The problem of privacy in blockchain networks is twofold, i) inefficiency of privacy preserving methods, and ii) absence of privacy quantification framework. Existing privacy-preserving frameworks are validated based on computing resources, i.e., memory, time, storage, throughput, etc., only, which is not sufficient. To solve these two problems, this research work proposes two frameworks, i.e., privacy preserving framework, and privacy quantification framework. The proposed privacy-preserving framework is a threelayered framework to protect privacy in blockchain applications. The first layer protects the anonymity and confidentiality of transactions using optimized zero-knowledge proofs. Second layer identifies and filters adversarial insiders to limit transaction propagation across the network, reducing the chances of network listening and transaction fingerprinting for user deanonymization. Finally, the third layer reduces the number of verifying nodes to improve system performance. This privacy preserving framework is evaluated using the privacy quantification framework proposed in this study. The quantification framework analyses the amount of privacy retained by privacy-preserving framework based on effectiveness of various factors that affect privacy in blockchain networks. This analysis then results in privacy attribute score, which is a quantifiable measure to empirically assess privacy retainment in blockchains. For validation, the proposed privacy-preserving framework is compared with benchmarking frameworks based on system design, performance, privacy quantification, highlights and limitations. Extensive results presented in this thesis show that the proposed privacy preserving framework successfully preserves 40.5% greater privacy as compared to existing benchmarking frameworks, while being more computationally efficient.

Khairuddin, Siti Hajar (2022) *Interval Type-2 Trapezoidal Membership Function for Fuzzy C-Means through Gaussian Distribution and Genetic Tuning.* Doctoral thesis, Universiti Teknologi PETRONAS.

Fuzzy C Means (FCM) is one of the mostly used techniques to generate membership functions (MF) for the fuzzification component of fuzzy inference system (FIS). FCM produces Gaussian MF due to an elementary distribution of clusters. The objectives of this research are to improve FCM in performing data clustering to generate trapezoidal MF (TrapMF) for interval type-2 (IT2) FIS; and to formulate effective range of footprint of uncertainty (FOU) using genetic weak tuning and lateral adjustment to construct IT2 FIS using the proposed TrapMF. This research also assesses the performance of IT2 FIS developed using the proposed method in terms of accuracy. The theory of Gaussian distribution is investigated to construct TrapMF from FCM outputs, which firstly involves fuzzy type-1 (FT1), and then it is expanded to IT2. Lateral adjustments and genetic weak (amplitude) tuning techniques are explored due to its parameter tuning methods which is suitable to be adapted for MF constructions. The techniques are adapted in investigating the range of effective FOU; a characteristic of IT2 that differs from FT1 and gives impact to FIS's performance. The effective FOU range is estimated using ignorance function value, W. Based on these methods, this research proposes the IT2WTLA1-TRAP and IT2WTLA2-TRAP algorithms. The algorithms differ in terms of the number of parameters involved in the tuning process. The results show that W=0.15 is the optimum value for effective FOU since it produces least error. The results also show improvements where the proposed IT2 TrapMF obtain 10.12% and 38.4% accuracy increment for both internal and external clustering quality testing. The proposed methods also gain 11.8% better in performance. To conclude, the positive evaluation results prove that both methods, which is to construct IT2 TrapMF from FCM Gaussian output through the theory of Gaussian distribution, and to construct TrapMF-based IT2 FIS using lateral adjustments and genetic tuning are successful and can produce better performance.

Khan, Huma Warsi (2022) *Ionic Liquid Based Emulsion Membrane For The Extraction Of Biologically Active Compounds From Wastewater.* Doctoral thesis, Universiti Teknologi PETRONAS.

Emulsion liquid membrane (ELM) has received significant attention for the removal of biologically active compounds (BACs) due to its high selectivity and simple operation. The limitations of conventional ELMs are the instability of emulsion, use of petroleum-based solvents and edible oils. To address such challenges, the aim of this study was to formulate a green and stable ELM for the removal of BACs. Ionic liquids (ILs) were employed as a carrier to improve the stability. Conductor-like screening model for real solvents (COSMO-RS) was used to screen ILs from thousands of ILs. Waste vegetable oil (WVO) was employed as green diluent to eliminate the environmental constraint. The screened IL was used to formulate WVO based ionic liquid emulsion membrane (WVO-ILEM). Span 80 was used as an emulsifier meanwhile sodium hydroxide and nitric acid were used as a stripping agent. The formulated WVO-ILEM was used to extract diclofenac (Dcf), ibuprofen (Ibf), and lactic acid (LA) from aqueous streams. To optimize the extraction process, the effect of various parameters including concentration of surfactant, stripping agent and carrier, phase ratio, homogenizer speed and time, treat ratio, stirring speed, stirring time on stability and extraction efficiency was investigated. Optimization was carried out using response surface methodology (RSM). The best IL screened for BACs was tetramethylammonium sulfate [TMAm][SO4]. A highly stable WVO-ILEM was developed using screened IL with maximum stability for more than two hours. Maximum extraction efficiency was achieved using developed WVO-ILEM at the optimized conditions obtained using one factor approach. RSM optimized results were in good agreement with experimental results leading to maximum stability and efficacy of WVO-ILEM. The extraction followed first-order rate kinetics with high permeation rates. It was found that WVO-ILEM can be reused up to five to six times with good extraction efficiency. This study suggests that WVO-ILEM are a promising alternative for removing BACs.

Khan, Muhammad Imran (2022) *Development of Sustainable Cementitious Grout Containing Irradiated Waste Polyethylene Terephthalate for Semi-Flexible Pavement Surfacings.* Doctoral thesis, Universiti Teknologi PETRONAS.

Road pavements are usually categorized into flexible and rigid structures. However, both structures still have disadvantages related to some specific loading and environmental conditions, leading to the need to look for an alternative structure. One such option is semiflexible pavement surfacing or grouted macadam, which is constructed by injecting cementitious grout into voids of an open-graded asphalt surfacing. It should be noted that the use of cementitious grouts might cause environmental impact due to the consumption of cement, thus increasing CO2 emission from cement production. Therefore, this study is aimed to investigate the potential use of irradiated waste polyethylene terephthalate (0-10%) and fly ash (0-10%) as partial replacement of cement in the formulation of cementitious grouts in semiflexible pavement surfacing. In addition to that, the study also focuses on the design, analysis, and optimization of grout compositions using an experimental design and analysis tool and their feasibility in the performance evaluation of semi-flexible pavement surfacings. The cementitious grouts were evaluated for physical and strength properties. The detailed design, analysis, and optimization of the grouts were performed using experimental design and analysis tools. The optimized combination of cementitious grouts was then used to produce semiflexible surfacing specimens and evaluated for Marshall stability, indirect tensile strength, thermal expansion, flexural strength, and resistance to moisture and fuel spillage, rutting and fatigue. Furthermore, a multi-layer elastic system was also used for the design and simulation of proposed semi-flexible pavement section. The results from the testing on cement grouts indicate that replacing cement with different percentages of regular PET causes a substantial reduction in compressive strength (i.e., 26 to 78%) and flexural strength (up to 13%). However, the irradiated PET recovered some of the compressive strength (i.e., 8 to 24%) and flexural strength (up to 5%) that were reduced due to regular PET. The semi-flexible surfacing specimens also showed superior performance, higher stiffness modulus, and better fatigue life compared to that of hot mix asphalt (HMA). The design and analysis of stresses/strains using a multi-layer elastic system indicate that semi-flexible pavement has rutting life (65-86%) and fatigue life (20-40%) higher compared to flexible pavements. The approach of irradiation technique will lead to a sustainable solution for recycling increased quantity waste PET in highway materials to construct a semi-flexible pavement surfacing.

Khan, Parvez Alam (2022) *Examining Holistic Sustainable Innovation, Firm Financial and Sustainable Development Goals Performance: A Study of Malaysian Public Listed Companies.* Doctoral thesis, Universiti Teknologi PETRONAS.

The world has frequently faced severe environmental and social challenges due to the tremendous impact of inefficient industrial sustainability practices, which eventually leads to financial losses in terms of market share, share price, and environmental fines. These challenges are not of any individual alone; instead, it is a global problem which creates a pressing need to shift the current business approach from reactive & individualist to a proactive, collaborative & holistic (PCH) approach. This PCH approach is achievable by adopting open innovation as an imperative variable of sustainable innovation, allowing this research to shift from current sustainable innovation practices to Holistic Sustainable Innovation practices. The proposed measurement instrument measures holistic sustainable innovation, and its effect was investigated on firm financial performance and firm sustainable development goal performance. Moreover, this study also investigated the moderation effect of independent director chair and women board representation. To conduct this research, panel data was collected using purposive sampling, through a weighted content analysis technique for collection of data on holistic sustainable innovation, and firm sustainable development goals, from the CSR, and the annual report of the top 186 Bursa listed firms. On the other hand, the firm's financial performance variables, return on equity (ROE), and return on asset (ROA) were collected from DataStream. The Generalized least square (GLS) fixed and random regression was used to investigate the causal relationship between all variables. This research has shown a significant positive relationship between holistic sustainable innovation, and firm financial and firm sustainable development goals performance. Furthermore, an independent director chair's moderation effect was insignificant, while women's board representation showed a negative relationship with firm performance. In addition, the comparison of sustainable innovation and Holistic Sustainable Innovation provides new findings that Holistic Sustainable Innovation can enhance the financial and sustainable development goals performance of firms. These new findings viii provide insights to the practitioners, regulators, policymakers, and international bodies that the environmental & social challenges can be mitigated and are able to contribute to a firm's financial performance, enabling to achieve the United Nations 17 sustainable development goals.

Khosravi, Vahid (2022) *Enhancement Of Oil Recovery From Sandstone Reservoirs Using Smart Water.* Doctoral thesis, Universiti Teknologi PETRONAS.

In the recent decade, there have been discussions about the underlying wettability alteration mechanism caused by Smart Water technology in sandstone. Furthermore, determining the effective range of water ionic concentration resulting in altered wettability has erupted the argumentative debates. Along with this, there is still a requirement to identify the in-situ wettability change and optimum water concentration. Therefore, this research navigates to advancing water chemistry studies via a systematic approach of experimental and simulation processes by the contributions of monovalent (Na^+) and divalent (Ca^{2+}) ions. To do this, molecular dynamics simulation was utilized to elucidate physicochemical interactions that led to changes in wettability. Besides, one-factor-at-a-time (OFAT) and design of experiments (DOE) methods were employed to conduct contact angle and interfacial tension (IFT) measurements to determine the effective range of ionic concentration. Likewise, water force displacement tests and reservoir simulations were run to ascertain the in-situ changes and optimum brine concentration considering relative permeability, fractional flow, and ultimate oil recovery curves. As a result of molecular dynamics calculations and configuration, two new phenomena named brine prong and oil vortex effects have been discovered. These effects contribute to detaching oil from the sandstone surface, thus, alter the wetting state. Accordingly, one novel model has been developed to forecast contact angle based on solvation free energy (SFE). In addition, two new empirical models were generated to predict contact angle and IFT based on brine concentration. The effective range of brine concentration has been found to be 1-15 kppm NaCl and 15-20 kppm $CaCl_2$. In addition, the optimal mix range of Smart Water flooding was measured to be 8 kppm NaCl-20 kppm $CaCl_2$ brine concentration, resulting in a 3.63% increase in ultimate oil recovery. This research advances new aspects of Smart Water flooding and brine/oil/rock behaviour, specifically in sandstone reservoirs.

Lekan, Oladosu Temidayo (2022) *Evaluation Of Deep Eutectic Solvents As Green Dehumidifiers And Magnetic Field Assisted Electrodialytic Regeneration Optimization.* Doctoral thesis, Universiti Teknologi PETRONAS.

> Greener desiccant solvents (biodegradable, biocompatible, and non-corrosive), highperformance membranes, and regeneration approaches for indoor energy consumption optimization are among ongoing investigations in liquid desiccant air conditioning system (LDAC) technology. For the first time, deep eutectic solvents (DESs) are presented as alternative desiccants for the LDAC system. BIOVIA material studio software 6.0(ACCELRYS) was used for DES material profiling, after which DES samples were synthesized and characterized. The work synthesized different deep eutectic solvents. Hydrogen bond acceptors (Choline chloride, N, NDiethylethanolammonium chloride, 1-Butyl-3-methylimidazolium chloride, $ZnCl_2$) and hydrogen bond donor (Ethylene glycol) were synthesized in different ratios to form these categories of deep eutectic solvents. Electrodialysis regeneration technique adopted in this work aims to overcome the re-cooling limitation in thermal regeneration techniques. Electro-dialytically regeneration of DES solvents was evaluated numerically and experimentally using COMSOL Multiphysics Software and MATLAB LIVE Link connection for user-defined functions and for the experimental regeneration, ED model was fabricated. The coupling of external magnetic fields was found to mitigate the drawbacks of ED regeneration such as over limiting current, electro osmosis, polarization due to concentration. The rheology of the investigated samples was found between 0.015 and 0.04 Pa·s, which are low compared to conventional ionic liquids and some nanofluids reported in the literature. The average thermal conductivity of the investigated binary DESs was between 0.228 and 0.17 W/m·K at 25 °C. Additionally, toxicity analyses of the DESs emitted compounds with health benefits, including triacetin, procainamide, monoacetate, and 2, 2 difluoro-ethyl acetates. At 65 % relative humidity, 30 °C air temperature, and 3.77×10^{-4} m^2 moisture-desiccant contact area, the estimated dehumidification mass flux of DES A1 and DES D1 are 4.61×10^{-2} and 3×10^{-2} $g/m^2 \cdot s$, respectively. These solutions are found promising as alternative solutions for dehumidification and thermal regeneration compared with viii $CaCl_2$. The flow rate factor could perform best at the third level of around 0.0058 m/s as the magnetic field point of interest could be around 2-4 mT.

Masroor, Komal (2022) *A Heuristic Optical Transceiver Placement Technique For Improving BI-DirectionalQuality-Of-Service In Remote Patient Monitoring.* Doctoral thesis, Universiti Teknologi PETRONAS.

The off-body uplink (UL) and downlink (DL) communication in optical body area network (OBAN) based remote patient monitoring (RPM) systems is crucial and necessitates the provision of quality-of-service (QoS). Therefore, reliability and signal-to-noise ratio uniformity (SNR-U) must be guaranteed within the coverage area. Broadly, the DL and UL SNR-Us are governed by transmitter (Tx) and receiver (Rx) placements, respectively. Several UL studies have reported the effects of different transceiver-related parameters, yet the optimization of SNR-U, and Rx locations has not been addressed. Conversely, the DL Tx-placement studies are well-established. However, they employ complex optimization routines, provide dedicated solutions for fixed room sizes, and/or fail to comply with the lighting engineering requirements. To resolve these issues, a DL geometry-based placement technique called Corner Illuminated Quadrants (CoIQ) is proposed in this study. Also, a heuristic formula is devised to compute optimum Tx positions for varying room sizes using five Txs. The performance of CoIQ is then compared with two techniques i.e., Centrally Lit Quadrants (CLQ) and Iterative Placement Technique (IPT). Since in RPM, UL is more crucial than the DL, therefore, once the DL placements are optimised to ensure SNR-U, then the principle of reciprocity (POR) is used to estimate the UL SNR-U. Furthermore, factors that can adversely affect the UL QoS performance are also investigated. The DL study revealed that CoIQ reduces the fluctuations in SNR from 1.48 dB in CLQ to 0.68 dB, which is a significant reduction of 54.18%, and it improves the illuminance uniformity by 74.8%. The same results were obtained for UL SNR-U via POR. Besides, the excellent UL QoS performance was found to be independent of the changes in operating wavelengths and transmitted power. Conclusively, CoIQ significantly outperforms CLQ, and its practical design would enable the technicians to easily find the optimized DL Tx and UL Rx locations.

Mathur, Nirbhay (2022) *Probability Risk Assessment And Visualization For Reliability Of Final Control Elements.* Doctoral thesis, Universiti Teknologi PETRONAS.

A process plant consists of many devices, among which control valves are considered the most widely used actuators. Since control valves are connected with many loops to perform the operation and produce output in a digitized manner, this provides a wide platform to understand the reliability of the valve. However, getting process failure data is a changeling task. Therefore, this research focuses on generating failure data by performing a control valve simulation and collecting failure data. The collected data is preprocessed and transformed into time-ranked observations to visualize the failure pattern. This research examines a novel approach in which statistical models such as the Weibull distribution, exponential distribution, log-normal distribution, and normal distribution are used to estimate component failure using the bathtub curve. Furthermore, the predicted values can be graphically plotted to visualize the trend of the bathtub curve. Specifically, the predicted value will give a 95% confidence interval to estimate the failure occurrence. Also, the estimated values are optimized with the maximum likelihood estimation (MLE) technique and are linked, in the meantime, to a failure to deliver 95% of the best fit. The proposed method will be able to identify the sensitivity of failure occurrence at an early stage, an intermediate stage, and the end of the life cycle. Moreover, the predicted models were able to estimate the early warning, midterm warning, and end-of-life warning, which will help system engineers perform predictive maintenance, which will increase the impact of productivity and cost-effectiveness.

Memon, Mehak Maqbool (2022) *Semi-Supervised Ensemble Model For Semantic Segmentation Of Semi-Dark Images.* Doctoral thesis, Universiti Teknologi PETRONAS.

Scene comprehension via Deep Learning (DL) based semantic segmentation is deployed to automatically monitor and analyse visual scenes by identifying image pixel class. However, the existing workflows provide constrained functionality due to the dynamic nature of the incoming visual scenes specifically semi-dark images. In this thesis, it is shown that semi-dark images inherit complexities which substantially reduce the resulting prediction efficiency. This research mitigates the effect of image complexities associated with low light imagery by designing a novel ensemble model composed of three layers. Firstly, to classify the image based on content visibility a novel image classification protocol is proposed using HSL (Hue, Saturation, Lightness) colour model. Proposed RPLC (Relative Perceived Luminance Classification) method identifies image content visibility in terms of overall image pixel luminance. Secondly, to capture the local context in terms of super-pixels (image pixel grouping), a novel content-aware pixel abstraction method is used. The existing methods lack the contentaware nature due to the irrelevant distance measures used to create super-pixels based on the local context of individual image pixels. To address this problem, a hybrid distance measure to induce content-aware nature is introduced by keeping Euclidean base distance intact and addition of geodesic distance to retain angular movements. The hybrid distance measure provides base for the novel extension of the super-pixel creation method namely SLIC++ (Simple Linear Iterative Clustering). Thirdly, to add semantic labels over these super-pixels an enhanced unified DL based approach is proposed namely Unified DeepLabV3+. The enhancement is in form of incorporation of additional dilation layers to tackle the problem of biased centric exploitation receptive field. While to increase the representational power non-linear group normalization layer are introduced alongside identity residual connections. The extensive experimental study shows RPLC attains 13.4% better classification accuracy, SLIC++ attains 8% better segmentation score and Unified DeepLabV3+ attains 3% better class-wise overall accuracy as compared to the contemporary baselines.

Musarat, Muhammad Ali (2022) *Incorporating Inflation Rate in Construction Projects Cost: Development of Construction Rates Forecasting Model.* Doctoral thesis, Universiti Teknologi PETRONAS.

The construction industry has the potential to fill up the financial deficit gaps and improve the day-to-day lifestyle of society. However, in spite of the advancement in the management of the construction industry, construction projects still facing the issue of cost overrun. Cost overrun is one of the most critical aspects of the construction industry tarnishing the financier's faith in construction investment as it eventually directs towards the project failure. One of the most critical issues is the inflation rate, which plays a vital role in deviating the prices of construction rates during the project lifecycle. Therefore, this study aims to investigate the behaviour of construction rates, i.e., building materials prices, labour wages, and machinery hire rates and their correlation with the inflation rate. The Spearman test was adopted to measure the correlation between the construction rates and the inflation rate. Also, the dynamic budget estimation model is another deliverable in this study. The correlation coefficient revealed that significant positive and negative relationships between the inflation rate and the construction rates exist as the correlation value was equal and above 0.05, indicating that the change in the inflation rate will also affect the prices which will result in deviating the initial budget of a project. In construction rates, building prices, labour wages and machinery rates were forecasted from the year 2020 to 2025 using the collected data from 2013 to 2019. Akaike information criterion (AIC) was used to validate the self-developed budget estimation model where it was revealed that the model gives better results when the construction rates were compared with the ARIMA time series model results. The developed model incorporates the changing impact of the inflation rate on construction rates and predicts the prices in a particular year which can be adjusted at the time of developing the Bill of Quantities. The model is applicable to be used on any type of construction project where rates are affected due to the inflation effect.

Nawaz, Muhammad (2022) *[Fault detection and diagnosis framework using wavelet-based kernel principal component analysis for chemical process systems.](#)* Doctoral thesis, Universiti Teknologi PETRONAS.

Process monitoring is essential for ensuring that the chemical process system functions smoothly and consistently. Multivariate statistical process monitoring (MSPM) plays a significant role in assuring the safe and efficient operation of industrial and chemical processes. Existing techniques are incapable of dealing with real-time nonlinear process data, resulting in inaccurate process fault interpretation. The objective of this study is to develop multiscale fault detection and diagnosis framework capable of detecting faults in real-time nonlinear process systems as well as identifying the underlying cause of faulty variables. In the proposed framework, wavelet transform (WT) is combined with kernel principal component analysis (KPCA). WT was initially used to extract the dynamics of process data at various scales. A moving window technique was introduced in WT, which aided data extraction for real-time process data. The wavelet coefficients from the analysis were reconstructed and then put into the KPCA for dimensionality reduction. Finally, T2 and squared prediction error (SPE) statistics are utilized to locate faults, and the reconstruction-based contribution (RBC) model is used to identify fault variables. The proposed fault detection and diagnosis framework was tested using two different chemical processes: the continuous stirred tank reactor (CSTR) system and Tennessee Eastman (TE) process. The average fault detection rate for the CSTR system's faults is 69.67% and found to be 81.20% for T2 and SPE monitoring charts. Whereas for the TE process, the average fault detection rate for all faults is found to be 45.85% and 82.51% for T2 and SPE monitoring charts. The diagnosis investigation is carried out by using SPE based RBC model and the results showed that the proposed framework successfully identifies the faulty variables. Furthermore, it is observed that the proposed framework provides better fault detection compared to principal component analysis (PCA) and KPCA methods. The proposed framework in this research work could be used for early and accurate fault detection as well as successfully identifies the root cause of the faulty variables.

Oluwagbemiga, Balogun Abdullateef (2022) *Rank Aggregation Based Hybrid Multi-Filter Wrapper Feature Selection Method For Software Defect Prediction.* Doctoral thesis, Universiti Teknologi PETRONAS.

Software Defect Prediction (SDP) is a machine learning approach used for identifying defect-prone software modules or components. However, the performance of any SDP model depends on the quality of datasets used for developing such a predictive model. High dimensionality is known as a data quality problem that has a detrimental effect on SDP models. This drawback makes applying feature selection algorithm(s) in SDP processes necessary. FS approaches can be categorized into three, namely: filter FS (FFS), wrapper FS (WFS), and hybrid FS (HFS). HFS has been established as superior as it combines the strength of both FFS and WFS methods. However, selecting the most appropriate FFS method (filter rank selection problem) for HFS is a challenge as the performance of FFS methods depends on the choice of datasets and classifiers. In addition, the local optima stagnation and high computational costs of WFS due to large search spaces are inherited by the HFS method. Therefore, as a solution, this research proposes a rank aggregation-based hybrid multi-filter wrapper feature selection (RAHMFWFS) method for the selection of relevant and irredundant features for SDP. The proposed RAHMFWFS is divided into two (2) stepwise stages. The first stage involves a rank aggregation-based multi-filter feature selection (RMFFS) method that addresses the filter rank selection problem by aggregating individual rank lists from multiple FFS methods to generate a single, robust and non-disjoint rank list. In the second stage, the aggregated ranked features are further pre-processed by an enhanced wrapper feature selection (EWFS) method based on a dynamic re-ranking strategy that is used to guide the feature subset selection process of the HFS method. The feasibility of the proposed RAHMFWFS was demonstrated on benchmarked software defect datasets with Naïve Bayes (NB) and Decision Tree (DT) classifiers, based on accuracy, the area under the curve (AUC), and f-measure values. The experimental results showed the effectiveness of RAHMFWFS to select optimal features from SDP datasets while enhancing the performance of SDP models over existing HFS methods (IWSS and IWSSr).

On, Ooi Joo (2022) *Fine-Grained Concurrency And Parallelisation Of Cross-Isa Dynamic Binary Translation And Optimisation Using Partitioned Seq-Resizable Scheme.* Doctoral thesis, Universiti Teknologi PETRONAS.

Modern portable software generally behaved as the hybrid of short- and longrunning applications, in which active apps may invoke others to fulfil a task. Thus, implementing dynamic binary translation and optimisation (DBTO) into multithreaded multicore system-on-chip would require careful re-assessments to ensure core usage efficiency. Thus, mixed modes of static and dynamic binary translation and optimisation systems would require concurrent compilation techniques with parallel binary processing to improve the DBTO conversion overheads efficiency from source to target architecture in terms of the instruction set architecture (ISA) perspective. This study performed a comprehensive analysis of the DBTO process's overheads, including coarse- and fine-grain levels of the overhead components,on the custom built DBTO system from open source QEMU and LLVM, particularlyy to tackle the context switching and thread contention more efficiently.The sources of overheads in multiple stages has been categorised and characterised,through analysis,thus to create novel concurrent and parallel techniques,which were implemented into this system by improvised data structure of hash table and partitioned memory system. Benchmark experiments were performed for the DBTO overheads, on the virtual platform which modeled ARM Cortex-A53 and Intel i386 architecture; and yield performance improvement approaching 2.0x for application based programs and 1.25x for kernel based programs, for x86 to x86-64 emulation. A novel measurement technique in the form of overhead formula was derived to model the overheads behavior of typical DBTO software system which includes contention probablity in the critical memory section usage.The concurrent and parallel technique’s implementations, together with this improvised formula which derived from Amdahl's law, will serve as useful research tool towards measurements and analysis of fine-grained DBTO overheads on mobile SoC used in billions of portable devices.

Otchere, Daniel Asante (2022) *[Development of a New Model for the Determination of Sandstone Wettability Using Machine Learning.](#)* Doctoral thesis, Universiti Teknologi PETRONAS.

Accurately quantifying wettability is of the utmost importance because it influences several reservoir parameters while also impacting reservoir potential, recovery, development, and management plan. This study proposes a new mathematical model based on the correlation between the Amott-USBM lab-based wettability measurement and field NMR T2LM log. The exponential relationship based on immiscible fluids in the pore space had a correlation coefficient of 0.95. Earlier studies on laboratory core wettability measurements using T2 distribution to increase water saturation were modified to include T2LM field data. Based on the trends observed, water-wet and oilwet conditions were qualitatively identified. The various wetting conditions were quantitatively measured using the mean T2LM for the intervals of interest and the new mathematical formula. These results agreed with the various core wettability measurements used to develop the mathematical equation. The results expressed the validity of the mathematical equation to characterise wettability at the field scale. With the cost of running NMR logs not favourable and hence not always run, a Deep Ensemble Super Learner was employed to establish a relationship between NMR T2LM and wireline logs. This model is based on the architecture of a deep learning model and the theoretical background of ensemble models due to their reported superiority. The super learner was developed using nine ensemble models as base learners. The performance of nine ensemble models was compared to the Deep Ensemble Super Learner. The Deep Ensemble Super Learner recorded errors of 2.73 ms MAE, 4.878 ms RMSE, 0.496 ms MPD, 0.192 MAPD and 0.99 R2 . This conclusion indicates that the Deep Ensemble Super Learner can potentially predict NMR T2LM in the field. By applying the methodology and mathematical formula proposed in this study, the wettability of reservoirs can be accurately characterised.

Rahim, Ku Nurhanim Bt Ku Abd (2022) *Human Activity Recognition With Wearable Sensors Using Machine Learning Algorithms.* Doctoral thesis, Universiti Teknologi PETRONAS.

Human activity recognition (HAR) has wide applications in the field of healthcare systems, such as health monitoring and physical rehabilitation. The wearable sensors data processing unit and classification technique should be significant and rapid to resolve realtime HAR complemented by highest accuracy, low complexity, and minimal computational time for HAR system. Limitations from previous research works such as small databases, which contain a few numbers of subjects and high dimensional features data affected the classification performance that impact the robustness of the classification model, and the accuracy rate of classifiers are needed to improve for the highest accuracy of classification. This research aims to investigate the various machine learning algorithms for the improvement of classification performance based on three approaches: approach 1- classification of inertial measurement unit (IMU) signals, approach 2 - classification of accelerometer signals, and approach 3 - classifications of a fusion of electromyography (EMG) and accelerometer signals. Filter methods feature selection and ensemble methods classifier are executed for approach 1 based on the open-source database. The results show that the Random subspace-Support Vector Machine (Random subspace-SVM) has the best accuracy of 99.28% excuted with Relief F of filter method feature selection. In approach 2, classification is implemented by optimizing SVM parameters and feature selection with six different artificial intelligence techniques classifier based on an experimental work database. The results demonstrate that the SVM-competitive swarm optimizer (SVM-CSO) produced the best accuracy of 99.56%. In approach 3, optimized correlation-based feature selection (CFS) and single classifiers such as RF, logistic regression (LR), SVM, and stacking classifiers, namely, stacking SVM-RF-SVM and stacking SVM-RF-LR-SVM are executed with an experimental work database. The results presented shows stacking SVM-RF-LR-SVM has given the best accuracy with 99.40% executed with CFSrhinoceros search algorithm (RSA) feature selection. All proposed HAR approaches are proven to improve the accuracy and minimize the computational time of the HARsystem which is important for the development of health monitoring and designing the rehabilitation robot applications.

Rehman, Abdul (2022) *Trust Evaluation And Management Framework For Internet Of Vehicles: A Context Cognitive Approach.* Doctoral thesis, Universiti Teknologi PETRONAS.

The recent development in vehicular communication is the Internet of Vehicles (IoV) that is originated from the merger of Vehicular Ad Hoc Networks (VANET) and the Internet of Things (IoT). The most significant problem that IoV faces is communication security, i.e., before acting on a received message, its integrity must be evaluated. Therefore, Trust Management (TM) is one of the essential parts of ad hoc network security. TM was always a challenge, and many approaches have been proposed for TM. The existing TM solutions are insufficient to meet IoV needs, they are inflexible and static and do not provide a firm solution for malicious node detection. They accept either inadequate inputs or predetermined scenarios for trust evaluation. IoV requires a dynamic TM framework that can adapt to diverse traffic scenarios. In reality, the IoV network topology can change dramatically. In addition, the TM system must be capable of dealing with a wide range of parameter data. Hence, IoV TM needs dynamic and intelligent solutions to evaluate the integrity of received information. This thesis aims to develop a dynamic TM framework designed explicitly for IoV to tackle the above challenges. The proposed TM framework employs "context-awareness" an artificial intelligence method to adapt IoV dynamics. Context-awareness can flexibly adjust to suit diverse circumstances with its robust characteristics. The suggested context-aware cognitive TM framework gathers all the information about an event that enhances the capabilities of the trust evaluation. In an experimental simulation, the proposed TM framework achieved positive results, particularly in critical traffic circumstances, where most existing frameworks struggle. Some of the relevant notable TM frameworks were compared with the proposed TM framework. The performance of the presented TM framework measured by a matrix consists of the level of trust, handling critical events, and trust under malicious nodes. In addition, the confusion matrix was also used to measure comparative results. The presented TM framework achieved approximately 5 to 10% improved results in different experiments. The result shows improved performance; by better trust management, operating with limited information, handling uncertainty, and identifying malicious nodes.

Selvam, Arun Mozhi Devan Panneer (2022) *Arithmetic-Trigonometric Optimization Algorithm Based Fractional-order Predictive PI Controllers for Real-Time Process Plants.* Doctoral thesis, Universiti Teknologi PETRONAS.

The proportional-integral (PI) controller is one of the most common controllers used in the process control industries because of its simple design, easy implementation, and fewer tuning parameters. However, in the dead-time and varying set-point processes, the controller performance is degraded due to the proportional kick effects that deteriorate the control actions leading to the oscillatory process output. Hence, the conventional PI controllers need additional improvements to cope with industrial demands. Therefore, in this research, a fractional-order predictive PI (FOPPI) is designed using the robust fractional-order PI and the dead-time compensating Smith predictor to achieve effective set-point tracking and disturbance rejection. In addition, novel set-point and noise filters are proposed along with the hybrid iterative learning controller to generate a smoother control action to handle stochastic disturbances, external noises, and load variations. The controller parameters obtained using the analytical design methods are ineffective in handling the real-time process dynamics. Thus, a novel hybrid arithmetictrigonometric optimization algorithm (ATOA) is designed based on the sine cosine and arithmetic optimization algorithms. The results obtained from benchmark models and the real-time pressure process plant show that the proposed fractional-order control strategies have achieved nearly 20% better performance in overshoot and quickened the settling time almost by 50s in first-order and 130s in the second-order process. The proposed filters effectively remove the external disturbances from the control signals and minimize the load disturbances in the process output signal, resulting in an average of 3.77% peak overshoot reduction in all the performances. The simulation and realtime pressure process plant performances of the proposed ATOA showed two times faster convergence and a massive 113.668% reduction in the ITAE value with efficient repositioning while maintaining the simple design structure.

Singh, Harvin Kaur Gurchran (2022) *Interfacial Rheological Study Of Waxy Crude Oil Emulsion.* Doctoral thesis, Universiti Teknologi PETRONAS.

Accurate evaluations of waxy crude oil and the emulsion properties and prediction of flow behaviour are crucial. Recent published rheological models incorporating the amount of wax precipitated below the wax appearance temperature (WAT) for waxy crude oils with wax content between 1% to 26% possess margins of error up to 50%, and they do not account for the interfacial layer. This research aims to evaluate the rheological behaviour and develop an interfacial rheological prediction model of waxy crude oil which incorporates critical properties of the crude oils governed by the viscosity matching and microcrystalline wax. The research contributes to the development of integration between interfacial rheology and emulsion stability. Thirteen different waxy crude oil from Malay Basin with API between 23 and 48 were characterized and evaluated. Bottle testing method at 80°C was utilized to predict the emulsion stability mechanism immediately after mixing and at 2 weeks was then measured. Controlled-stress rheometer is used to evaluate rheological behaviour of waxy crude oil. The rheological analysis assessment showed that precipitated microcrystalline wax was a dominant factor for the waxy crude oil rheology. General interfacial rheological model for waxy crude oil emulsion covering Newtonian and nonNewtonian regime has been developed in this research. The rheological analysis on the crude oil emulsions indicates that the viscosity and the yielding property have been governed by a combination effect of wax crystals and water droplets with the presence of water droplets to be the dominant factor. This thesis has proposed a better prediction of the interfacial rheological behaviour for waxy crude oil emulsion by incorporating Reynolds number equation into the existing Navier-Stoke's settling equation and Boussinesq (Bo) number to the interfacial layer for the boundary condition. This new equation provides a more accurate interfacial rheological behaviour prediction for emulsion stability with an averaged absolute deviation of 21.86%, while the other models produced an averaged deviation of 55.17%, for the waxy crude oils.

Suhaimi, Nadia Hartini (2022) *NH2-MIL-125 (Ti)/6FDA-Durene Composite Membrane for Separation of CO2 from CH4 : Membrane Synthesis and Process Optimization Study.* Doctoral thesis, Universiti Teknologi PETRONAS.

Since the past decade, oil and gas industries as well as various researchers have focussed on the application of membrane technology for the removal of impurities from natural gas, especially carbon dioxide (CO_2), because CO_2 potentially causes pipeline corrosion, lowers the heating value of natural gas, and increases the transportation costs. However, a major constraint in membrane applications is the trade-off between gas permeability and gas pair selectivity on the membrane material used. To address the aforementioned challenge, this work fabricates a new combination of composite membrane containing amine-functionalized metal organic framework (MOF) named NH_2-MIL-125 (Ti) (MIL = Material Institut Lavoisier) filler and 6FDA (4,4-(hexafluoroisopropylidene) diphthalic anhydride)-durene polymer. The structural properties and morphology of the fillers and resultant composites membranes were investigated by using different analytical tools. The permeability of CO_2 and the ideal selectivity of CO_2/CH_4 increased 86 % to 118 %, respectively, upon the addition of non-functionalized and amine-functionalized MIL125 (Ti) fillers into 6FDA-durene matrix. Membrane loaded with 7.0 wt% of NH_2- MIL-125 (Ti) filler showed the highest CO_2 permeability of 1115.70 Barrer and CO_2/CH_4 selectivity of 37.10, surpassing the 2008 Robeson upper bound. After integrating MIL-125 (Ti) and NH_2-MIL-125 (Ti) fillers into the 6FDA-durene membrane, the dual-mode sorption parameters (C'H, KD and b) of composite membranes of CO_2 gas were enhanced by 29 - 36 %, 131 - 180 % and 12 - 104 %, correspondingly. Also, the investigation of gas transport properties revealed that the higher CO_2/CH_4 selectivity of 7.0 wt% NH_2-MIL-125 (Ti)/6FDA-durene composite membrane accounted to the highest diffusivity coefficient of 35.1 x 10-8 cm2 s -1 . Further, the central composite design (CCD) and response surface methodology (RSM) were applied for optimization of operational parameters that influenced gas separation performances. The optimum operational parameters were found at feed pressure of 12.5 bar, temperature of 34.7 °C, and CO_2 feed concentration of 70 mol%, viii yielding the highest CO_2 permeability of 609.3 Barrer and CO_2/CH_4 separation factor of 11.6. The average errors between the experimental data model prediction for CO_2 permeability and CO_2/CH_4 separation factor were 5.1 % and 3.3 %, indicating that the model's validity was 95 % of the prediction interval. Overall, this study revealed that the inclusion of NH_2-MIL-125 (Ti) fillers into the 6FDA-durene polymer matrix has significantly increased the membrane performances and resolved the trade-off concern by improving the interfacial adhesion, which resulted in higher gas transport properties over the membranes. The combination of NH_2-MIL-125 (Ti) fillers and 6FDA-durene polymer matrix were positively improved the membrane separation performances, suggesting that it is a potential membrane material for gas separation applications particularly for CO_2 removal from CH_4. This new combination of NH_2- MIL-125 (Ti)/6FDA-durene composite membrane potentially be extended to hollow fibre configuration for pilot applications.

Thanh, Nguyen Tien (2022) *Fundamental and Process Study of In-situ Transesterification from Wet Paste Chlorella vulgaris.* Doctoral thesis, Universiti Teknologi PETRONAS.

In-situ transesterification from microalgae biomass is an efficient approach to produce biodiesel as it combines extraction and reaction in a single step. Nevertheless, this process is challenging especially for wet microalgae biomass due to the negative impact of water in the reaction. In addition, fundamental and process study of this reaction are still lack in the literature such as the contribution of reaction parameters towards fatty acid esters (FAE) composition and yield, as well as reaction kinetics and thermodynamic study. In the present study, in-situ transesterifications of Chlorella vulgaris was conducted from dry (0.05 wt% moisture) and wet (75 wt% moisture) biomass under low temperature range (< 65 ºC) together with other different reaction parameters, such as catalysts concentration, methanol to lipid molar ratio, effect of cosolvents addition and reaction time. For the dry C. vulgaris feedstock (0.05 wt% moisture), the increase of catalyst concentration (KOH and H2SO4) resulted the increase of C18:2 and C18:3 content in FAE yield. On the other hand, for wet C. vulgaris feedstock (75 wt% moisture), a 99 wt% of FAE yield was obtained in excess methanol condition, and the required methanol was reduced remarkably (33% reaction) by adding a small volume of co-solvents (0.1 mol co-solvent/mol MeOH) such as n-butanol and tetrahydrofuran (THF). Moreover, different type of co-solvents resulted to different FAE compositions, whereby high concentration of long chain FAE (65 wt% of C18) were attained when n-butanol was used, while short chain FAE (54 wt% of C10 and C16) were obtained by adding THF. The in-situ transesterification of wet C. vulgaris was found to follow first order reaction with the highest attained reaction rate constant at 0.1065 min-1 and activation energy of 50.4 to 60.4 kJ/mol. The reaction was endothermic (ΔH = 50.4 to 60.4 kJ/mol) and non-spontaneous (ΔG = 87.7 to 88.4 kJ/mol) which decreased the randomness of reaction system (ΔS = -0.082 to -0.114 kJ/mol·K). Overall, the findings indicated the high FAE yield and suitable composition for biodiesel production from wet microalgae (75 wt% moisture) through in-situ transesterification process.

Usmani, Usman Ahmad (2022) *A Reinforcement Learning Algorithm for object segmentation in complex images.* Doctoral thesis, Universiti Teknologi PETRONAS.

Segmentation accuracy is limited since most recent segmentation algorithms do not explicitly identify the geometric structure or semantic information. Data-dependent difficulties, including low image contrast, noisy backgrounds, and complex objects of interest, make segmentation difficult. Dense prediction is a problem due to these difficulties, making it impossible for the current approaches to study data-specific properties for robust feature extraction. This work adapts the Deep Query Network formulation for active learning to perform semantic segmentation. The segmentation process is proposed as a Markov Decision Process and is solved by training an agent to segment the region using a Deep Reinforcement Learning algorithm. The agent follows a set of serial actions for the region delineation and the action space is defined as a set of continuous action parameters. The segmentation algorithm learns in continuous action space using Deep Deterministic Policy Gradients. The agent concurrently calculates and adds the responses of co-attention in the joint feature space. The algorithm is trained using pairs (or groups) of video frames, which adds to the training content, thus increasing the learning capacity. The proposed algorithm encodes the important information during the segmentation phase by a simultaneous process of various reference frames that are subsequently utilized to predict the persistent and conspicuous objects in the foreground. On the ISIC 2017 dataset, the algorithm achieves an accuracy of 96.33% for the naevus cases, 95.39% for the melanoma cases, and 94.27% for the seborrheic keratosis cases. On the DAVIS 2016, the results reveal that the proposed algorithm boost the state-of-the-art algorithms on the F1 Measure by 4%, SegTrack V2 by a Jaccard Index of 12.03%, and YouTube Object by a Jaccard Index of 13.11%. Meanwhile, our algorithm improves the accuracy by 8%, F1 Measure by 12.25 %, and precision by 14% on the CdNet 2014. Our algorithm's performance is superior to the conventional deep learning algorithms in detecting 8 out of 11 classes on the Camvid road segmentation scene dataset. It achieves an accuracy of 90.56%, a mIoU score of 87.17%, and a BF score of 93.14%. On the SUNRGB indoor scenes dataset, it gives an accuracy of around 75.82% and a BF score of 77.25%, thus outperforming the current state-of-the-art algorithms.

Yusuf, Mohd (2022) *Syngas Production Via Dry Reforming Of Methane Over Ni-W Bimetallic Catalyst Supported On Al2O3-MgO.* Doctoral thesis, Universiti Teknologi PETRONAS.

Dry reforming of methane (DRM) is a promising technique for utilization of greenhouse gases (GHGs) to give syngas. The main limitations of DRM are the catalyst deactivation by sintering and coking. This proposes the necessity to find an active and stable catalyst that can confront these issues and facilitate the DRM process. In this doctoral study Ni-based catalysts supported on binary oxide support (i.e., Al2O3-MgO) were prepared by coprecipitation followed by impregnation method. The catalyst with 12wt.% Ni loading on Al2O3-MgO showed the optimum activity and stability for DRM carried out at 800oC, 1 atm, and CH4:CO2 ratio of unity in a fixed-bed tubular reactor. The fresh and spent optimum catalyst were then characterized to analyze the physico-chemical properties and carbon formed during DRM reaction. The effect of W addition on the optimum (12wt.%Ni/Al2O3- MgO) catalyst was further investigated. W addition resulted in enhanced catalytic activity and stability, and the Ni-W bimetallic catalyst with 4wt.% W exhibited most steady performance (with 88.8% and 91.5% conversion of CH4 and CO2 and syngas ratio of 0.9 respectively), even after 24 h of reaction. The fresh and spent Ni-W catalysts were characterized and the corresponding textural properties, crystallinity, morphology, basicity, enhanced physico-chemical properties, and the type of carbon formed on the catalysts are analyzed. The amorphous carbon-nanosheets were formed on monometallic Ni catalyst, whereas the MWCNTs on Ni-W catalyst. Further, the process parameters for DRM over optimum Ni-W catalyst were optimized using response surface methodology (RSM), within temperature range of 600oC-800oC and CH4:CO2 of 0.5-1.5 via CCD of RSM. It has been found that a temperature of 777.29oC and CH4:CO2 of 1.11 is optimum for the proposed catalyst. Finally, the reaction kinetics of DRM over optimum Ni-W catalyst was investigated via four typical kinetic models i.e., Power-Law, Langmuir-Hinshelwood, Eley-Rideal I, and Eley-Rideal II models. The analysis showed that Langmuir-Hinshelwood model showed the best fitting between experimental and estimated reaction rates with R2 value of 0.983.

Lam Ghai, Lim (2021) *Optimizing Mental Workload Estimation By Detecting Baseline State Using Vector Phase Analysis Approach.* Doctoral thesis, Universiti Teknologi PETRONAS.

Non-invasive brain imaging techniques offer an objective measure of mental workload by tapping directly into cognitive function. Among them, functional near-infrared spectroscopy (fNIRS) is an emerging technique that measures the hemodynamic response (HR). However, improper baseline return from the previous task-evoked HR contributes to a large variation in the subsequent HR, which affects the mental workload estimation. In this study, we propose a method using vector phase analysis to detect the baseline state as being optimal or suboptimal. Oxygenated (HbO) and deoxygenated (HbR) hemoglobin concentration changes are integrated as parts of the vector phase. We hypothesize that selecting neuronal-related HR as observed in the optimal-baseline blocks will lead to an improvement in mental workload estimation. The proposed method was applied to a block-design fNIRS dataset, measured on 24 subjects performing multiple difficulty levels of mental arithmetic task. Significant differences in hemodynamic signal changes were observed between the optimal- and suboptimal-baseline blocks detected using the proposed method. Using response time as the standard for intra-subject evaluation, significant improvements were observed in 19 and 17 subjects for HbO and HbR activations, respectively. In addition, the proposed method was further validated with another dataset employing visual spatial working memory task. This supports the effectiveness of the proposed method in detecting baseline state for better estimation of mental workload. The results further highlight the need of customized recovery duration to ensure an optimal baseline can be achieved. In short, the proposed method offers a practical approach to detect task-evoked signals, without the need of extra probes.

Mat Shayuti, Muhammad Shafiq (2021) *Mechanism Of Crude Oil Removal From Sand Using Ultrasonic Energy.* Doctoral thesis, Universiti Teknologi PETRONAS.

Crude oil-contaminated sand from petroleum wells and oil spill sites pose threats to the environment with its dangerous toxic attributes. Ultrasound holds a potential to be the remediation means owing to its green technology and ability to penetrate inner section of sand particles. However, the mechanism of ultrasonic remediation for oily sand still lacks in comprehension, causing high power consumption and non-optimized treatment. Therefore, the objective of this study was set to deduce the ultrasonic cleaning mechanisms for crude oil-contaminated sand by evaluating the sand, mapping the ultrasonic field, and analyzing cleaning test at various ultrasonic settings. Produced sand from an oilfield in Sabah and beach sand from Terengganu were selected in this study to represent the most common sand casualties by crude oil. The sands were prepared with crude oil before subjected to various tests. Comparatively, the produced sand was five times smaller, had lower permeability of 18.75 Darcy, and stronger bond with the crude oil at 65.88 mN/m, alluding towards more challenging oil separation than the beach sand. The effect and interaction between ultrasonic power (30-120 W), frequency (28-60 kHz) and sand load (10-100 g) were tested in a customized ultrasonic bath reactor. Statistical analysis showed that the most significant factors in cleaning were the sand type and ultrasonic frequency. The optimum setting for suspended samples involved high frequency of 60 kHz, whereas bottom samples preferred low frequency at 28 kHz. This finding was justified by the ultrasonic mappings, where acoustic pressure and cavitation patterns were found in a correlation with the cleaning efficiencies. Overall analysis successfully reveals the cleaning mechanisms namely microjetting and shockwave as the most influential, followed by localized heat spots, bubbles microstreaming, bubbles oscillation, and mechanical agitation. They subsequently resulted in physical effects viz oil stripping, particle cracking, and surface pitting. Chemical effects also accounted for parts of the treatment, covering oil emulsification and degradation by $^{\circ}OH$ radical. With ultrasonic alone contributed 50-viii 60% cleaning, it signifies a huge potential in the method. The performance is improvable by integration with other techniques such as mechanical/chemical/thermal to create hybrid system with lesser power consumption and more eco-friendly. Towards the end, this thesis proposes novel prediction models to estimate ultrasonic energy required/exerted, limiting factors in remediation, and recommendations to improve the process.

Mahat, Siti Qurratu' Aini (2021) *Investigation On Performance Of Cationic-Anionic Scale Inhibitors On Formation Of Silicate Scale.* Doctoral thesis, Universiti Teknologi PETRONAS.

The use of highly alkaline formation water has disintegrated the quartz silica in sandstone reservoirs, and these dissolved silicas are stable at high pH. However, as the alkaline formation water flows into the production well, it encounters neutral pH water. This results in a substantial reduction in the pH of the alkaline formation water and precipitation of the dissolved silica. Other parameters such as pH, temperature, and the presence of divalent cations in water also contribute to silica scale formation. Silica scale is a severe problem in the oil and gas industry, which forms in perforation holes, casing surface, tubing, and surface facilities. Recently, the use of poly(aminoamide) dendrimers as silica polymerisation inhibitors has been the subject of numerous researches. Unfortunately, these cationic poly(aminoamide) dendrimers are widely used in wastewater treatment for mitigating silicate scale and are yet to be applied in the oilfields. Besides, the effect of mixture anionic-cationic scale inhibitor in mitigating silicate scale at the dynamic condition and squeeze treatment is not yet studied. Therefore, this study aims to investigate the effect of cationic dendrimers (i.e., PAMAM-1 and PAMAM-2), polyelectrolytes (i.e., PGLU), and the mixture of cationic-anionic scale inhibitors in reducing silica scale formation. Specifically, this study examined the effects of pH, temperature, and Ca2+/Mg2+ ions on silica scale formation using static and dynamic methods. The static methods involved several tests such as bottle test, scanning bottle test, silica polymerisation test, silica dispersion test and adsorption test. Meanwhile, the dynamic method highlights dynamic tube blocking and core flooding tests. The results of this study indicated that the presence of cationic-anionic scale inhibitors enhanced inhibitory properties. Additionally, the mixture of scale inhibitors demonstrated excellent efficiency in reducing the formation of colloidal silica and increasing the time for silica polymerisation. Besides that, the use of mixture scale inhibitors also enhanced the permeability of oil and brine in the core flooding test. Interestingly, PAMAM2/PGLU proved to be more effective than the conventional scale inhibitor, DETPMP.

Akhter, Jave (2021) *Theoretical And Experimental Evaluation Of A Modified Compound Parabolic Concentrating Solar Collector Using Oil-Based Nanofluids.* Doctoral thesis, Universiti Teknologi PETRONAS.

Thermal oils, generally used as heat transfer fluids (HTFs) in the medium temperature compound parabolic concentrating (CPC) collectors, bear weak thermal properties that negatively affect their performance thereby creating a major hurdle in the successful application at industrial scale. The emergence of nanofluids has shown promising results in improving the output of non-concentrating solar collectors. However, the performance of CPC collectors employing oil-based nanofluids is rarely studied. Therefore, this research was aimed to investigate the thermal effectiveness of oil-based nanofluids on the performance of a modified CPC collector. The main objectives were to develop and evaluate optical behavior of a modified CPC collector under different configurations, examine itsthermal performance theoretically and experimentally using oil-based nanofluids. A multiphase methodology was devised to accomplish the outlined objectives. The modified CPC was developed by implementing a geometric model in MATLAB and Solidworks. The optical performance was evaluated using Monte Carlo ray-tracing method in TracePro software. Thermal characteristics of HTFs as a combined function of temperature and weight fractions of CuO and TiO2 (0.25 wt.% - 1.0 wt.%) dispersed in Therminol-55 oil were measured and correlations were developed using response surface method. The thermal performance was examined by developing and iteratively solving a detailed mathematical model in MATLAB. The results demonstrated that the convective heat transfer coefficient was enhanced by 32 % and 26 % by using nano-oils with 0.5 wt.% of Titania and CuO respectively. As a result, heat transfer rate from the absorber to the fluid was increased thereby reducing the absorber surface temperature and thermal losses. Thermal efficiency was also improved by almost 2 % by increasing the flow rate from 0.014 kg/s to 0.029 kg/s. The maximum efficiency of 62.3 % was achieved at flow rate of 0.029 kg/s and solar irradiance of 800 W/m2 . In conclusion, a significant improvement in the heat transfer coefficient and thermal performance of the developed CPC collector was achieved by using oil-based nanofluids. Hence, the system could be recommended for full-scale testing and subsequent application in small-medium sized industries for sustainable supply of solar thermal energy in the medium temperature range.

Dalha, Ibrahim Babangida (2021) *Experimental Investigation And Optimization Of Synthetic Biogas Intake And Mixing Regimes In Dual-Fuel Rcci Combustion.* Doctoral thesis, Universiti Teknologi PETRONAS.

The measures for addressing nitrogen oxides (NOx) and soot (PM) in reactivitycontrolled compression ignition (RCCI) combustion cause increased unburned hydrocarbon (UHC) and carbon monoxide (CO) emissions. The gaseous biofuel combustion still causes hazardous emissions and a contradictory trend between the CO and UHC in RCCI. Disparities in biogas constituents and high inert content pose combustion control challenges. Modified port fueling and systematic understanding of how biogas containing high carbon dioxide (CO2) reduces peak pressure rise rate (PPRR), CO, and UHC emissions at low loads still require more effort in RCCI research. This experimental study examines the impact of high-CO2 biogas and directinjected fuels to improve combustion and reduce hazardous emissions at various engine loads (4.5 – 6.5 bar IMEP) and speeds (1600 – 2000 rpm). At medium engine loads and 1600 rpm, the effects of biogas intake parameters and mixing in a modified fueling method were evaluated. The results reveal that B5/diesel-biogas reactivity retards the combustion phase and reduces PPRR due to increased engine load at 2000 rpm. In suppressing CO and UHC emissions at 1600 rpm, diesel-biogas was effective than B5- biogas. Due to increased intake compositions, the emissions compromise was reduced at 5.5 bar IMEP and 50% fraction of 35% CO2 Biogas. The process at 5.5 bar IMEP causes increased homogeneous temperature, uniform fuel stratification, and more distributed temperature across port mixing distances that further reduces the emissions except for UHC. An optimum mixture homogeneity occurs at a 22 to 26% exergy destruction rate. Injection at the valve increases biogas early burning and near-wall boundary temperature while reducing emissions at 4.9 bar IMEP, 1 bar biogas pressure, and 80% swirl ratio as the optimum conditions. At the optimum settings, the CO, UHC, NOx, and PM emissions were minimized to 0.103%, 109.58 ppm, 0.577 ppm, and 2.33 ppm, respectively. Therefore, using high-CO2 biogas improves combustion and lower emissions and compromise at medium loads. Injecting high-CO2 biogas of low pressure at the valve in swirling air adds to the emission reduction strategies at low engine loads.

Patil, Namdev Ashok (2021) *Characterization And Parameter Optimization Of Friction Stir Processed Aa7075 Hybrid Surface Composites.* Doctoral thesis, Universiti Teknologi PETRONAS.

The aerospace grade AA7075-T6 alloy possesses deprived surface properties because of its behavior prone to fretting fatigue and adhesive wear under dry sliding conditions. The frictional heating and repetitive surface loading lead to over-aging and surface covered with coarsened precipitates within the soft matrix. The coarsened isomorphous precipitates can be weakened easily by hard debris particles and brittle oxide phases formed between the mating surfaces. The AA7075 surface cannot be hardened like steels because of martensitic phase absence and coatings do not sustain with thin ice effect. Thus surface wear behavior improvement with retaining microhardness of the alloy is required for increasing its wider applications. For that surface isomorphous precipitates and soft matrix need to be protected through dispersion of hard thermally stable ceramic SiC/TiC with solid-lubricant graphite particles. The dispersion through friction stir processing (FSP) avoids detrimental phase formations by processing metal alloy below its melting point temperature. Thus dispersion of SiC-graphite, TiC-graphite and SiC-fly ash through FSP for enhancing the surface wear and microhardness of AA7075-T6 FSP is the main objective of this study. The correlations between the enhanced surface properties with the microstructure and wear mechanisms have been further investigated through microscopic characterization. The wear resistance and microhardness properties of the composites have been improved up to 78% and 56% than the base alloy. The mechanically mixed graphitized-TiC/SiC layers at the mating surfaces have reduced the wear rate significantly. The graphite layers have exfoliated to form lubricative graphitized-SiC/TiC zones with good interfacial bonding with base alloy. The grain boundaries pinning have led to obtain the refined equiaxial grains structure. Thus wear mechanisms have changed prominently from fretting fatigue/adhesion to abrasion/delaminations through the hybrid reinforcements. The tendency of fatigue wear have more effectively improved for graphite-SiC/TiC than fly ash combination. FSP stirring action have controlled reinforcement dispersion and fragmentation of inherent isomorphous precipitates, which leads to hardening due to grain refinement and softening due to precipitates dissolution. The distinct model equations for wear rate and microhardness have been defined and validated through confirmation experiments.

Saeidi, Tale (2021) *Development Of Non-Invasive Ultra-Wideband Antenna Array Sensors For Oil Palm Trunk Hollow Detection.* Doctoral thesis, Universiti Teknologi PETRONAS.

The oil palm trees in Southeast Asia face a major challenge of hollows in the trunk caused by a fungus. Among the trustable techniques to detect the hollowness with least effects on the trees and the environment are the tomography techniques. However, the current tomography systems lack image accuracy and data transmission for implementation of wireless network sensor in plantation. One of the emerging methods is microwave imaging (MWI) which depicted nearly cheaper, fast processing, more system mobility, and the least side effects on the environment and the person who conducts the test. The proposed method is using MWI, with novel elliptical ultra-wideband (UWB) antenna, and robust time reversal (RTR) algorithm that offers the completed information about the dielectric properties of the oil palm trunk (OPT) applying for image reconstruction. The novel elliptical patch UWB antenna sensors loaded by stubs, slots, shorting pins, and truncated ground (GND) show complementary results for the imaging of wood. The proposed UWB antenna achieved wider bandwidth (BW) of >16 GHz, simple elliptical shape, high gain of > 5.5 and directivity of > 6 dBi, high and consistent radiation efficiency of > 89 %, smaller dimensions (15 × 15 mm2 at center frequency of 12.5 GHz), high fidelity (> 80 % hence low distortion), and consistent radiation pattern in comparison with recent similar studies. A RTR algorithm is developed to improve the image quality by removing the clutter in the imaging environment. The imaging results show that the RTR obtains better results in terms of accurate localization, and better removal of image clutter. The propose imaging system offers the accuracy of more than 95 % detection of the actual hollowness and being able of detection of a hollow with diameter of 3.5 mm (spatial resolution) in any location within the trunk. Besides, a good agreement between the simulated and measured results of UWB antennas (in terms of reflection coefficient and BW) and between the images using simulated and measured data (in terms of the location of the hollow) indicates the system's ability in hollowness detection of OPT.

Shaik, Nagoor Basha (2021) *Pipe Condition Prediction Models For Oil And Gas Pipelines Using Artificial Neural Networks.* Doctoral thesis, Universiti Teknologi PETRONAS.

Pipelines are like a lifeline that is vital to a nation's economic sustainability; as such, pipelines need to be monitored to optimize their performance as well as reduce the product losses incurred in the transportation of petroleum chemicals. A significant number of pipes would be underground; it is of immediate concern to identify and analyze the level of corrosion and assess the quality of a pipe. The condition of these pipelines is unpredictable and is interconnected with time by different parameters. The task of determining under which conditions the most appropriate repair or replacement initiatives are continually being faced by pipeline operators. Also, oil and gas producers have always placed their equipment as the highest priority for operations, but unfortunately, a study shows that many failures in the facility associated with piping systems lead to billions loss. These piping systems are subjected to various failure mechanisms since these have been operated in various processes and harsh geographical environments. The aim of this research is to propose the development of artificial neural network-based models for predicting the life of oil and gas pipelines. This work focused on the specific factors that contribute to the life of the piping system based on the historical inspection data (pigging data) that were obtained from oil and gas industrial facilities. The models are developed using Feed Forward Back Propagation Network (FFBPN), Support Vector Machines (SVM), and Gaussian Process Regression (GPR). The deterioration profiles of considered factors are generated to identify the individual impact on pipeline condition. The sensitivity analysis is carried out to understand the interrelationship between the factors, and the assessment scale is designed to assess the pipe condition. The results obtained are found to be satisfactory based on the highest R 2 and lowest MSE values. The contribution of developed models is that they can evaluate the life condition and assist decision-makers in estimating the failure time of existing pipelines. The significant benefit of the present work is that the developed intelligent model can estimate the type of metal loss due to which the pipeline condition would mostly deteriorate. The results of developed models viii are then validated with previous studies for their robustness. It can be concluded from the results that the developed models outperformed the previous studies based on R 2 and RMSE values close to 1.0 and 0, respectively.

Uba Zango, Zakariyya (2021) *Optimization Of Adsorption Parameters For Effective Removal Of Polycyclic Aromatic Hydrocarbons From Water Using Metal-Organic Frameworks Uio-66(Zr) And Mil-88(Fe).* Doctoral thesis, Universiti Teknologi PETRONAS.

Adsorption of polycyclic aromatic hydrocarbons (PAHs) namely anthracene (ANT), chrysene (CRY) and pyrene (PYR) from water using UiO-66(Zr) and MIL-88(Fe) metal-organic frameworks (MOFs) has been focused of this research. The MOFs were synthesized according to solvothermal techniques and characterized using X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), thermal gravimetric analysis (TGA), X-ray photoelectron spectroscopy (XPS), Fourier transformed infrared spectroscopy (FTIR) and nitrogen adsorption-desorption measurements. Experimental design and validation of the adsorption studies were performed by response surface methodology (RSM) and artificial neural network (ANN) modeling respectively. Optimization studies have shown the equilibrium of the process established within 25 - 35 minutes at PAHs concentration of 1 - 4 mg/L, MOFs dosage of 2 - 6 mg, pH of 2 - 12 and temperature of 25 - 45 °C. The highest adsorption efficiency achieved by UiO-66(Zr) was 98.52, 99.66 and 99.33% with the corresponding adsorption capacity of 23.64, 23.52 and 23.54 mg/g for ANT, CRY and PYR, respectively. On the other hand, MIL-88(Fe) achieved adsorption efficiency of 98.09, 98.22 and 98.78% with corresponding adsorption capacity of 23.54, 23.53 and 23.35 mg/g for ANT, CRY and PYR, respectively. The kinetics and isotherms of the process was favored by pseudo-second order and Langmuir models, respectively for both UiO-66(Zr) and MIL-88(Fe). Also, the thermodynamics study for the effect of temperature changes has shown the exothermic nature of the process. Molecular docking simulation have shown the binding interaction of the MOFs with the PAHs. ANT was preferably adsorbed onto the inner pores of the inner pores of the MOFs, while CRY and PYR were preferably adsorbed on the outer pores of the MOFs. Overall findings have shown the super adsorption efficiency of the MOFs for PAHs removal from water as compared to other conventional adsorbents. Thus, they could be used as potential adsorbent materials for organic pollutants remediation from environmental waters.

AL-QURAISHI, MAGED SLAEH SAEED (2021) *MULTIMODAL APPROACH BASED ON PHYSIOLOGICAL SIGNALS FOR DETECTION AND RECOGNITION OF THE LOWER LIMB MOVEMENTS.* Doctoral thesis, Universiti Teknologi PETRONAS.

Employing biosignals to capture the user's intentions behind the motion via a human-robot interface (HRI) is a promising technique in the domain of rehabilitation and assistive robotics. Some of these HRI systems are based on brain signals such as electroencephalogram (EEG) or functional near-infrared spectroscopy (fNIRS) whereas others rely on a myoelectric signal such as an electromyogram (EMG). EEG signal is one of the most common biosignal used in the rehabilitation and assistive robotics realm. However, EEG suffers from some issues such as low detection accuracy and low spatial resolution of the EEG signal that results in a redundant channel. Therefore, there is a need to integrate the EEG signals with other biosignals such as fNIRS and EMG signals to increase the detection accuracy and select the most related channels to the movement task. This research aims to develop a multimodal approach based on the fusion of the biosignals to detect and recognize lower limb movements. The first aim is to select the optimal EEG channels that are related to the lower limb movements. To achieve this aim, a relationship between the hemodynamic response and brain oscillation activity was investigated using the concurrent recording of functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG) during ankle joint movements. The highest correlation coefficient was observed between fNIRS channels in the dorsal primary motor cortex area in both hemispheres during the right and left ankle joint movements. The second aim is to investigate the influences of muscular fatigue on the ankle joint movement's classification accuracy based on the EMG signal. Finally, those two bio signals (EEG and EMG) were fused at the feature level using discriminant correlation analysis (DCA) and then fed to three different classifiers for movement recognition. The outputs of the classifiers with multimodal and single modality data were assessed with five different window sizes. The highest recognition accuracy was recorded 96.15 ± 4.58 % with a window size of 250 sample points and LDA classifier for the fused modal , in contrast with 92.22 ± 5.24 % and 90.86 ± 8.32 % for EMG and EEG data, respectively. These promising outcomes reveal the potentials of the fusion-based approach for accelerating the pace of future development of a human-machine interface for the rehabilitation of the lower limbs

Hafeez, Yasir (2021) *Enhanced Neurofeedback Content To Improve The Training Efficacy For Stress Mitigation.* Doctoral thesis, Universiti Teknologi PETRONAS.

Neurofeedback training has been used for several psychological and physiological applications. The efficacy of neurofeedback training depends on a number of factors. One such factor is the neurofeedback stimulus content, which directly implies the efficacy of neurofeedback and is considered challenging in clinical practice. This study investigates the effects of stimulus content selection and enhancement of the content to improve the training efficacy for stress mitigation. The research design is divided into two phases: selecting suitable stimulus content among audio, video and games for stress mitigation and development of enhanced neurofeedback content for improved efficacy in terms of stress mitigation performance and reduction in training time. A sample of thirty healthy adults (mean age: 23.89 ± 3.52) was recruited and divided among nonstress, group1 (stress), and group2 (stress). Group1 performed neurofeedback training in phase1 and phase2, while group2 participated only in phase2 for stress mitigation. The efficacy of the stimulus contents was measured and verified by statistically comparing the quantitative electroencephalogram features such as alpha power and alpha asymmetry. Participant feedback was also recorded after every session of neurofeedback. The data in phase1 is analysed by independent samples t-test ($p = 0.038$, at $\alpha = 0.01$) to compare alpha asymmetry of non-stress (mean: 0.125 ± 0.102) and group1 (mean: 0.019 ± 0.110), and post hoc test to verify the statistical significance of the efficacy of neurofeedback for stress mitigation. The results of phase1 depicted that game stimulus content (GSC) is more effective to increase in alpha asymmetry (mean: 0.120 ± 0.037) for stress mitigation than audio (mean: −0.046 ± 0.042) and video (mean: −0.018 ± 0.037). In phase2, enhanced GSC is developed. The enhancement is based on the selection of colour, environment and interactive messages. The developed neurofeedback contents resulted in improved efficacy for stress mitigation with reduced training time for neurofeedback session. The enhanced neurofeedback stimulus content can be effectively used by neurofeedback therapists for improved performance and shorter training time.

Nawaz, Rab (2021) *Photodegradation Of Phenolic Compounds In Treated Pome Using Mn-Modified Defective Tio2 Photocatalyst Under Visible Light Irradiation.* Doctoral thesis, Universiti Teknologi PETRONAS.

The presence of phenolic compounds in treated palm oil mill effluent (TPOME) is a major human health and environmental concern. The present research aimed to develop an optimized visible-light-driven TiO2 based photocatalytic system for the removal of phenolic compounds from TPOME. Visible-light responsive defective TiO2 was synthesized via glycerol-mediated precipitation method followed by calcination at 300 and 400°C for 1 h. The defective TiO2 was further modified with manganese (Mn) via wet impregnation method. The photocatalytic process was optimized via central composite design (CCD) in response surface methodology (RSM). It was demonstrated that tuning the band structure of TiO2 by inducing Ti3+ defect states play an important role in boasting visible light absorption, promote efficient charge carriers' separation and suppressing electron-hole pair recombination. Consequently, the improved optical and electronic properties of the defective TiO2 (T2) prepared in 1.163 mol/L glycerol and calcined at 300°C have led to 48.17% phenolic compounds removal from TPOME which was 2.6-fold higher than P25 (18%). Further modification of T2 with 0.3wt% Mn led to enhancement in phenolic compounds removal to 60%. A remarkable overall remediation efficiency of the TPOME was confirmed by 86.04%, 88.87%, 62.76%, and 84.66% removal of phenolic compounds, COD, color, and TOC, respectively under the optimized conditions of 0.85 g/L TiO2 loading, 0.048 mol/L H2O2 dosage, 0.30wt% Mn, and 204 min of visible-light irradiation. The phenolic compounds and COD removal efficiencies by Mn modified defective TiO2 were reduced by 7.66% and 8.83%, respectively after five repeated cycles under the optimized conditions indicating good stability of the synthesized photocatalyst. The optimized photocatalytic process developed in the present study has a strong environmental application potential for the treatment of waste effluent originating from palm oil mills along with various other agro-industries, where multiple pollution indicators such as phenolic compounds, COD, and TOC can be abated at the same time.

Veerendra, Chitturi (2021) *Investigation On Weldability Of Dissimilar Friction Stir Welded Aa5052 And Ss304 Alloys.* Doctoral thesis, Universiti Teknologi PETRONAS.

Friction stir welding is considered an ideal and better technique to weld dissimilar materials when compared to conventional welding methods. However, the main challenges faced during friction stir welding of different materials are defects and intermetallic compounds formed at the interfacial region. In this context, dissimilar friction stir welding of AA5052 and SS304 has been carried out in butt and lap configurations with suitable Taguchi's orthogonal array at various tool rotational speeds, welding speeds, penetration depths and tilt angles to obtain a sound joint without defects. Friction stir butt welding was not successful in achieving a defect free joint. Friction stir lap welding with aluminium as the top plate achieved a defect-free joint when the experiments were conducted at a tool tilt angle of 2.5°. Microstructural analysis of the defect-free welds revealed that the intermetallic layer's thickness had influenced the joint strength. When the thickness of the intermetallic layer below 3 μm, the samples achieved higher joint strengths. X-Ray Diffraction analysis further helped in detecting the intermetallic compounds formed in the weld zone. AlFe $AlFe_3$, $Al_{13}Fe_4$, and Al_5Fe_2 are the IMCs detected in the interfacial region of the welds. Taguchi's S/N ratio analysis of the shear strength with "larger the better" criteria has shown that optimum process parameters for achieving high joint strength are tool rotational speed of 800 rpm, welding speed of 20 mm/min and a penetration depth of 4.1 mm at a tool tilt angle of 2.5°. The predicted lap shear strength from the characteristic response equation was 3.39 kN, and the experimental lap shear strength result was 3.46 kN. An error of 2.06% confirms that the results achieved were acceptable. A mathematical model was formulated using log-linear regression analysis to predict the shear strength for a given set of process parameters. Regression analysis of the model with R^2 and adjusted R^2 values of 89.58% and 83.3% with a standard error of 0.076 show that the model developed is statistically significant.

Abdul Aziz, Ahmad Fuad (2021) *Compensation Circuit Of Inductively Coupled Power Transfer For Electric Motorcycle Wireless Charging.* Doctoral thesis, Universiti Teknologi PETRONAS.

In an inductively coupled power transfer (ICPT) device for electric vehicle (EV) wireless charging, there are two issues to concern which are the uncoupled coil location during power transfer process and receiver circuit failure due to electronic device malfunction in EV. These two circumstances result in an overcurrent issue in the transmitter circuit because of the circuit resonance. The high current in the transmitter circuit can defect the inverter's transistors when the current exceeds the transistor maximum current rating. This thesis proposes a capacitor-inductor and series capacitor (CL/S) compensation circuit to constrain the inverter overcurrent. The parameter of CL/S compensation is detuned out of resonant while ensure the required power transfer for the battery charging achieved. Comparative analyses on the electric motorcycle (EM) battery charging simulation show that the inverter current from the CL/S compensation maintains below its maximum current rating, 55 amperes, when the equivalent resistance of the EM battery reaches 200 Ω. At the same time, the doublesided inductor-capacitor-capacitor (LCC) current has exceeded significantly. Moreover, the CL/S compensation output performances, including the receiver load voltage, the output power, and the power transfer efficiency, are acceptable for charging the EM battery. From the experiment result, the CL/S compensation limits the inverter current to 7.8 amperes for uncoupled coils condition and 9.1 amperes for the open circuit load condition. The percentage errors of the output power and voltage are less than 10%, while the highest efficiency difference between experiment and simulation is 14 %. The CL/S compensation circuit prototype can achieve 50 volts of output voltage, 250 watts of output power, and 89% of efficiency at aligned coil position and 10 Ω of resistor load. Hence, the proposed CL/S compensation is acceptable for EM wireless charging applications.

Jawed, Soyiba (2021) *Deep Learning-Based Assessment Model For Identification Of Visual Learning Style Using Raw Eeg Signals.* Doctoral thesis, Universiti Teknologi PETRONAS.

Learning style has its importance especially for long-term learning provided that an appropriate style is selected. The importance of determining a suitable learning style using brain patterns cannot be ignored as suggesting learning style without knowing brain patterns can increase the cognitive load. In the literature, various studies based on electroencephalography (EEG) have been proposed to identify the learning style. However, the utility of these methods is not clear as they lack a common framework. Also, as these methods are based on self-assessment, they give biased results that warrant further research. The objective of this study was to develop an EEG based assessment model for the identification of visual learning style. EEG signals were recorded during resting state (eye open, eye close) conditions and during performing learning tasks and recall tasks. Correct responses were analyzed for two recall sessions: Recall session one and Recall session two. The EEG features, Power Spectral Density (PSD) and Discrete Wavelet Transform (DWT) feature extracted from frontal, occipital and parietal brain regions were found to be the most significant for identifying the visual learning styles of students. The feature selection is done using principal component analysis (PCA). The k-Nearest neighbour (k-NN) classifier with Mahalanobis distance metric and Support vector machine (SVM) classifier are used for classification. Validation of machine learning (ML) models is done using 10-fold cross-validation. For ML models, the classification accuracy on an average oscillates between 0.56 to 0.98. This limitation of the ML models highlights the lack of robustness of used features. In order to solve that, high dimension features were automatically extracted from raw EEG data reducing preprocessing steps, using deep learning (DL) models: Long short term memory (LSTM), Long short term memory – Convolutional neural network (LSTM-CNN) and Long short term memory – Fully Convolutional neural network (LSTM-FCNN). Out of all three deep learning models, LSTM-FCNN exhibited the highest classification accuracy of 1. Results showed that the DL models were consistently reaching high accuracies while ML models were oscillating between high and low accuracies. Based on the results it is concluded that DL models can be used for identifying students with visual learning style. The work mainly contributes to the identification of the visual learning style of students using a memory recall test with EEG signatures. This advances the conventional techniques by incorporating objective scientific evidence from neuroimaging technique. This work paved the way towards real-time EEG based systems.

Mohamad Jamel Basha, Mohd Hafif Basha (2021) *Investigation Of Downdraft Co-Gasification Of Palm Kernel Shell And Polystyrene With Air As The Gasifying Agent For Production Of Synthesis Gas.* Doctoral thesis, Universiti Teknologi PETRONAS.

Palm kernel shell (PKS) and polystyrene is a promising combination of feedstock for co-gasification. PKS has high energy content, while the use of polystyrene as a cofeedstock can reduce polystyrene waste held in landfills. However, there were no previous study on the performance and characteristics of the air co-gasification of PKS and PS. The information on the performance and characteristics using this combination of feedstocks is important for the design of an industrial reactor. In this work, the characteristic of the air co-gasification of PKS and PS was investigated. The thermal decomposition behaviour of the co-gasification of PKS and PS was investigated, and it was found that for PKS, three stages of major decomposition was observed, while for PS, only one major decomposition stage was observed. For the PKS-PS mixture, four major decomposition stages were observed. The activation energy, EA of the gasification of PS obtained from the kinetic analysis ranged from 99.70 to 124.33 kJ/mol, while the EA for PKS ranged between 52.26 to 65.36 kJ/mol. The EA of PKS-PS mixture ranged between 41.61 to 69.76 kJ/mol. Investigation on the air co-gasification of PKS and PS using an electrically heated lab-scaled downdraft gasifier was performed. The range of temperature tested is from 700 to 900 °C, while the equivalence ratio (ER) tested are 0.07 to 0.27. The PS content of the mixed feedstock is varied from 0 to 30 wt%. The volume percentage of CO and H2 of the syngas increased with temperature, while CO2, CH4 and the tar generation decreased. High heating value (HHV) and gas produced is increased with higher temperature. Increasing ER increased the production of gas, but with reduced HHV. Generally, increasing PS content increased the HHV of the syngas. At higher temperature of 900 °C, increasing the PS content increased the percentage of the produced gas. However, at a lower temperature of 800 °C, increasing the PS content reduced the percentage of gas produced. Tar generation increased with increasing PS content. Process optimization using Response Surface Methodology with BoxBehnken design was performed using Design Expert software, to achieve the viii optimized conditions for the lowest tar generation, and highest gas yield and HHV. It was predicted and validated that process condition of 900 °C with 2.35 L/min air flow rate with PS content of 10 wt% achieved the given condition.

Mat Yaakob, Sarini (2021) *Performance Evaluations Of Glass Fiber Reinforced Geopolymer Composites As Coating For Carbon Steel Protection From Corrosion.* Doctoral thesis, Universiti Teknologi PETRONAS.

The brittle nature of geopolymer restricted major application of geopolymer. Technically, the addition of fiber seems to improve the brittleness of material. The main objective of the present study is to evaluate the performance of glass fiber reinforced geopolymer composite as a coating for carbon steel protection from corrosion. Three test parameter of curing time, Na: Al and water: solid ratio with a range of 3 to 180 days, 0.6 to 1.2 and 0.30 to 0.36, respectively, was evaluated to find the optimum value to produce better geopolymer. A glass fiber with two different lengths of 6 and 12 mm with 0.2 to 2.0 wt% of fiber content was added into geopolymer system. Mechanical properties of geopolymer composite were measured based on adhesion, flexural, compressive and corrosion testing via Electrochemical Impedance Spectroscopy (EIS) measurement technique. Characterization of geopolymer composite was examined using Brunauer Emmet Teller (BET) and Fieldemission Scanning Electron Microscope (FeSEM). It was found at Na: Al = 1.0, water: solid = 0.33 and 3 days curing time gave the optimum mechanical strength of geopolymer 3.9 MPa and 17.7 MPa for adhesion and flexural strength, respectively. FESEM images show the presence of pores inside the geopolymer structure was reduced, contributed to the excellent strength of geopolymer. Compared to 12 mm glass fiber system, the geopolymer obtained the highest strength with 1.0 wt% of 6 mm fiber as 6.5 MPa, 25.9 MPa and 34.0 MPa of adhesion, flexural and compressive strength were recorded, respectively. Water immersion test shows the geopolymer composite successfully reduced the corrosion rate 0.096 mm/yr after 28 days immersion period. Based on EIS analysis, it was proposed the main protection mechanism of geopolymer composite coating was attained by physical barrier protection. As a conclusion the ratio of Na: Al =1.0, water: solid=0.33, 3 days curing period, together with 1.0 what% of 6 mm short glass fiber need to be used to produce excellent geopolymer.

Mohammed Hassan, Anas (2021) *A Novel Hybrid Enhanced Oil Recovery Method By Smart Water Assisted Foam (Swaf)-Flooding In Carbonate Reservoirs.* Doctoral thesis, Universiti Teknologi PETRONAS.

The demand for and supply of fossil-fuel continues to be significant and contributes in the order of 85% to the total energy mix. A major part is delivered by crude oil. Due to the climate change concerns, the prospects of finding new giant oil and gas fields are declining and therefore, enhanced oil recovery (EOR) techniques can be a powerful tool to unlock a significant amount of residual and remaining oil from existing hydrocarbon reservoirs. The ultimate goal of this contribution is to investigate the potential of a newly proposed hybrid EOR method, which combines Smart-water injection and Foam flooding in carbonate reservoirs, known as Smart Water Assisted Foam (SWAF) flooding. The main function of the SWAF process is to displace crude oil to the production wells by the injection of smart-water (SW) followed by SAG, i.e., an alternating injection of a Surfactant Aqueous Solution (SAS) and Gas. Our designed smart-water has a dual improvement effect on crude oil displacement. It changes the carbonate rock wettability towards more water-wet by altering the surface charge at the rock-fluid interface. At the same time, it improves the stability of the foam film by minimizing the shielding effect of the electrical double layer (EDL). These altered surface charges at both rock-fluid and fluid-fluid interfaces cause that the rock-water interface and the water-oil interface have the same sign, resulting in a stable water and foam film. For a variety of reasons, a water-wet medium is usually more effective in displacing oil and thus enhancing oil recovery. Subsequently, SAG is applied for interfacial tension (IFT) reduction and improved mobility control, which also benefits from the smart water enhanced stability of foam films. To investigate the optimum smart water and SAG injection, we apply various theoretical and experimental research techniques, viz., surface complexation modelling, wettability measurements, foamability and foam stability tests, and core-flooding experiments. Moreover, the SWAF technique possesses various synergies and mitigates limitations associated with non-hybrid techniques, namely, water injection and foam flooding. Besides, the SWAF process provides new insights necessary for understanding the mechanisms of Crude Oil/Brine/Rock (COBR) interactions under reservoir conditions (80◦C) for successful field application in carbonate reservoirs. Based on the laboratory results, the recovery factor of SWAF process is up to 42% incremental recovery of oil initially in place or OIIP (i.e., 92% of the cumulative OIIP), which represents an optimistic scenario. Even the pessimistic scenario with 20% incremental recovery of the SWAF process is still higher than the one obtained with conventional EOR (i.e., average 17%), which is reported in the literature. Finally, it is expected that the SWAF under optimum conditions can make the proposed newly hybrid EOR method economically and environmentally attractive.

Mohd Nor, Mohd Azri (2021) *Analysis And Optimization Of Hydrocyclone Geometry Using Box-Behnken And Multi-Objective Optimization Algorithm.* Doctoral thesis, Universiti Teknologi PETRONAS.

Sand presence in oil and gas industry is detrimental to oil extraction operations as it leads to erosion issues and downtime that leads to higher operating cost. Hydrocyclone is considered as promising tool due to its high efficiency, fast processing and small footprint in comparison to gravity settling tank. However, the process of designing an optimal hydrocyclone is difficult due to its sensitivity to many parameters such as geometrical dimensions and operational parameters which is still lacking. The lack of understanding and non-linear modelling of hydrocyclone geometry against performances hamper any optimization process. Therefore, the objectives of this research are to investigate hydrocyclone geometrical parameters impact onto performance (pressure drop, flow split and separation efficiency) using Box-Behnken, analysis of multivariate analysis of variance of geometrical parameters against performances and investigate and validate the effectiveness of multiobjective optimization algorithm. The analysis shows all geometrical parameters are significant to pressure drop. Overflow and underflow diameters, cylindrical and vortex finder lengths, inlet height and width are significant to flow split. Separation efficiency dictates conical length, inlet width, overflow diameter and vortex finder length are critical. It is investigated that generalization and recommended length and diameters of parameters may not always be applicable in any case. The optimization algorithm successfully manages to propose several optimal hydrocyclone designs with acceptable prediction accuracies with maximum 11.52% difference when validated with simulated results. Two new proposed hydrocyclone designs U3 and U4 by the algorithm are more optimal than commercially available and published Mognon hydrocyclone design under the same operating conditions. Design U3 has of 33.24%, 76.78% and 66.59% improvement for pressure drop, flow split and separation efficiency respectively. Design U4 attains of 54.77%, 75.24% and 55.86% enhancement in regards to pressure drop, flow split and separation efficiency respectively.

Mohd Shafian, Siti Rohaida (2021) *Development Of Colloidal Silica Nanoparticles For Fines Migration Control.* Doctoral thesis, Universiti Teknologi PETRONAS.

Formation damage due to fines migration is among the main cause for productivity decline. This occurs due to minerals dislodging when fluid flow beyond the critical velocity and by poor cementation after acid stimulation activities. Conventional chemical methods are widely used to prevent the fines migration, however, most of the chemical fines' stabilizer are not robust which functionalize based on composition of exchangeable cations of fines minerals, temporary stabilization and are not environmentally friendly. This research work explored the potential of colloidal silica nanoparticles (C-SNPs) as new solution to control fines migration at various reservoir conditions through an integrated quantitative and qualitative methods. The efficiency of four commercial C-SNPs has been demonstrated via series of porous media testing. The most efficient organosilicasol, NPC-ST that generated the highest fines attachment (60% to 70%) have been selected for high pressure high temperature core flooding tests. Different sets of Berea Buff sandstone cores were initially examined for permeability impairment analysis at 30°C, 60°C, 80°C and 95°C. The permeability impairment ranges from 7% to 30% that caused by nanoparticles adsorption and aggregation. The evidence of nanoparticles adsorption and aggregation had been examined through field emission scanning electron microscopy (FESEM) and nanoparticles effluent particle size. These results are supported by aggregation visualization in micromodel. The performance of NPC-ST as fines control agent has been established by a series of critical velocity core flooding tests derived from permeability comparison k (baseline after elevated flow rates) and kw (baseline at initial). The critical velocity of treated cores was enhanced more than five times as compared to untreated cores from 1.0 mL/min to beyond 41.5 mL/min at all test temperatures that showed no fines migration had occurred. Treated cores showed low surface roughness demonstrated by the modification of pore surface that strongly attach the fines from migrating when high velocity was imposed. The experimental results are supported by total interaction forces analysis based on modified Derjaguin, Landau, Verwey and Overbeek (DLVO) theory

Shad, Muhammad Kashif (2021) *Enterprise Risk Management Implementation And Its Economic Value Added Analysis: The Moderating Effect Of Corporate Sustainability Reporting.* Doctoral thesis, Universiti Teknologi PETRONAS.

Enterprise risk management (ERM) and corporate sustainability reporting (CSR) have become popular concerns to ensure the firm's long-term performance. Although, number of studies related to ERM, CSR, and firm performance exists but the research lacks in providing a clear understanding of the intertwined relationship between ERM implementation and CSR towards firm performance. Applying the Stakeholders' Theory as an underpinning theory alongside the Modern Portfolio and Signaling Theory, this study examines the causal relationship between ERM implementation and firm performance and its value creation transmission mechanism. This study also examines the moderating effect of CSR on ERM and firm performance relationship. This research is based on panel data (2008 to 2017) derived from 41 oil and gas listed companies on Bursa Malaysia, involved in production & explorations, refinery & retailing, engineering support, infrastructure, equipment, and services. The weighted average content analysis is employed to convert qualitative information of the companies ERM and sustainability practices into quantitative data; while the information on firm performance which is measured through economic value added (EVA) including net operating profit after tax (NOPAT), weighted average cost of capital (WACC) and return on invested capital (ROIC) are sourced through Thomson Reuters DataStream. The empirical analysis is performed through panel data analysis, using Generalized Least Square (GLS) random effect regression estimator. The results indicate that: (1) the extent of ERM penetration and sustainability practices among the sampled companies have an upward trend, (2) ERM implementation has significant positive effects on the firm performance; (3) confirms the value creation transmission mechanism of ERM implementation via EVA modeling. Conclusively these results support the arguments made by ERM proponents and further support the usefulness of EVA analysis for the firm's ERM performance appraisal. The findings also indicate that overall CSR and individually economic and environmental sustainability exhibit moderating influence on the intertwined relationship between ERM implementation and EVA components. Whereas, social sustainability shows no moderating effect at all on the relationship between ERM and EVA components. Discussion on empirical analysis revolves the guidelines to managers to improve shortcomings in the quality of ERM and CSR practices. It could also assist regulators and policymakers to articulate and emphasize on developing an integrated ERM system and CSR framework for companies to cope with the risks and uncertainties in the oil and gas industry whilst creating a synergistic effect for value creation and operational excellence.

Singh, Niharika (2021) *Q-Reinforcement Learning Based Multi-Agent Bellmanford Routing Algorithm For Smart Microgrid Communication Network.* Doctoral thesis, Universiti Teknologi PETRONAS.

Microgrids help to achieve power balance and energy allocation optimality for the defined load networks. The communication network in microgrids is a very complex and time-variant system that needs to reserve network resources to count on several possible situations of failure resulting in limited recovery ability and inefficient resource utilization. The network link failure can lead to imbalance network load, increased packet loss ratio, higher network recovery delay. The solution to these associated problems can be resolved by improving the Quality of Service and network reliability of the microgrid communication network. In this thesis, the focus is to enhance the intelligence of microgrid networks using a routing-oriented multi-agent system and reinforcement learning while performance assessment is carried out using network performance metrics, i.e., delay, throughput, jitter, and queue parameters. Network performance is analyzed for the small, medium and large scale microgrids using the IEEE reliability test systems. In this research work, a data rerouting algorithm, multi-agent-based bellmanford routing (MABR) has been proposed that combines the features of a multi-agent system and bellmanford routing technique to produce an autonomous microgrid by providing an alternate path when the working path of the microgrid fails. It helps a microgrid to learn the associated paths in the network and train the grid to establish alternate path in advance to mitigate network path failure. Further, an intelligence algorithm Q-reinforcement learning-based multi-agent bellmanford routing (Q-RL MABR) is proposed to improve network quality and network reliability. The research compares the proposed Q-RL MABR with various other routing approaches, i.e. Optimized Link State Routing (OLSR), Open Shortest Path First (OSPF) and Routing Information Protocol (RIP) for five IEEE microgrid standards, i.e. IEEE 9, IEEE 14, IEEE 34, IEEE 39 and IEEE 57. The network reliability was tested for exponential reliability distribution using the failure rate of the network in the presence of various faults. The analysis was performed in IEEE 9 and IEEE 14 for 3 faults, in IEEE 34 and 39 for 5 and 10 faults, over IEEE 57 for 7, 14, and 20 faults. Overall, the proposed methodology was able to improve the communication network performance and network reliability of the microgrid network.

Wan Bakar, Wan Zairani (2021) *Improved Water Saturation Estimation In Shaly Sandstone Through Clay Minerals Electrochemical Study.* Doctoral thesis, Universiti Teknologi PETRONAS.

Petrophysical interpretation in shaly sandstone is a complex process. Previous studies suggested that excess conductivity from clay minerals causes different conductivity characteristic in shaly sandstone, hence the Archie's Law for formation factor-porosity correlation is no longer applicable. This study aims to propose an improvement to the mathematical correlation of formation factor-porosity in shaly sandstone. The equation was derived based on the physical theory of clay surface conduction in combination with geometric effect. It furnishes a variable cementation factor m that explains the data deviation from Archie's straight line on the log-log plot of formation factor versus porosity; thus providing possible solution for the non-linear part of shaly sandstone conductivity curve. The proposed mathematical equation provides good estimation of shaly sandstone formation factor F * for different types of data used for validation i.e established core data, field core data at overburden pressure from different regions and experimental data of collected shaly sandstone samples. Error analysis shows that mean errors for calculated F * are less than 0.10 for all types of data used in the validation. Since the equation provides non-constant but variable cementation factor, excellent agreement in calculated and measured formation factor can be seen even for scattered data sets. The experimental data analysis performed on the collected shaly sandstone samples also shows that deviation from Archie's straight line is influenced by the value of clay surface conduction BQv. The deviation is more evident for samples with higher Qv, as predicted by the proposed equation. The application of the proposed F * equation into water saturation Sw estimation provides a good match with laboratory-measured quantity since the estimated formation factor is closer to the laboratory-measure's. The MAAPE for Sw estimation using the proposed approach is as low as 0.01 with maximum error of 0.15. In comparison to this, MAAPE for conventional approach is more than 0.10 with maximum error of 0.46. The good approximation of Sw is contributed by good F * estimation and this can be seen from the supplementary well log analysis. The viii proposed equation predicts lower water saturation in less shaly zones as a result from the variable cementation factor.

Hussain Shah, Syed Zulfiqar (2021) *Characterization And Damage Modelling Of Resin Infused Thermoplastic 3d Fibre Reinforced Composite.* Doctoral thesis, Universiti Teknologi PETRONAS.

Three-dimensional (3D) textile composites are widely used in structural applications due to their superior transverse properties and low manufacturing cost. However, these composites are limited to the thermoset matrix, which is sensitive to the low-velocity impact (LVI) and degrades their residual strength. Furthermore, the available damage models for 3D textile composites are computationally inefficient for large scale dynamic simulations. On the other hand, the use of novel thermoplastic resin (Elium) has the potential to improve mechanical, impact and damage tolerance properties of composites due to its higher fracture toughness and strong fibre/matrix interface. Also, the multiscale damage model based on coupled micro-meso-macro approach envisaged as an efficient and reliable model for damage modelling in 3D textile composites. Thus, the objectives of this research work were to evaluate the mechanical, impact, damage tolerance properties and failure mechanisms of novel resin-infused thermoplastic (TP) and conventional TS 3D textile composites, and to develop a nonlinear 3D multiscale progressive damage model for 3D textile composites. The mechanical tests revealed that the TP composites exhibited up to 11% higher tensile strength, 19% higher compressive strength and 20% higher interlaminar shear strength. Whereas, in single and repeated LVI, they showed up to 44% and 50% less damage area, and 20% and 42% higher load carrying capacity, respectively. Finally, the residual strength test highlighted that the TP composites were insensitive to the impact-induced damage. The improved performance of TP composites was due to the plastic deformation, strong fibre/matrix interface, plastic kinking, and yarn straining, which delayed the propagation of cracks, reduced damage severity under impact loads and made them less sensitive to the impact-induced damage. This work demonstrated that the novel TP composites were an effective replacement for conventional TS counterparts, for improved impact and damage tolerance applications. Moreover, a generic computational framework was developed for the design/development of 3D textile composites, which was computationally efficient and successful in demonstrating the damage response under different mechanical loads.

Abu Bakar, Zurina (2021) *Intrinsic Motivation And Job Satisfaction Of Female Teachers In Perak: The Mediating Role Of Work-Family Conflict.* Doctoral thesis, Universiti Teknologi PETRONAS.

Work-family conflict is increasing among female teachers. The lack of balance between work and family responsibilities to meet the needs of these two domains ultimately lead to workfamily conflict. The conflict between the family and professional demands also leads to a lower level of intrinsic motivation and job satisfaction among female teachers. This study aims to examine the effect of role overload, role conflict, family involvement, and spouse support on the level of intrinsic motivation and job satisfaction using the mediating effect of work-family conflict. Data was collected from 298 married female secondary schools teachers in Perak, Malaysia. Data were statistically analysed in the statistical package for social science (SPSS) for the preliminary analysis of the study and structural equation modeling (SEM) using SmartPLS software as the main statistical technique. The result indicate that role overload and role conflict were determined to be directly related to work interfering with family. It was also found that spouse support reduced the occurrence of family interfering with work. Nonetheless, the direct relationship between family involvement and family interfering with work was not significant. Given these findings, the work-family conflict played a very important role as a mediator in developing and improving female teachers' intrinsic motivation and job satisfaction. These findings were endorsed by appropriate literature and were compatible with prior studies in both local and international settings. Further, the study had identified several limitations and recommendations that may help coordinate future studies.

Mohd Azmee, Norzaireen (2020) *Development Of Sustainable Ultra-High Performance Concrete Using High Volume Fly Ash And Ultrafine Calcium Carbonate.* Doctoral thesis, Universiti Teknologi PETRONAS.

Concrete technology advancement and expanding interest for high-quality construction materials have prompted the development of Ultra-High Performance Concrete (UHPC). Despite the many advantages gained using UHPC, however, the conventional design of UHPC poses many concerns, especially on sustainability issues. Producing UHPC requires a relatively high amount of cement content, and in most cases, the compositions are not optimized. Furthermore, due to the extremely low water to binder (W/B) used in UHPC, large amount of cement remains unhydrated causing a waste of resources and increase in material cost. Much effort has been put in place to reduce the cement content in UHPC without affecting its performance. This research reports on the development of UHPC, taking into account both the economic and environmental sustainability considerations. Locally blend UHPC, with 28-day compressive strength of above 130 MPa using high volume of fly ash (HVFA) replacement (up to 70% by weight) of cement, are proposed in this study. Hydration and microstructure investigation of hardened UHPC mixes are intended to help understand how to enhance further the performance of this concrete and to find the optimum cement replacement material (CRM) content facilitating higher substitution. Experimental results show that the development of non-heat treated UHPC with relatively low cement usage of 450 kg/m3 was possible using the combination of 40% FA and 10% ultrafine CaCO3 (UFCC). The synergistic interaction between HVFAUFCC in UHPC show the highest efficiency factor of 1.39 at 90 days with 15% overall strength improvement (compared to control specimen) by achieving higher cement hydration and pozzolanic reaction while reducing environmental impact through the use of industrial waste material instead of cement. Microstructure investigation also indicated that the incorporation of 10% UFCC in UHPC containing HVFA densified the microstructure, which led to the improvement of the interfacial transition zone (ITZ) and hardened concrete strength.

Wan, Roselind (2020) *Pu'un Tam - Dahun, Adet, Asen: Language, Culture, And Identity Of Kayan Elders, Sarawak, Malaysian Borneo.* Doctoral thesis, Universiti Teknologi PETRONAS.

This thesis investigates perception on language, culture, and identity of Kayan in Long Panai, Sarawak, Malaysian Borneo, and how Kayan language and culture shape cultural identity of the Kayan. Relying on ethnographic approach and a theoretical perspective that conceives Kayan language as endangered, linguistic, and cultural experiences of twenty (20) elders, aged between 50 to 80 at the time of the study provided context for exploration. Additionally, a case study of two groups of elders provides further in-depth analysis to understand and establish a comprehensive picture and pattern of different experiences of language, culture, and identity of Kayan elders. The study found Kayan cultural identity is manifested in several key themes. These themes are classified under two components: Symbolic Component (Perception on being Kayan, Belonging and Attachment, Sense of Pride, and Notions of Purity) and Behavioural Component (Practices and Ju Kayan). While the themes indicate certain commonalities, they are experienced quite differently depending on the individual elder. Essentially, the study revealed two key findings. Firstly, the study shows that conception of asen [origin] is key to developing a cultural identity as Kayan. Under this conception, a 'pure' Kayan identity is tied to proficiency in the origin language [daho' asen] and being born of Kayan parents. Further, within this concept of asen, practicing Christian beliefs is fundamental to retaining a complete sense of being Kayan. Secondly, Kayan traditional dwelling, the longhouse, remainsintegral to Kayan cultural identity and is a place where culture and language are lived and experienced. Overall, overarching features of Kayan cultural identity are grouped under Ju Kayan [Kayan Way], a cultural concept which features three overarching notions: purity of asen, Kayan language proficiency and Christian religion, and ties to place.

Babiker, Areej Babiker Idris (2020) *Empirical Mode Decomposition Based Wavelet Energy For Detection Of Situational Interest In Mathematics Classroom Using Eeg.* Doctoral thesis, Universiti Teknologi PETRONAS.

Situational interest (SI) is proven to have positive effects on learning and academic achievements. For subjects such as mathematics which many students fear, situational interest was found useful for engaging students and catching their attention during classes. Nonetheless, not much work was performed for assessing the feasibility of qualifying physiologically this interest in natural classroom. There is a lack of an automatic method to detect SI and majority of available methods are inappropriate for classroom because they distract lecture flow, unfriendly or subjective. The prospect of employing dry electroencephalogram (EEG) sensors with low number of channels remain challenging. Further, the application of time-frequency analysis for EEG data in this context is overlooked and the focus on time or frequency analysis led often to neglecting signal properties that require localization in time and frequency domains. Hence, this study investigated the possibility of characterizing SI using EEG in classroom learning. The study had two phases: 1) examining the development of SI during mathematics lecture and explore the corresponding students' brain activities; 2) utilizing phase 1 result to develop a feature extraction scheme for classification of high and low SI. In the first phase, the application of Approximate Entropy (ApEn), Power Spectral Density (PSD) and Singular Value Decomposition (SVD) to subject's EEG signal of lecture and baseline data indicated significant increase of delta rhythm in frontal lobe for low SI compared to high SI students. Therefore, delta rhythm was used to develop a feature extraction scheme for classification of high SI and low SI students based on Empirical Mode Decomposition (EMD) and Discrete Wavelet Transform (DWT), combined with weighted k-Nearest Neighbors (wkNN) classifier. The developed scheme was optimized by investigating several parameters such as wavelet levels, data segmentation and length and specific region of interest (ROI). Using 10-fold cross-validation, the developed scheme achieved an accuracy of 90.5% in discriminating between high and low SI students during mathematics lecture suggesting that SI modulates EEG rhythms clearly in delta band.

Abdul Basit (2020) *Study on The Effect of Process Parameters on Droplet Spreading Behaviour Over Porous Urea Surface.* Doctoral thesis, Universiti Teknologi PETRONAS.

Slow release urea provides nutrients to the plants at their required rates. Coating layer is mostly produced by fluidized bed coating. Coating uniformity is a strong function of droplet spreading behavior which is characterized by contact angle, spreading factor and residual drop volume. Droplet spreading is affected by coating liquid, surface characteristics and impact conditions. Droplet spreading on porous urea surface and optimization of process parameters has not been studied in the past either under non-dissolutive or dissolutive conditions. The optimized process parameters for droplet spreading can be the guidelines for operating conditions for fluidized bed coating. Moreover, the effect of dissolutive wetting should be considered while coating urea with water borne coatings. This study investigated the interactive effect of process parameters on droplet spreading behavior on porous urea surface under non-dissolutive and dissolutive conditions. The droplet spreading behavior on pre-wetted porous urea surfaces is also investigated. The porous urea surface used for the experimentation is prepared by pressing urea powder with the help of hydraulic press. Central composite design was used for the design of experiments and the droplet spreading experiments were recorded using high speed camera. Results were subsequently optimized using response surface methodology. The comparison of non-dissolutive and dissolutive wetting of macro droplet revealed that the dissolutive wetting showed 81% lesser contact angle and 21% great spreading factor. Whereas, comparison of non-dissolutive wetting and dissolutive wetting of micro droplet indicated that dissolutive wetting showed 27% lesser contact angle and 26% greater spreading factor. The less significant effect of solubility in case of micro droplets was because of the smaller liquid volumes involved. A multiphase VOF model was developed using Ansys Fluent, to simulate the droplet spreading over porous urea surface. Simulation results were in good agreement (5.16% error) with experimental data. The model developed in this work can predict maximum coating coverage following the impact of droplets on porous urea surface.

Loshini Thiruchelvam (2020) *Spatio-Temporal Correlative Modelling of Dengue Cases In Selangor, Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

This study aims to investigate the relationship of dengue cases with Air Pollution Index (API), climate variable (represented as mean temperature, relative humidity and cumulative rainfall parameters) and spatial effects (represented as neighbouring regions‟ dengue models). The study area covers few regions in the state of Selangor, Malaysia, using weekly dataset, with zone and district spatial scales, for the dengueAPI and dengue-climate analysis, respectively. This work develops dengue prediction models using the Autoregressive Integrated Moving Average (ARIMA) and Autoregressive Integrated Moving Average with Exogenous variable (ARIMAX) time series methodologies with API, climate variable and spatial effect as the exogenous variables. The Box Jenkins approach based on maximum likelihood is used for analysis as it gives effective model estimates and prediction. Model comparisons with respect to these two models are carried out for each study area: between the ARIMA (without API, climate variable or the spatial effect) and ARIMAX (with API, climate variable or the spatial effect) model structures. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), which chooses the optimal model based on goodness-of-fit versus parsimony criteria are used for comparison between all elicited models. This study concluded three issues; first there is no long term correlation found in the dengue-API and dengue-climate analysis, this is true for all the study area (except for Banting and Hulu Langat regions). Once the localized best model is identified, other variables like the API or climate variables do not contribute to yield better prediction models. Second, there is a significant improvement in model fit when the single dengue models are expanded into their respective ensemble forms. This explains that the neighbouring dengue models are not a redundant factor and significantly influence the pattern of dengue incidences in an area. Finally, study found application of model selection using AIC and BIC simultaneously enable selection of optimal models with respect to both over-fitting and under-fitting error

Mohammadali Beheshti (2020) *The electrochemical carbon dioxide conversion to Synthesis Gas (SYNGAS) by Zinc-Nickel bimetallic electrocatalysts.* Doctoral thesis, Universiti Teknologi PETRONAS.

In the last decade, there are some research about conversion of carbon dioxide (CO2) to energy form. CO2 can be converted to value added chemical such as formic acid, carbon monoxide, methane, ethane, and liquid hydrocarbons that can be used in various industries (such as gas and oil industries) to convert energy. Among all the methods, electrochemical methods are of interest due to their ability to operate with high reaction rate and good efficiency at room temperature and can be easily coupled with renewable sources. But there are various fundamental and practical challenges mainly due to high cost or unsatisfactory conversion performance (undesirable cell design, high coke formation, low current density, low gas selectivity and high overpotential) of existing electrocatalytic system for commercialization. In this thesis, Zn and Ni single metals, Znx-Ni1-x bimetallic and ZnNi-Co alloys have been investigated to find out which one has better performance, lower coke formation and higher catalytic activity and stability. For this purpose, nickel-zinc coating with different compositions have been investigated against nickel, zinc, and nickel-zinc-cobalt for electrochemical CO2 reduction reaction (CO2RR). Also, the electrochemical parameters such as different solution, pH and potential range were investigated. Gas chromatography analysis was carried out to determine which compounds were derived from the reaction. At each step of the electrochemical reaction, the electrocatalyst samples were subjected to SEM and EDX analyses to determine which microstructural changes occurred before and after the reaction. Among the electrocatalysts for CO2 reduction reaction, the 65%Zn-35%Ni electrode with cluster-like microstructure had best performance for CO2 reduction reaction by according to minimum coke formation (

Muhammad Babar (2020) *Desublimation Based Co2 Capture From Multicomponent Natural Gas Mixture Using Cryogenic Packed Bed.* Doctoral thesis, Universiti Teknologi PETRONAS.

Designing a cryogenic CO_2 capture process from natural gas (NG) requires proper thermodynamic phase study of the individual components and the NG mixture. Due to the intense energy requirement and its non-applicability for continuous CO_2 capture, the cryogenic CO_2 capture technology was not extensively investigated. Moreover, limited work was reported for the effect of packing material on cryogenic CO_2 capture in the cryogenic packed bed. The present work provides a simulation and experimental approach for the cryogenic CO_2 capture from NG. Using simulation in Aspen HYSYS, the thermodynamic phase envelopes of the multicomponent NG mixtures with high CO_2 content (75 and 90 mol %) were established. Based on these thermodynamic phase envelopes, desublimation based CO_2 capture in the two-phase solid-vapor region was optimized. Furthermore, the effect of packing material on the CO_2 capture performance of the cryogenic packed bed was investigated using glass, pure Cellulose Acetate, and composite polymeric CA/NH_2-MIL-101(Al). Moreover, the proposed switched cryogenic packed bed system, energy requirements, CO_2 capture, and switching time were evaluated. The thermodynamic phase envelops predicted by Aspen HYSYS simulator in the solid-vapor, solid-liquid, liquid-vapor, and solid-liquid-vapor phase has a Mean Absolute Deviation of 0.8, 2.5, 6.5, and 2.5 K. The optimized process parameters for the cryogenic CO_2 capture has more than 99 % of CO_2 recovery. The predictions of the established CO_2 frost point model have an R^2 value of 0.99. The packing material study revealed that the composite hollow fibres provide 2.30 times more specific surface area, 61 % less pressure drop, and 1.42 times more CO_2 capture than glass beads. In the continuous process study, a switching time of 200 sec was found for the NG sample 1 (75 mol % CO_2), while for the NG sample 2 (90 mol % CO_2) it was 195 sec. The current work provides an optimized cryogenic CO_2 capture process, along with an cost-effective packing material study for more than 99 % CO_2 capture in the cryogenic packed bed. Hence, this work could be exploited for the thermodynamic phase study of NG mixtures for the utilization of highly contaminated NG reservoirs.

Sadaqat Ali (2020) *Development and Characterization of Modified 316L Stainless Steel Alloy for Biomedical Applications using Powder Metallurgy.* Doctoral thesis, Universiti Teknologi PETRONAS.

Austenitic 316L stainless steel (SS) is one of the widely used biomaterials for manufacturing implant and medical devices. It is not only low cost but also possesses adequate mechanical properties, corrosion resistance and biocompatibility compared to its counterpart materials. However, this material is prone to localized corrosion attacks and leaching of metal ions in human physiological conditions limiting its usage as implant material. It is hypothesized that addition of boron, titanium and niobium in SS matrix with increased sintering dwell time can solve the above highlighted problems. The objective of this research is to synthesize a modified SS alloy with better corrosion resistance, improved mechanical properties and enhanced biocompatibility. In this research, SS matrix has been reinforced with boron, titanium and niobium additions with varying concentrations of 0.5 to 2 wt.%. Five main formulations were designed to improve the performance and properties of SS using powder metallurgy process. The samples were prepared by cold compaction followed by sintering in nitrogen atmosphere at optimized sintering parameters of 1200°C temperature and 8 hours dwell time. The sintered samples were characterized using OM, FESEM, XRD and XPS techniques. The micro hardness of the 2 wt.% niobium added SS exhibited an increase of micro hardness value by 64.68%. The corrosion and cytotoxicity assessments were carried out in artificial saliva solution and human oral fibroblast cell culture respectively. The corrosion resistance of the alloy systems increased by 30% and cytotoxicity results indicated that the developed alloy formulations were non-cytotoxic. The optimal sintering parameters resulted in the formation of passive oxide layer along with surface nitriding of the samples. These layers minimized the leaching of chromium and nickel ions to maximum values of 0.003 to 0.090 ppm respectively, which are far below the critical value for human body.

Alansari, Abubaker (2020) *Enhanced Characterization of Upper Ordovician Reservoir, Sahara Field, Murzuq Basin, Libya: Petrophysical and Seismic Inversion Approaches.* Doctoral thesis, Universiti Teknologi PETRONAS.

The Murzuq Basin is an intracratonic basin located in the south and southwest Libya covering 35,000 km2 . The Upper Ordovician reservoir is one of the best producing units of the Murzuq basin. It has a complex architecture inherited from the glacial effects on the braided fluvial deposits of the late stage at this era, which made it hard to characterize even with dense well and seismic dataset. In addition, the lack of an integrated petrophysical and seismic inversion studies has severely affected the outcome of mature exploration and appraisal activities in the basin. Therefore, this research aims to evaluate the reservoir properties by considering microporosity and defining a robust petro-elastic cutoff for determining the primary lithology. Seismic interpretation methods and seismic inversion were integrated to enhance the delineation of the reservoir boundaries. An integrated 3D reservoir characterization was performed to outline the main petro-elastic properties of the Upper Ordovician reservoir. To achieve this aim, this study quantified microporosity, and its effect on the petrophysical parameters. The resulted petrophysical properties upscaled to reservoir level and merged with the estimated elastic properties cutoffs and guided seismic inversion process for the 3D petro-elastic static model. Among all the examined petro-elastic cross-plots, Poison's ratio, VP/VS and effective porosity with compressional compliance enhanced the definition of the Upper and Lower boundaries of the thinly interbedded sand and shale layers of the Ordovician succession. As a result, five petroelastic facies (FA1-FA5) and eight electro-facies templates for the Upper Ordovician reservoirs were developed. The prediction of the Upper Ordovician reservoir boundaries and sub-boundaries in seismic section in the areas with density parameters overlap is enhanced by computing a velocity ratio attribute. By benefitting from the differences between the velocity ratio of sand layers (1.6-1.75) and the velocity ratio of the shale units (> 1.8). The attribute defined main reservoir units in the study area furthermore delineated the sub-reservoir unit directly from the inverted seismic section. The distribution of the high-resistivity zones controlled by the facies type. For instance, viii the high resistivity values appear in the areas with clean reservoir facies (FA4), higher pressure and well-defined oil-water contacts (OWC). Whereas, the regular resistivity readings are associated with the occurrence of facies association three (FA3) and one (FA1), hence, the fluid contact is not well defined and believed to be oil down to (ODT). The fluid contact shift is attributed to the facies change of the Lower Mamuniyat reservoir from poor reservoir quality facies (FA1 and FA5) in the northern part to the shaley-sand (FA3) and sandy facies (FA4) at the southern part of the study area. Merging all the findings from the 3D petro-elastic reservoir characterisation, led to the identification of two stratigraphic traps in the study area. The first is a working Mamauniyat pinch out and the second is a non-working Mamuniyat pinch out due to the lateral facies change from (FA5) to (FA3), which allowed the escape of oil into the Lower Ordovician reservoir. The findings and application of the above-stated workflow will contribute to building more accurate geomodels and robust FDPs (Field Development Plan).

Alsaih, Khaled Abdulhameed Manea (2020) *Retinal Fluid Segmentation On Optical Coherence Tomography Scans Using Volumetric Deep Learning Networks.* Doctoral thesis, Universiti Teknologi PETRONAS.

The deterioration of the retina center could be the main reason for vision loss. Morphological changes related to different diseases that occur in the retina, such as age-related macular degeneration (AMD), diabetic retinopathy (DR), and diabetic macular edema (DME), have attracted the research community. The recent standard in assessing the existence and mass of retinal fluids is the optical coherence tomography (OCT) modality, in which retina is imaged in 3D shape. Nevertheless, manual segmentation of retinal fluids can be subjected to variability, giving prominence to the demand for robust automatic segmentation methods. Approaching the performance of ophthalmologists remains the main challenge in retinal disease segmentation. Artificial intelligence techniques have shown enormous achievement in various tasks in computer vision. Most of the developed methods utilized the 2D information only. Hence, the main aim of this work is to develop deep models in different dimensions that either process 2D, 2.5D, or 3D information in order to incorporate volumetric information within the model. Besides, the number of volumes released is relatively low for developing robust deep models. Therefore, extracting patches in different ratios and dimensions is proposed to overcome the shortage in data. Additionally, adopting a meaningful loss function in the 3D novel model helps in localizing the small lesions more accurately with the rate of 72% in comparison to the models trained with 2D or 2.5D information using standard loss function. The proposed algorithms are compared with state-of-the-art deep learning models based on the dice similarity coefficient (DSC) metric, and the highest average DSC score is 0.78. The human performance has scored 0.71 on the retinal fluid segmentation using the DSC metric. The proposed 3D novel model achieved the highest DSC average score of 0.86. The performance of the developed model proves to be beneficial for ophthalmologists.

Arshad, Haroon (2020) *Experimental Study on Performance of Microwave-metal Interaction Pyrolysis of Plastics.* Doctoral thesis, Universiti Teknologi PETRONAS.

The microwave-metal interaction pyrolysis technique has proved to be an effective process for rapid recovery of useful hydrocarbons from waste plastics. An improved understanding of the process performance can help to develop the technology for potential benefits in the waste-to-energy research. However, the past studies on microwave-metal interaction pyrolysis were mainly focused on waste polystyrene (PS) and demonstrated the effectiveness of the process limited to a fixed power (700 W) of a domestic microwave oven to pyrolyze waste PS using a metal coil. The aim of this research, therefore, was to study the effect of microwave power on the oil yield, temperature, reaction time and composition of liquid oil fraction, and determination of optimal conditions for maximum oil recovery. The experiments were conducted using metal coil to pyrolyze different plastics selected as model materials. It was found that maximum heating occurred in the first five minutes of microwave exposure during microwave-metal interaction pyrolysis of each plastic comprising PS, polypropylene (PP) and low density polyethylene (LDPE), respectively. The iron coil was found to perform better than copper coil giving higher oil yield in lesser time. The increase in microwave power resulted in an overall rise of oil yield with a shorter reaction time. The oil yield was observed to be maximum for PS at 88.7 wt.% followed by PP (54.65 wt.%) and LDPE (30.15 wt.%), respectively. The oils recovered from PS were aromatic in nature and composed styrene as the most abundant compound. Contrarily, PP and LDPE produced aliphatic class of hydrocarbons that contained alkanes, alkenes, and cycloalkanes as the representative species. The study was also demonstrated for the plastic blends and waste PS (PSW). The optimal operating conditions with maximum oil recovery determined for each plastic using the central composite design model were found to be 87 wt.% at 2008 W and 25 minutes for PS, 57 wt.% at 2271 W and 31 minutes for PP and 43 wt.% at 2466 W and 32 minutes for LDPE, respectively.

Babasafari, Amir Abbas (2020) *New Approach to Reservoir Properties Prediction Using Petro-Elastic Inversion in a Transversely Isotropic Media.* Doctoral thesis, Universiti Teknologi PETRONAS.

A reliable reservoir model plays a significant role in the successful development and production of oil and gas fields. To generate such a reservoir model, petrophysical properties are traditionally distributed between the wells using geostatistical techniques. Incorporating only well data, geological facies, and petrophysical information, may not be sufficient for disclosing anomalous zone particularly in presence of lithofacies changes. Although, well logs and core data possess high vertical resolution, interpolation solely based on sparse well data is not geologically consistent due to non-uniform lateral variation of reservoir properties. To overcome this issue, seismic data, as a laterally extended data, is widely used in a seismic reservoir characterization scheme. However, seismic data inherently has some limitations; anisotropic effect, vertical resolution, and non-uniqueness in converting seismic data to reservoir properties are among the most predominant challenges. The main objective of this research is to reduce uncertainties associated with the seismic reservoir characterization by enhancing prediction of reservoir properties through seismic anisotropic amplitude correction and presenting a new method in Petrophysical Seismic Inversion (PetroSI). To achieve this, a new application of Petro Elastic Modeling (PEM) is employed to improve distinguishing lithofacies classification and hydrocarbon prediction. Five different novel and practical approaches were developed. These are as follows: (I) First a new methodology for lithology dependent seismic anisotropic amplitude correction in a Transversely Isotropic media with Vertical axis of symmetry (VTI) was proposed. This resulted in improved elastic properties estimation. In addition, a new anisotropic parameter (ν) was introduced for better lithology identification in clastic reservoirs. (II) The second technique is the application of Petro-Elastic Modeling (PEM), by integrating stochastic seismic elastic inversion and Bayesian probability classification in clastic reservoirs to enhance hydrocarbon prediction. Such an integrated technique is capable of hydrocarbon prediction and A viii lithofacies classification in thin reservoir layers with high lateral variation. (III) The third technique deals with the application of Petrophysical Seismic Inversion based on lithofacies classification. Estimation of the reservoir properties, using this approach, shows higher than 70% correlation with measured logs. Root-Mean-Square Error (RMSE) values at blind well were calculated to be 0.017 and 0.027 for Petrophysical Seismic Inversion and Probabilistic Neural Network techniques respectively. (IV) The fourth part presented a technique of seismic spectral enhancement named “Blueing Reflectivity Integration (BRI)”. This method is capable of disclosing sub-seismic structural and stratigraphical features and also revealing more details in hydrocarbon prediction of thin layers. (V) The fifth proposed technique is the Petro-Elastic Modeling (PEM) in the carbonate reservoir. The technique is based on extended pore space stiffness theory. The result is a more appropriate estimation of elastic properties. In this methodology, the aforementioned workflows from parts one to four were sequentially integrated in order to improve reservoir properties estimation and hydrocarbon prediction. All the results were cross-validated with blind test analysis.

Chee, Chin Hoong (2020) *An Efficient Frequent Itemset Mining Algorithm Using the FP-DB Approach.* Doctoral thesis, Universiti Teknologi PETRONAS.

Data mining provides insights that offer vast benefits such as increased revenue, cost cutting, and improved competitive advantage. However, the hidden patterns of the frequent itemsets become more time consuming to be mined when the amount of data is big. Moreover, significant memory consumption is needed in mining the hidden patterns of the frequent itemsets due to its enormous combinations that are required to be processed. Most of the current algorithms are still facing these two problems because the frequent itemsets are mined into the main memory and the storage space is quite limited for mining the entire data set. Therefore, an efficient algorithm is necessary to be constructed for mining the hidden patterns of the frequent itemsets especially when the amount of data is big. Frequent Itemset Mining (FIM) and Association Rule Mining (ARM) are the two main steps in Frequent Pattern Mining (FPM), and the focus of this research is in FIM. The objectives of this research are as follows: (1) to design an algorithm that constructs a Frequent Pattern Collection (FP-Collection) in a Frequent Pattern Database (FP-DB) for storing the frequent patterns which need to be used for data analysis in FPM, (2) to develop an algorithm that efficiently mines the frequent patterns within a shorter run time and with less memory consumption even though the amount of data is big in the data warehouse, and (3) to evaluate the algorithm in order to ensure that it is capable to mine the frequent patterns within a shorter run time and with less memory consumption for both the sparse and dense data sets. In this research, FP-NoSQL is proposed and constructed as an algorithm for FIM using the Not Only Structured Query Language (NoSQL) because NoSQL is able to support the mining of big data set in a flexible manner. The experimental research method is used as the methodology to implement this research. Four sets of data that are in the sparse or dense structure have been utilized for experimental testing to evaluate the performance of the algorithm. In order to further confirm that the algorithm is robust enough for mining the frequent itemsets in an efficient manner, two sets of data have vii been mined to compare against the Apriori and Extended Frequent Pattern (EFP) algorithms. The experiments conducted have proven that the FP-NoSQL algorithm is able to mine the hidden patterns of the frequent itemsets within a shorter run time and with less memory consumption even though the amount of data is big in the data warehouse. The FP-NoSQL algorithm is also evaluated to having a linear, logarithmic or log linear time complexity relationship through the Big-O notation. Apart from this, the FP-NoSQL algorithm is able to selectively retrieve the frequent patterns that matched the requirements of users from the FP-DB for generating the frequent itemsets. Thus, it is not required to mine the entire data warehouse again for identifying the frequent patterns even after a power failure.

Khan, Muhammad Rehan (2020) *Development Of Semi Empirical Sand Fines Erosion Model For Elbows In Liquid-Solid And Slug Flow.* Doctoral thesis, Universiti Teknologi PETRONAS.

Erosion-corrosion in elbow pipes resulting from sand fines is an ineluctable flow assurance problem confronted in hydrocarbon transportation and production systems which may result in equipment malfunction and even failure. A lack of understanding of the extent of erosion-induced damage in elbows from sand fines entrained in airwater slug flow exists. The primary objective of this research is to quantify erosioncorrosion induced damage due to sand fines and develop semi-empirical models for predicting sand fines induced damage in elbow pipe configurations for liquid-solid and erosive slug flow. In this study, the discrete phase model (DPM) and multiphase flow loop apparatus was employed to assess the erosion-corrosion behavior and mechanism relative to AISI 1018 carbon steel (CS) and AISI 304L stainless steel (SS) 90°,60°, and 30° long radius horizontal-horizontal (H-H) elbows with an inner diameter of 50.8 mm. Qualitative techniques such as multilayer paint modeling and microscopic surface imaging and profiling were used to scrutinize the flow accelerated erosion-corrosion mechanism and the extent of material degradation is reported in detail for 50 μm sand fines by mass loss analysis. Four semi-empirical erosion models were developed using regression analysis to predict sand fines erosion rate in elbows, assuming that the sand fines transport velocity is the same as the carrier fluid velocity. It was observed that the erosion or corrosion pitting mechanism prevailed on the 1018 CS elbow surface and the 304L SS displayed excellent erosioncorrosion resistance properties. Also, the transition of a liquid-solid to liquid-solid-air slug flow generates an erosion rate of 11.2 mm/yr this leads to 156 times higher material degradation with comparison to single phase flow with an erosion rate of 0.072 mm/yr for identical sand fines concentration. An attempt has been made to increase the accuracy of sand fines erosion prediction of the existing erosion model using a liquid-solid and liquid-solid-air experimental sand fines erosion, correction factors are introduced to account for over-prediction and under-prediction in the erosion rate calculated by the existing erosion models.

Ku Ishak, Ku Esyra Hani (2020) *Application of Anfis in Predicting Oil Removal Efficiency in Liquid-liquid Hydrocyclone (LLHC) From Enhanced Oil Recovery Produced Water.* Doctoral thesis, Universiti Teknologi PETRONAS.

In Chemical Enhanced Oil Recovery (CEOR) application, the presence of surfactant (S) and polymer (P) and the mixture of both (SP), has degraded the efficiency of the Liquid-liquid hydrocyclones (LLHC). Failure in treating this produced water is harmful to the environment. The application of the existing models in predicting the LLHC efficiency in the presence of S, P and SP is unknown. In this study, experimental work was performed by using fabricated-to-actual size LLHC test rig. Six parameters were involved: surfactant concentration, polymer concentration, salinity, initial oil concentration, feed flowrate, and split ratio. The existing models in predicting the LLHC efficiency from S, P and SP produced water were tested. It was shown that the existing models are unable to predict the LLHC efficiency in the presence of SP. New models were developed using 75% of the total experimental data by Adaptive NeuroFuzzy Inference System (ANFIS) and Response Surface Methodology (RSM). These models were then tested using 25% of the unused and unseen experimental data. The ANFIS and RSM models were compared statistically based on the training and testing data sets. Both models made good predictions. However, it was shown that the ANFIS model outperformed the RSM model with an R 2 value of 0.999 and AAPE 1.131% compared to RSM with the R 2 value 0.972 and AAPE 3.715%. Both models were then being validated using real data from the industry, and the results were compared. Results have shown that ANFIS performed better than RSM with R2 value and AAPE of 0.91 and 1.3% compared to RSM with R2 value and AAPE of 0.85 and 11.9%. Trend analysis was deployed to confirm that both models are physically sound. It was shown that the ANFIS and RSM models were able to predict the correct trend of each parameter. Finally, standalone Graphical User Interface (GUI) was developed as a final product to provide convenience to the user to explore the ANFIS model features and showcase the optimized values of the parameters.

Kumar, Pradep (2020) *Gold Nanoparticle-Decorated Graphene-Carbon Nanotube Hybrid Transparent Conductive Electrode as Anode for Organic Light-Emitting Diode.* Doctoral thesis, Universiti Teknologi PETRONAS.

Indium tin oxide (ITO) has been the transparent conductive electrode (TCE) of choice for the anode of organic light-emitting diode (OLED). However, it can diffuse into the active layer of OLED degrading the OLED optical emission-efficiency. Furthermore, to develop a flexible OLED technology requires flexible TCE which is not suitable for the brittle ITO. Recently, research on ITO replacement has been very active and graphene has emerged as one of the most potential candidates due to its attractive features such as high optical transparency (T) and carrier mobility. Graphene on its own, however, cannot meet the industrial standards due to its high sheet resistance (RS) and low work function. Hence, in this research work, a hybrid film of graphene and carbon nanotube (CNT) partially decorated with gold nanoparticles (Au NPs) is proposed as potential anode TCE for OLED. It is believed that the presence of CNT networks improves the electrical properties of graphene while maintaining its optical properties. Partial decoration of TCE using Au NPs can enhance its work function with additional boost in electrical conductivity. Hybrid graphene-CNT (GCNT) nanostructure was developed by synthesizing graphene around CNT-network on catalytic Cu foil using CVD method. Material characterization exhibited a crystalline, well-interlinked hybrid TCE of single-layer graphene (SLG) and CNTs with RS ~300 ohm/sq and T ~96.6%. Au NPs decoration further reduced the Rs to ~100 ohm/sq while retaining T at ~96%. The p-type behavior of TCE achieved after decoration indicates an enhancement in its work function. To demonstrate the functionality of the TCEs, solution-processed OLEDs were prepared using super yellow poly-(p-phenylenevinylene). OLED with decorated hybrid TCE shows a 4-fold improvement in current efficiency (CE) with lower turnon voltage (VON) and higher brightness (L) as compared to OLED with SLG-TCE. By introducing a thin layer of Al-doped zinc oxide (AZO), OLED with CE ~2 cd/A, VON ~5 V, and L ~650 cd/m2 was realized. OLED with decorated hybrid TCE and interlayer realized the comparable CE but significantly improved efficiency roll-off than commercial ITO-based OLED. The developed hybrid TCE is not only suitable for OLED but also for future flexible optoelectronic devices.

Mahmoodi, Syed Muhammad Ibad (2020) *Impact Of Heterogeneities On Sorption Capacities Of Potential Paleozoic Gas Shales From Western Peninsular Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

Organic–rich shales comprise significant resources of natural gas, which occurs as free, dissolved, and adsorbed gas. Despite the increased importance of sorbed gas, uncertainties remain regarding controls on gas sorption capacity by lithological variations as well as shale mineralogical, geochemical and petrophysical properties. Therefore, the overall aim of this research was to relate variations in mineralogical, geochemical, and petrophysical properties of selected Paleozoic shale samples from Western Peninsular (WP) Malaysia comprising seven formations namely Baling, Bendang Riang, Timah Tasoh, Sanai, Singa, Batu Gajah and Kubang Pasu to their sorption capacities. The bulk mineralogy through XRD and thin section of all Paleozoic shale formations is dominated by a medium to low clay content, non-existent or rare carbonates content, and the high proportion of quartz content. The Silurian-Devonian and Permian shales are generally more brittle than Devonian and Carboniferous shales. Pore sizes analyze through N2 and CO2 adsorption reveals radii of lesser than 25 nm contribute mostly to porosity and total pore volume. The measured total organic carbon (TOC) for Silurian-Devonian, Devonian, Carboniferous, and Permian shale samples ranged from 0.73 to 24.6, 0.1 to 9.91%, 0.12 to 2.79% and 1.01 to 19.56% respectively. The kerogen has reached to the metagenesis stage (>Ro=2.5%). Biomarker analysis depicts that organic matter composed of hydrogen-rich kerogen which is deposited in marine conditions by algal material selective accumulation. The S2 and HI of the Paleozoic shales are extremely low (>0.4 mg HC/g TOC and >20 mg HC/g TOC) calculated through Rock-Eval analysis. FTIR and UV-vis analyses suggest the dominance of aromatic over aliphatic HC compounds. Trace element analysis suggests the tectonic settings in which Paleozoic shale formations were formed significantly impact the hydrocarbon generation, potential, and storage capability. ix Methane sorption studies indicate that methane adsorption/desorption capacity of the Devonian Sanai and Permian shales are higher than other Silurian-Devonian, Devonian, and Carboniferous shales. The adsorption isotherms shape differs from sample to sample, because of thermal maturity, TOC content, pore properties, clay mineral, along with the applied pressure and temperature. Results indicate that Paleozoic shales especially all Silurian-Devonian, Permian, and some Devonian are overmatured with an abundance of organic matter and significant adsorbed gas content and comprises Type 3 kerogens. This suggests that these shales from WP Malaysia could be highly prolific sources of gaseous hydrocarbons.

Saw, Bing Bing (2020) *Sedimentary Geology Of The Late Oligocene To Early Miocene Cycle Ii Carbonates In The Balingian-Tinjar Province, Sarawak.* Doctoral thesis, Universiti Teknologi PETRONAS.

A sharp decline of oil price in 2015 and predicted decrease of oil and gas production in 2020 have led companies to reinvestigate in previously-known fields for any older and deeper reservoirs. The Subis Limestone is one of the carbonate units pertaining to the lower Miocene Cycle II, in the stratigraphic framework of the Sarawak Basin, NW Borneo. The Subis Limestone crops out near the coast of Sarawak. The stratigraphic sections studied are located (1) at three different quarries along the southern edge of the Subis platform (the Debbestone, Yong Shin, and Hollystone quarries), (2) at the Niah National Park on the northern part of the platform, and (3) in four wells located both offshore (Suai-5, Serunai-1, and Rebab-1) and onshore (Subis-2). Fieldwork study and core descriptions were carried out for stratigraphic and sedimentological descriptions, and samples were taken from the outcrops as well as the Subis-2 well. Thin sections were made, and petrography and cathodoluminescence analyses were performed. Selected samples from the quarries were run for XRD analysis. As for the Oligocene succession, four siliciclastic lithofacies, three carbonate lithofacies and five carbonate microfacies have been described and interpreted herein. The carbonate sequences are metre-scale in thickness, with a sheet-like architecture, both indicative of fore-shoal to shoal settings. The lower Miocene succession is found to crop out at the other two studied quarries and the Niah National Park, rimmed by a coral-algal reef. Nine lower Miocene lithofacies and microfacies were distinguished. The youngest lower Miocene succession is found in limestone at the Rebab-1 well, where three microfacies were distinguished. The early Miocene carbonate represent isolated reefal platforms, composed of facies of talus, reef rim to lagoonal environments.

Yusuf, Ishaq (2020) *Impact Of Rock Fabric On Critical Petrophysical Properties: Variation In Some Selected Reservoir Sandstones From West Baram Delta, Offshore Sarawak, Malaysia.* Doctoral thesis, Universiti Teknologi PETRONAS.

The West Baram Delta (WBD) still contains a substantial amount of hydrocarbon reserves. The implementation of enhanced oil recovery techniques (EOR) requires an understanding of the variation and distribution of critical petrophysical properties at the microscale. Previous studies on reservoir heterogeneity in the delta are based on the traditional qualitative evaluation, but this study bridge the gap between the scale of variations in geological heterogeneity by the integration of some non-traditional statistical, sedimentological scale, and 2D petrographic image analysis (PIA) techniques to acquire new quantitative fine-scale input dataset for reservoir property model for the field. The primary research objectives of this study are to evaluate the microfabric variation using the image analysis technique, to statistically investigate the relationship between microfabric pore attribute and critical petrophysical property and to develop a permeability predictive model from a novel certain pore attribute using the deep learning method. Petrography reveals five main fabric types namely clasts-support, matrix-support, random, fractured-dominated, and laminar based on dominant features. The analysis indicates that several fabric types may occur within each lithofacies. The fractured-dominated fabric appears dominant in all wells. Pore-walls appear to be lined with clay-sized minerals. This lining provides evidence that flow through these pores will experience various degrees of retardation that may have serious implications on porosity-permeability relationships, as well as, on our understanding of the role of pore tortuosity in reservoir rocks. The Pearson correlation shows that pore tortuosity within different fabric types exhibits variable degrees of relationships with permeability. Stepwise regression analysis reveals that there are two classes of pore tortuosity which affect the permeability significantly. The prediction of permeability improved by 8% by using the artificial neural network (ANN) instead of linear regression analytical methods. It has been shown in this study, that at 77% accuracy, the artificial neural network predictive model developed to evaluate critical petrophysical properties at the fabric or sub fabric level, appear to be more informative than traditional approaches. The outcome of this research (qualitative and quantitative information) can be adopted to calibrate well logs (sonic density and resistivity logs) for reservoir property model and upscaling as a contribution to the ongoing EOR processes in the West Baram Delta.

Peng, Wong Lai (2019) *Ultrasound Pretreatment Of Palm Oil Mill Effluent To Enhance Biogas Production.* Doctoral thesis, Universiti Teknologi PETRONAS.

Palm oil mill effluent (POME) is a high organic wastewater that can be a source of biogas production. Align with Malaysian green target to increase renewable energy production, research work has been initiated to explore improvement of organic matter digestion and biogas production through pretreatment techniques. Among possible techniques, ultrasonication pretreatment exhibits a great potential for being environmentally sound. This research examined the effect of ultrasound pretreatment of POME before anaerobic digestion and the influence on the microbial community dynamic by applying 20 kHz low frequency ultrasound. The ultrasonication conditions were optimized by response surface methodology (RSM) using three factors central composite design. Two separate 3.3 L continuous stirred batch-fed anaerobic reactors (CSFBA) were fabricated. One reactor fed with un-ultrasonicated POME (control) and another fed with ultrasonicated POME. The influence of ultrasonication pretreatment on organic solubilization of POME and biogas production was investigated by using CSFBA. The optimum hydraulic retention time (HRT) was determined and the anaerobes community dynamic was subjected to metagenomic sequencing analysis. The results from optimized ultrasonicated conditions (ultrasoncation density: 0.88 W/mL, ultrasonication duration: 16.2 min and total solids concentration: 6%) showed effective disruption of POME solids and transformation of organic substances into soluble form with improvement of organic matter solubilization and soluble chemical oxygen demand (SCOD) by 16.10% and 8.5% respectively. Comparing with the control CSFBA reactor, the SCOD removal increased from 68% to 90%. The improvement of organic solubilization efficacy corresponded with significant enhancement of biogas production by 24% with 85% of methane fraction at HRT 15 days. In addition, archaea identified from CSFBA fed with ultrasonicated POME was 16.7% higher compared to control reactor. This study indicated that ultrasonication pretreatment of POME could benefit treatment plant operation by increasing energy yield derived from improved biogas production.

Shahbaz, Muhammad (2019) *H2-Rich Syngas Production In Catalytic Steam Gasification Of Palm Kernel Shell Using Coal Bottom Ash.* Doctoral thesis, Universiti Teknologi PETRONAS.

The production of syngas through biomass gasification is a promising and environmentally friendly technique to fulfill the growing energy demand. However, the quality and quantity of syngas produced significantly depend on the type of biomass, gas cleaning process, removal of by-products, and gasification technique. The significance of this study is to utilize the palm kernel shell (PKS) for syngas production in order to contribute towards renewable fuel production and the enhancement of syngas yield through catalytic biomass steam gasification that makes the process to be economical. The main objective of the present study is to investigate the production of syngas in catalytic steam gasification of PKS using coal bottom ash (CBA) as catalyst and CaO as CO2 sorbent. Furthermore, the performance of catalytic gasification system was evaluated at different parameter in terms of syngas production. PKS and CBA are waste products of palm oil industry and thermal power plants, respectively. These waste products have been used as feedstock and catalyst due to abundant availability and disposal issues. This study has been performed at bench scale for 20 mg of PKS using thermogravimetric analysis coupled with mass spectrometry (TGA-MS) and pilot scale catalytic steam gasification system for 1 kg/hr of PKS. The Design Expert 8.0® software was used for the design of experiments. Response Surface Methodology (RSM) was used for the optimization of the process parameters. The process parameters were optimized for biomass conversion, gasification rate, hydrogen (H2) production, syngas production, and methane production. The temperature of 650-750ºC, particle size of 0.5-1mm, CaO/biomass ratio of 0.5-2, and coal bottom ash wt% of 0.02-0.10% were employed. At bench scale, the composition of H2 and syngas were obtained 36.57 vol% and 61.5 vol% at optimum temperature of 692ºC, particle size of 0.75, CaO/biomass ratio of 1.42, and coal bottom ash wt% of 0.07%. The pilot plant was run at optimum parameters. The product gas composition obtained was 79.77 vol% of H2, 5.48 vol% of CO2, 5.93 vol% of CO, and 8.81 vol% of CH4 at higher steam/biomass ratio of 1.5. The yield of hydrogen and syngas were about 79.77 vol% and 85.7 vol%, respectively and viii showed that good potential of PKS for clean fuel production. The present study provides the basis of utilization of CBA and PKS in steam gasification for syngas production through clean process.

Gebremedhen, Hailu Shimels (2019) *Enhancing Computational Efficiency Of Stress Constrained Topology Optimization.* Doctoral thesis, Universiti Teknologi PETRONAS.

Structural topology optimization is a mathematical approach which seeks optimal material distribution for a given design domain under defined loading and boundary conditions. It has been formulated and solved either to minimize compliance or weight under volume and stress constraints, respectively. Though considering stress constraints in the optimization process is more practical for those designs where stress is major design factor, it has been facing challenges associated with introduction of the stress constraints. Different solutions have been proposed by considering two dimensional problems to address these challenges considering the stress constraints only. Global optima, existence of micro-void structures in the final topologies, and being sensitive to initial guesses are the challenges in formulating and solving formulated problems. In this thesis, existing two–dimensional stress-based topology optimization is extended to a three-dimensional model. The developed model was validated by benchmark problems and compared with optimal material distribution, maximum stress induced and compliance of compliance-based formulation using Matlab. The results showed that the developed model can generate less complex optimal topologies than compliance-based formulations. Individual and combined effect of modeling parameters namely, minimum filtering radius (Rmin) and penalization factor (Penal) on the computational efficiency of Solid Isotropic Material with Penalization (SIMP) based stress constrained topology optimization were investigated. Numerical results show, through a combination of these parameters in the range of 1.7< Rmin <3 and 3< penal<4.5, the iteration number taken for convergence can be reduced up to 50% with less complex optimal topologies. A firefly algorithmbased hybrid method was proposed and validated using benchmark problems to address global convergence and dependence of optimal material distribution on initial values of design variables. Simulation results show the objective function which is weight of the design domain can be further minimized in the range of 5-15%.

Tuan, Truong Thanh (2019) *Integrated Economic Model Predictive Control Using Linear Offset Free Algorithm For Chemical Processes.* Doctoral thesis, Universiti Teknologi PETRONAS.

In the current highly competitive market environment, economic optimal process operation is receiving more attention than tracking a set-point. To enhance the economic performance, the economic model predictive control (EMPC) has been proposed which integrates the economic objective into the process control layer. This study addresses some of the major problems in the existing EMPC approaches, such as the presence of model-plant mismatch (MPM) and disturbances, ensuring stability for a priori unknown optimal points, the possibility of infeasible optimization problem due to violation of soft constraints. Moreover, the current EMPC approaches result in sluggish responses. A novel algorithm is proposed to guarantee offset-free MPC under MPM and disturbances by using Disturbance-Kalman state method. The proposed offset-free MPC is extended to the offset free EMPC algorithm. The proposed EMPC algorithm is to guarantee the stability without using any terminal constraints by adding a stabilizing inequality constraint. An algorithm is also proposed to address the problem of infeasibility. The soft constrained EMPC algorithm is proposed by using a quadratic term in the cost function to address the problem of infeasibility when the process is at violation of soft constraints. Finally, the integrated two modes RTO-MPC and EMPCMPC algorithm is proposed to reduce the operation time to reach maximum profit operation comparing to only EMPC-MPC mode. The effectiveness of the offset free MPC algorithm is demonstrated through two case studies. The result shows that the proposed offset free MPC algorithm has much better performance than the existing algorithms. In another case study, the effectiveness of the proposed two modes RTO-MPC and EMPC-MPC algorithm is demonstrated by comparing it with an EMPC-MPC mode only. The result shows that, the proposed two modes RTO-MPC and EMPC-MPC algorithm results in three times faster than only one mode EMP-MPC.

Yar, Asfand (2019) *Study of Eco-Reduced Graphene Oxide and One-Dimensional Metal Oxides for Symmetric and Asymmetric Supercapacitor Application.* Doctoral thesis, Universiti Teknologi PETRONAS.

Graphene as an electrode material is superior choice due to its outstanding properties but mostly its synthesis procedures are based on oxidation routes which results in non-conductive graphene oxide. To make it conductive reduced graphene oxide by adopting chemical routes, hazardous waste by-products are obtained with quality compromise like restacking and agglomeration of the material, while elevated temperature routs are not cost effective. Also reduced graphene oxide suffers from low energy density due to limited voltage. To address the problems, study aimed to investigate simple, cost-effective and eco-friendly reduction process of graphene oxide to minimize the agglomeration and to develop symmetric and asymmetric devices by coupling it with high specific capacitance 1-D nanostructures of copper, nickel and cobalt oxides to enhance energy density. To minimize the agglomeration, freeze drying process was used while reduction was carried out by radiations of small inexpensive computer controlled laser engraver and radiations of sun by focusing through Fresnel lens. 1-D CuO, NiO and Co3O4 were synthesized by voltage controlled deposition and annealing. Different characterization techniques confirmed the efficient reduction of graphene oxide by both the methods and formation of metal oxides. As symmetric supercapacitor, laser RGO showed energy density of 7.9 Wh/kg and 16.6 Wh/kg for KOH and Na2SO4 respectively while Fresnel lens RGO showed energy density of 8.5 Wh/kg 20.3 Wh/kg for KOH and Na2SO4 electrolyte respectively. Additionally, when fresnel lens RGO was tested in EMIMBF4, the 59.3 Wh/kg energy density was achieve. Also reduced RGO when coupled with the as developed CuO and Co3O4 in asymmetric setup using KOH aqueous electrolyte, showed increased energy density of 15 Wh/kg for CuO and 28 Wh/kg for Co3O4. Such developed techniques not only pave the way for simple cost effective and ecofriendly reduction processes but fabricate superior supercapacitive devices with better energy density values in asymmetric and symmetric configuration.

Sikander, Umair (2019) *Development of Double-Layered-Hydrotalcite Based Spinel-Like Structure of MG-NI-AL Catalyst for Hydrogen Production by Methane Decomposition.* Doctoral thesis, Universiti Teknologi PETRONAS.

There is thrive for COx free hydrogen production for its use as an alternate energy source. The global hydrogen production today comes from fossil fuels, where technologies such as natural gas reforming and coal gasification are already employed in large industrial scales but high COx emissions is a major climatic concern with such process. Direct catalytic decomposition of methane is the most feasible and cleaner route to pure hydrogen generation. In methane decomposition hydrogen is liberated and carbon particles are deposited on the surface of the catalyst. Deactivation of the catalyst by carbon deposition is a major hindrance in viability of this process. Nickelmetal have shown high selectivity and stable performance for hydrogen production via methane decomposition but its activity decreased with time due to carbon deposition. Spinel like Mg-Ni-Al mixed oxides derived from double layered lamellar hydrotalcite clay are used as a catalyst for methane decomposition in this work. Nanostructured and porous hydrotalcite based catalyst allow getting more metal sites, and diffusion sites. Catalyst performance is tested for methane decomposition in a fixed bed reactor. Different hydrotalcite based Ni mixed oxide catalyst with varying Ni concentration from 15%-65% (molar %) were synthesized and tested. Structural properties of these catalysts were confirmed by different characterization techniques like FESEM, FTIR, XRD, BET and TGA-DTG. Conversion of layered hydrotalcite to mixed oxides was done by the calcination, effect of calcination temperature over material was fully investigated and structural changes were analyzed by the XRD analysis of material calcined at different temperatures. The synthesized mixed oxides were tested for hydrogen production by methane decomposition after reducing it with pure hydrogen. Experimental studies were carried out over pure methane gas and effects of temperature, nickel concentration and catalyst support structure are studied in detail. Catalyst were tested for longer period of 8 h on stream time to evaluate the catalyst on stream stability. The optimum results of methane % conversion of above 70% for 7 h were obtained when mixed oxide with 40% Ni concentration was viii operated at 650oC. FESEM images of spent catalyst revealed the formation of carbon nanofibres on the catalyst surface, and Ni active sites are levitated on the tips of fibers, which has kept the catalyst active for longer time. Kinetic studies were performed based on the 1storder of reaction to calculate activation energy and rate constant. A low activation energy of 63kJ/mol was calculated. These kinetic parameters were further used in CFD studies of fixed bed reactor. 2D-transient CFD simulation studies of reaction zone were also done in this work to predict the behavior of rate of reaction and carbon deposition. It is found that rate of reaction was not uniform throughout the reaction zone and was dependent on the carbon deposition behaviors inside reactor.

Jamil, Muhammad Asif (2018) *Polyetherimide-Montmorillonite Hollow Fibre Mixed Matrix Membranes For Co2/Ch4 Separation.* PhD. thesis, Universiti Teknologi PETRONAS.

Hollow fibre mixed matrix (HFMM) membranes with nano-filler embedded in polymer matrix offer an attractive route for the fabrication of high performance gas separation membranes. However, the major concern is the incompatibility of nano-filler like clay with the organic phase due to its inherent hydrophilic properties. In this work, montmorillonite (MMT) clay was modified with long chain aminolauric acid to impart organophilicity thereby enhance its compatibility towards organic polymer matrix. Furthermore, HFMM membranes comprising polyetherimide (PEI) with various unmodified and modified montmorillonite (MMT and f-MMT) ranging from 1 to 4 wt. %, were developed via phase inversion method. Morphological, filler distribution, dispersion, surface topology, thermal, and wettability analyses were carried out for developed hollow fibre (HF) membranes. Pure gas permeation tests using CO2 and CH4 were conducted at varying pressure of 2 to 10 bars at ambient conditions. In addition, mixed gas test at CO2/CH4 composition of 50/50 v/v % was conducted for selected membranes. Upon modification of MMT, the basal spacing increased from 12.38 to 17.22 Å. The developed mixed matrix membranes (MMMs) incorporating MMT showed decrease in CO2/CH4 gas separation performance compared to neat PEI membrane. In contrast, the performance of asymmetric membrane was enhanced by incorporating f-MMT in PEI matrix to form MMMs. Uniform dispersion, void-free morphology and hydrophobic properties were observed for the aforementioned membranes. Furthermore, an increasing trend in ideal selectivity was observed up to 2 wt. % f-MMT loading against all feed pressures. Thereafter, opposite trend was observed with increasing filler loading due to filler agglomeration. The maximum ideal selectivity achieved was 18.35 with 2 wt. % loading at 4 bar pressure, which is 52.2 % higher than neat PEI hollow fibre membrane. Moreover, for the aforementioned membrane, the mixed gas selectivity of 10.66 was achieved. This implies that polyetherimide-clay HFMM membranes have the potential to be considered for CO2/CH4 separation at commercial scale after further improvement.

Abdul Qayyum (2018) *Height Estimation Based on Convolutional Neural Network and Sparse Representation Techniques using Aerial Stereo Imagery for Monitoring of Vegetation Near Power Lines.* Doctoral thesis, Universiti Teknologi PETRONAS.

The dangerous overgrown vegetation / trees under high voltage (HV) transmission lines right-of-ways (ROWs) have caused severe blackouts / flashovers due to interference with the power lines which leads to short-circuiting among the conductors. Therefore, these dangerous encroachments are monitored periodically along the electrical distribution networks ROWs through visual inspection, or by the airborne system. Airborne LiDAR scanners, videography, and aerial multispectral images are now available for the monitoring of HV transmission lines from those unintended encroachments such as trees/vegetation. Each of these methods has their own attributes and limitations and have proved to be costly, time-consuming and not much accurate. This thesis proposes an innovative idea of utilizing aerial (UAV and satellite) stereo images for monitoring dangerous vegetation (trees, shrubs, and plants, etc.,) below and near HV lines ROWs. The main focus is to develop a system to monitor vegetation / trees near transmission lines poles using aerial based stereo images. After pre-processing and orthorectification of stereo images, the proposed algorithms based on Convolutional neural networks (CNN) and sparse representation (SR) has been used to estimate the disparity map which further used to estimate the height of vegetation / trees near power transmission lines / poles. The proposed system based on CNN and SR design are used to identify different threat levels by estimated the distance between vegetation / trees and power transmission lines and height of towers, vegetation, and trees in the ROWs. The proposed algorithms are compared with the state-of-the-art stereo matching algorithms based on performance metrics (accuracy, precision, and recall). The results show that proposed algorithm based on CNN model achieved highest performance metrics (91% accuracy) as compared to extant stereo matching algorithms. The performance evaluation of real-time developed proposed algorithms prove the feasibilities of integrating the method for HV transmission line maintenance.

Afrooz, Iman Eslami (2018) *A New Improved Gas Distributor Plate with Enhancing Properties for Hydrodynamics of Bubbling Fluidized Bed Gasifier.* Doctoral thesis, Universiti Teknologi PETRONAS.

The emissions of the fuels combustions are the major cause of the global warming. There are many technologies which can be used to reduce the emissions of pollutants to the atmosphere. Gasification rather than combustion of the fuel is one of the solution to this issue. To tackle this issue, it is crucial to ensure excellent mixing of petcoke and combustion air. Therefore, there is a need of a technology to distribute the combustion air through the petcoke particles homogeneously. This can be done using a heated bed of sand-like material fluidized within a rising column of air called fluidized bed. The main advantage of a fluidized bed is its capability in excellent gas-fuel mixing and gasifying. However, the lateral mixing of gas-solid in a fluidized bed is not adequate due to the lacks of gas radial momentum. Therefore, this research is focused on fluidized bed hydrodynamics enhancement using the modified gas distributor plate design. To this end, the effect of distributor plate orifice pattern configurations on hydrodynamics of fluidized bed was first examined. As a result of the hydrodynamic analysis, a better performance of vertical gas-fuel mixing was achieved while the bed was equipped with triangular orifice pattern distributor. In terms of bed geometry design, the geometry of swirl tube promotes swirling flow to the particles. This swirl motion of particles improves lateral gas-solid mixing. Coupling of both aforementioned concepts into a new design, swirl distributor plate (SDP), can induce the gas-fuel mixing in vertical and radial directions. In the matter of petcoke thermal gravimetric analysis (TGA) a normal distribution function kinetic model was modified to best fit the experimental data of TGA. The new kinetic model (Modified Normal Distribution Function) minimized the discrepancy in activation energy calculation for petcoke and the results are in a good agreement with those extracted from the literature. Considering the gasification investigation, an enhancement in syngas production was observed while the fluidized bed gasifier was equipped with novel SDP. Moreover, the results show 20.52 and 9.55 percent improvement in the values of carbon conversion and cold gas efficiency.

Ibrahim, Aidarus Mohamed (2018) *Computer-Based Identification of Breast Tumor in Mammogram Images using Shearlet Transform and Stacked Sparse Autoencoders.* Doctoral thesis, Universiti Teknologi PETRONAS.

Breast cancer is the second leading cause of women mortality in the world after lung cancer. To improve the diagnosis of breast cancer, early detection is used as prediction process. Mammography is the commonly used tool for breast cancer screening as it yields reproducible results. Screening of mammograms by radiologists is prone to interobserver variability, tedious and time-consuming. Hence, computer-aided diagnosis (CAD) helps the radiologists to diagnose the mammograms accurately. To improve the performance of CAD system remains a challenging issue for further researching. Moreover, CAD systems detect only microcalcifications. However, subtle masses and architectural distortion are hardly detected by CAD systems. Segmenting automatically the breast profile and detecting the region of interest (ROI) are the current issues faced by the CAD systems. In this thesis, a new method is proposed based on shearlet transform and stacked sparse autoencoders to increase the classification accuracy rate for breast cancer diagnosis. Shearlet transform generates high dimensional features in the mammogram image decomposition, and this lowers the classification accuracy rate of the mammogram image classification. Hence, to overcome this issue, a stacked sparse autoencoders is proposed to augment the classification accuracy rate. The experimental results show that shearlet transform coupled with stacked sparse autoencoders outperforms the method with solely shearlet transform. The two classifiers used in the experiments were support vector machine (SVM) and logistic regression (LR). For the segmentation, the results of automatic segmentation of breast profile and detection of ROI were presented. The final breast regions were fed to adaptive thresholding to identify automatically the suspicious regions. Subsequently, shearlet transform coupled with stacked sparse autoencoders were applied to extract coefficients and finally, LR classifier was used to differentiate between the suspicious regions into mass vs. normal vii and architectural distortion vs normal. For the mass vs. normal images, at a 100% sensitivity and 2.3 FPI were obtained whereas for architectural distortion vs. normal images 100% sensitivity and 2.0 FPI were obtained.

K. Sugathan, Savita (2018) *The Drivers and Outcomes of Green Supply Chain Management Within ISO14001-Certified Manufacturing Firms in Malaysia: A Perspective from Green IT and Green IS.* Doctoral thesis, Universiti Teknologi PETRONAS.

Environmental degradation is a global crisis. Products, services, technologies, buildings, cities and education are moving forward with ecological considerations. With Malaysia's manufacturing industry one of its top gross domestic product (GDP) contributors, this industry is under the spotlight with demands to accelerate its green movement. Many scholars have observed green supply chain management (GSCM), its drivers, barriers, practices and outcomes. However, what has been overlooked is the assessment of negative environmental consequences from the use of information technology (IT) and information systems (IS) within supply chains. This study, therefore, introduces two new variables: 'technological drivers' and 'technological performance'. Technological drivers consist of Green IT and Green IS variables, with the organizational and environmental drivers consist of internal commitment and regulatory pressure (the third and fourth are adopted from the work of previous scholars). Technological performance and environmental performance are used to measure the impacts of GSCM implementation. In this study, the research model is developed based on the input-process-output (IPO) theory and the technologicalorganizational-environmental (TOE) framework. This study is one of the first attempts to use both IPO and TOE theories to link these three areas of research, Green IT and Green IS, with GSCM, particularly in the context of Malaysia. The study is carried out with ISO 14001-certified manufacturing firms located in Malaysia with a survey questionnaire and participation of 165 firms. Using partial least squares-based structural equation modelling (PLS-SEM) analysis, the study found that all four drivers are positively significant in encouraging improvements in both environmental and technological performance. This study discovered that Green IT is the most significant driver influencing the implementation of GSCM, followed by regulatory pressure, internal commitment and, lastly, Green IS. This research provides additional findings beyond those of previously conducted research. The study has highlighted the importance of Green IT and Green IS which have often been ignored among vi industrial practitioners, particularly those from non-IT sectors. The ISO 14001-certified manufacturing firms are realizing the importance of using environmentallyfriendly IT and IS which consume less energy, emit less carbon, are safer for disposal and are cleaner for the environment. These findings provide many new perspectives for the managerial level of firms, industrial practitioners and policy makers on strategic areas that require further attention and improvement. As revealed in this study, the green practices that are actively being implemented within the supply chain are eco-labelling of products, green supplier selection and green logistics. This will open an avenue of research and development (R&D) among industrial practitioners as well as for policy makers, the formulation of future policies, programmes, incentives and international partnerships.

Raja Shahrom, Maisara Shahrom (2018) *Studies of Novel Amino Acid Polymerized Ionic Liquids for Carbon Dioxide Capture.* Doctoral thesis, Universiti Teknologi PETRONAS.

The existing processes for CO2 removal in natural gas is by using alkanolamine which caused several drawbacks i.e., high vapour pressure, corrosive nature and high energy input for regeneration. Therefore a new solvent to replace the alkanolamine is highly needed. Ionic liquids (ILs) are regarded as a potential option because they have negligible vapour pressure under ambient conditions and higher thermal stability. Much higher absorption capacity can be achieved if the CO2 is chemically absorbed instead of physically. Amino acid have been used as anions due to the functionality of amine group and known as Amino Acid Ionic Liquids (AAILs). However, AAILs suffer the problem of having high viscosities. Amino Acid Polymerized Ionic Liquids (AAPILs), are much easier to handle in solid form with higher CO2 capacity. In this research, eight different types of amino acids using arginine [Arg], lysine [Lys], histidine [Hist], taurine [Tau], proline [Pro], serine [Ser], alanine [Ala] and glycine [Gly] are synthesized. Different types of cations and alkyl chain length on the cation were also studied. The results showed that the highest CO2 sorption capacity was obtained with [VBTMA][Arg] with 0.83 mol/mol and this increased to 1.14 mol/mol at 1 atm, 298 K after polymerization. Arginine, [Arg] comprises of multiple numbers of amine, thus accessability for CO2 to react with amine is an advantage. By increasing the pressure to 10 bar, the CO2 sorption increased to 2.77 mol/mol. The sorption decreased at higher temperature and full desorption occurred at 80 oC. The AAPILs also can be reusable with 86 % sorption capacity on fifth sorption. FTIR showed the formation of carbamic acid species after CO2 sorption, hence proving the chemisorption occurred in AAPILs. From the BET model, it was confirmed that physical adsorption with multilayer formation occurred in AAPILs. Therefore, both chemisorption and physisorption are involved in AAPILs. CO2 sorption capacity increases gradually with water. The selectivity of AAPILs towards different types of gases showed higher CO2 sorption capacity with 12.9 wt% viii compared to CH4 (1.3 wt%) and N2 (0.8 wt%). The degradation temperature and glass transition temperature also increase after polymerization. Four adsorption isotherm models were applied for the CO2 adsorption e.g. Freundlich, Langmuir, Dubinin Raduschkevich and Temkin isotherm. The Freundlich model provides the best fit to the experimental data. The adsorption was also modeled through various kinetic models e.g. pseudo first order, pseudo second order, Elovich's kinetic model and an intra-particle diffusion model. It was found that pseudo first order model was well fitted with the kinetic data. Thermodynamic analysis proves that the CO2 sorption is spontaneous process (ΔG -3.16 kJ/mol) and exothermic in nature with ΔH is -30.3 kJ/mol. According to DFT calculation, CO2 that attached with one primary amine in argininate shows that ΔH calculated is -30.4 kJ/mol which good agreement with experimental ΔH. This proves it follows 1:1 mechanism. As a conclusion, AAPILs is a good alternative to replace the usage of alkanolamine (0.5 mol/mol) to capture CO2 in natural gas. The presence of amino acids as anion makes the AAPILs greener and easier to handle. In industry, this will be beneficial due to non volatile, reusable and low energy input for regeneration.

Ahmed, Sohel (2017) *Modeling The Purposive Shopping Behavior In The Presence Of Interferences : A Sequential Behavioral Approach.* Doctoral thesis, Universiti Teknologi PETRONAS.

Past studies revealed that nowadays purposive shopping is declining. Situational cues are deemed to adversely influence shoppers to opt for impulsive shopping. Nonetheless, the extent of influence of situational cues on purposive shoppers is still under-researched. Rationality is identified as a benefit of purposive shopping. Nonetheless, there are many interests by various stakeholders to understand the purpose-enactment gap of the shopping behavioral. The study of Effortful Decision Making and Enactment (EDME) model may inform the sequential progress of purposive shopping and the gap between purpose-enactment. However, many underlying factors that may influence the purpose-enactment gap may exist. Thus, there is a need to understand the shopping interferences and to reconcile the purposeenactment gap. On the other hand, Bounded Rationality (BR) theory provides the procedural limit to reconciliation of an inconsistent rationality. In this context, the present study proposes a model by integrating EDME and BR theories to understand the shopping interferences and reconciles purpose-enactment gap within purposive shopping behavior. Behavioral responses were collected using a Sequential Behavioral Approach (SBA). In SBA, respondents were invited to complete three parts of a questionnaire. In the first part, respondents were requested to identify the shopping behavior (implementation intention) prior embarking for the shopping trip. Respondents were requested to complete the second part of the questionnaire during shopping. In the final part, the respondents were required to complete the questionnaire after shopping. Therefore, data on the progression of a sequential goal-directed behavior and interferences over the course of a before-during-post shopping episode was captured.

Alashloo, Seyed Yaser Moussavi (2017) *Advanced Seismic Modelling and Imaging Algorithms with Application for Anisotropic Media.* Doctoral thesis, Universiti Teknologi PETRONAS.

The presence of sedimentary layers in the Earth's subsurface results in seismic anisotropy, which makes wave velocity dependent on the propagation angle. This phenomenon causes errors in seismic imaging. Among these errors are the mispositioning of migrated events and failure to retain energy during dip-moveout. Since most of hydrocarbon reservoirs are defined as anisotropic media, considering anisotropy is necessary not only to avoid distortions in imaging, but also provides valuable information about lithology and fracture networks. To consider the influences of seismic anisotropy, an anisotropic wave equation needs to be employed. Furthermore, imaging the subsurface with complex structures and steeply dipping salt boundaries is another challenging task. Wavefield-continuation migration techniques, such as phase shift and reverse time migration (RTM), are powerful in imaging salt domes, faults, anticlines and steep dips. The main objectives of this research are to incorporate anisotropic effects in seismic modeling and Kirchhoff depth imaging, plus enhancing an algorithm based on RTM for imaging complex structures. Three novel algorithms are developed which are vertical transverse isotropy (VTI) and tilted transverse isotropy (TTI) wave modeling, VTI Kirchhoff depth imaging, and leastsquares RTM (LSRTM). In the first part, a new TTI pseudo-acoustic wave equation is suggested for anisotropic forward modeling. In the second part, a VTI fast marching eikonal solver is constructed for calculating traveltimes. An anelliptic VTI wave equation, which uses a nonlinear approximation, is utilized to provide the P-wave velocity information. In this study, synthetic data, and a real dataset are applied to test the algorithm. In synthetic data, shallow area had no problem with mispositioning, whereas in the middle area, the error was around 100 m (3.3%), and in deeper part, 200 m (6.6%) error was detected. In real data, mispositioning only appeared in deep part, which was about 50 m. The spectrum comparison illustrated that the VTI algorithm produces images with higher amplitude around 30 percent more than isotropic condition, thus, better resolution. The third part contains developing an ix isotropic matrix-based LSRTM. A matrix formulation of LSRTM is proposed based on generalized diffraction-stack migration (GDM). The spectrum comparison of RTM and LSRTM demonstrated 70 percent enhancement in LSRTM resolution. Results of proposed algorithms showed that our algorithms are faster, more stable, and more accurate than the industry standard algorithms. They are capable to produce high quality synthetic data and images, which are competitive or better than the results of available approaches.

Ali, Wajahat (2017) *Factors Affecting CO2 Emissions in Malaysia: Do Technological Innovation, Structural Changes and Interest Rate Matters.* Doctoral thesis, Universiti Teknologi PETRONAS.

Global warming and climate change due to environmental pollution have been the center stage of discussion for the last two decades. To empirically investigate the problem of environmental pollution due to Carbon Dioxide (CO2) emissions, the current study analyzed the relationship between the selected determinants of CO2 emissions in Malaysia under the environmental Kuznets curve (EKC) hypothesis over the period 1971-2013. The study employed the cointegration techniques of autoregressive distributed lagged (ARDL) bound test and Johansen cointegration to detect the presence of long-run relationship while the short and long run estimates of the study were analyzed using the ARDL model. The results validated the presence of EKC hypothesis in two out of three models. The results also reveal that technological innovation and structural changes in the economy can improve the environmental quality. Furthermore, the study demonstrates that high rate of interest, trade openness, and increase in population leads to further environmental degradation. The results suggest that the course of energy consumption should be altered to renewables as energy efficiency and renewable energy resources can significantly affect the energyrelated CO2 emissions. The installations of less emitting environment-friendly technologies along with developed financial sector could improve the environmental quality and ensure the long-run economic growth. Likewise, a more services oriented economy could also help reduce the carbon emissions. Low interest rates can be helpful in stimulating and steering the investments in environmental protection and green technology. The results supported the Ramsay-Cass-Koopmans Model of low interest rate.

Ali Shah, Syed Ayaz (2017) *Minimising False Detection of Retinal Microaneurysm Using Curvelet, Hessian and Regional Feature Detection Techniques.* Doctoral thesis, Universiti Teknologi PETRONAS.

Diabetic Retinopathy (DR) is one of leading causes of blindness. It can be diagnosed from symptoms like hemorrhages, exudates, microaneurysm (MA), blood vessels areas etc. Among these symptoms, MAs, are said to be the first sign of DR. Hence their detection is very important. Due to low and varying contrast and noise inherited in color fundus images, MA detection in color fundus images is a very challenging task. Although many state of the art algorithms have been proposed, many MAs are often missed in the process, thus resulting in low sensitivity. To achieve a higher sensitivity with comparable specificity, there is a need for addressing the issue of false positives (FP). Automated microaneurysm detection system is proposed in which FP by category are addressed. The categories of FP are (i) those from background (ii) from the blood vessel (iii) and from other objects/ lesions in the image. In the proposed system, candidate MAs are extracted in two parallel modules. In module one, blood vessels are removed from preprocessed green band image and preliminary MA candidates are selected by local thresholding technique. In module two, based on statistical features, the image background is estimated. The results from the two modules allowed us to identify preliminary MA candidates which are also present in the image foreground. A collection set of features is fed to a rule-based classifier to classify the candidates into true MAs and false MAs. The proposed system is tested with Retinopathy Online Challenge database. The automated system detected 162 MAs out of 336, thus achieved a sensitivity of 48.21% with 65 false positives per image. The retinal vessel segmentation was further refined to reduce FP. Image homogenization was proposed to ameliorate the effects of low and varying contrast. The proposed blood vessel segmentation system uses local and Hessian features and classifies each pixel into vessel and non-vessel using a LMSE classifier. We achieved a sensitivity of 0.77 with 0.0283 FPR on DRIVE test images database. Counting MA is a means to measure the progression of DR. Hence, the proposed system may be deployed to monitor the progression of DR at early stage in population.

Bhaskoro, Petrus Trio (2017) *Viscosity Prediction for Waxy Crude Oil - Effects of Physico-Chemical Parameters.* Doctoral thesis, Universiti Teknologi PETRONAS.

Precipitation of paraffin-wax components significantly increases the crude oil's viscosity. Therefore accurate waxy crude oil properties assessments and flow behaviour predictions are critical in order to effectively and efficiently design the pipeline transportation system. Unfortunately, recent viscosity correlation models in the literature incorporating the amount of precipitated wax below the wax appearance temperature (WAT), for waxy crude oils with wax content between 1% and 26% possess margins of error up to 50% as reported in the literature and still require a rheological data input. The accuracy of the models is further impaired by poor repeatability especially below the WAT. WAT assessment has also been subjected to various debates. The work aims to evaluate the rheological behaviour and develop a viscosity correlation model of waxy crude oil which incorporates critical properties of the crude oils. Four different waxy crude oil from Malay Basin with wax content between 17% and 38% and with API between 19 and 41 are characterized and evaluated. Cross-polarized microscopy is used to observe wax precipitation behaviour and the morphology. High precision calorimetry is used to assess partial and full exothermic heat released during wax precipitation. Controlled-stress rheometer is used to evaluate rheological behaviour of waxy crude oil with and without precipitated wax. The rheological and thermal analysis assessment show that precipitated macrocrystalline wax is a dominant factor for the waxy crude oil rheology below the WAT as compared to the microcrystalline wax or the wax content. General viscosity model for waxy crude oil is developed, verified and validated. The model is a function of the molecular weight (Mw), enthalpy of wax crystallization (hwax), activation energy (Ea), total amount of wax and the precipitated wax. Comparison with existing models in the literature shows that the developed model is superior in predicting waxy crude oil viscosity with an averaged absolute deviation of 46.86% while the other models produced averaged deviation of more than 100% for viii the crude oils in this study. The main advantage of the model as compared to the available models in the literature is the ability to accurately predict both Newtonian and non-Newtonian viscosity of waxy crude oils without any rheological data input.

Chandrasena, Dedimuni Charmaine Nadeesha (2017) *Development of Solid Waste Clog Resistent Open Drain System with Improved Storm Water Conveyance.* Doctoral thesis, Universiti Teknologi PETRONAS.

> Low and Lower-Middle income countries in the world are often faced with adverse consequences of natural disasters due to unpreparedness and sparse resource allocation to improve and maintain their physical infrastructure. Urban drainage infrastructure of these countries is not structured or constructed with compatibility to handle the drainage needs of the present era. This study based on finding answers the research question, “Why drainage systems fail in Low and Lower-Middle Income countries?” The presence of litter in open drains has been identified as one of the crucial factors that interrupted the storm water conveyance following an in-depth analysis of peer literature and case study observations. The effects of floating litter and its influence on clogging the crucial points of the drainage channel have been identified as an untouched area in previous attempts to resolve this problem. Hence, “Mahasinghe-Chandrasena mathematical model,” $bl\ D(t)\ dt = Qin - [Qout - k\ (bD(t) - c)\ 1.83\ (2D(t) - (d + \int (\sqrt{1+(flg)2} + \sqrt{1+(slg)2})b\ \ b\ \ 0\ ))\ 0.83]$ was formulated to approximate the rate of spillover of a clogged drain owing to the effects generated by sunken and floating litter items. The model outcomes lead to the hypothetical solution; “operational problems in clogged drainage channels can be corrected through a clog resistant drain design”. Accordingly, a dual layer Solid Waste Clog Resistant Open Drain has invented and prototyped. The invented and conventional drains were tested for hydraulic efficiency under a range of flow rates of 0.013m3 /s to 0.027m3 /s. The existing conventional clogged drain spilled over at an incoming flow rate of 0.013m3 /s while the improved Clog Resistant Open Drain unit did not spill over even at an incoming flow rate of 0.027m3 /s. A numerical approximation supported by EPA SWMM 5.0 computer simulation platform was used to validate the experimental results of the existing and improved drain conditions. In general, the improved drain was capable of handling storm water flow twice the efficiency of the conventional drain.

Habte, Azeb Demisi (2017) *Laplace-Tranform Finite-Difference and Quasi-Stationery Solution Method for two-and-three-phase Injection/Falloff Tests.* Doctoral thesis, Universiti Teknologi PETRONAS.

Injection and falloff tests are run on injection wells to obtain pressure transient data which are crucial for reservoir characterization, monitoring, and management. This study has two (2) main objectives: (1) Develope a semi-analytical solution method for efficiently and accurately simulating the pressure-transient behavior of oil-water flow associated with water injection and falloff tests and extend the solution method to immiscible water alternating gas (IWAG) injection problem. (2) Investigate effects of three-phase relative permeability hysteresis and capillary pressure on the pressure transient behavior of IWAG injection and falloff periods. A Laplace transform finitedifference (LTFD) method coupled with the well-known Buckley-Leverett frontal advance formula has been implemented to solve the radial diffusivity equation describing slightly compressible fluid flow. The solution is semi-analytical in time, and as a result, the issue of time discretization in finite-difference approximation method is eliminated. Thus, stability and convergence problems due to time discretization are avoided. The solution allows one to incorporate the effect of wellbore storage and thick skin and finite outer boundary conditions. It can also be efficiently applied to variablerate injection problems. The accuracy of the solution was evaluated by considering synthetic test cases with favorable and unfavorable mobility ratios and by comparing the pressure and pressure derivative signatures with a commercial black-oil simulator, and an excellent agreement was seen. The method is extended for IWAG injection and falloff tests, and accurate estimation of bottom-hole flowing pressure is observed. The pressure-derivative curves of falloff periods following gas injection periods exhibit a long transition period due to the high mobility contrast between gas and water/oil. It is shown that trapped gas (or hysteresis in gas relative permeability) and capillary pressure have significant effects on the pressure and pressure-derivative behaviors of injection tests, but less effect on falloff tests.

Hematpu, Hamed (2017) *Obtaining Model Parameters of SAG foam Process Using Unsteady State Experimental data.* Doctoral thesis, Universiti Teknologi PETRONAS.

Foam flooding is one of the Enhanced Oil Recovery (EOR) methods to mitigate the drawbacks of gas flooding. Whereas a number of studies have been carried out on foam flow through porous media, there are several untouched areas in foam flooding, especially for unsteady state foam flow. Most of the studies focused on the pregenerated foam flooding; however, a few on Surfactant-Alternating-Gas (SAG). Moreover, models' parameters for foam are derived based on steady state experimental data which is time-consuming and it is not the appropriate representative for real reservoir condition where is dominated by unsteady state flow especially in SAG foam flooding. This study aims to extend the insights of SAG foam process mechanisms and to propose a modified foam model to address problems of existing models. Moreover, it will obtain foam model's parameters using unsteady state experimental data. To achieve these objectives, a series of unsteady state experiments (one cycle of SAG) were conducted to evaluate the influence of different parameters on the foam performance. A new modified model is proposed to tackle the inadequacies of the existing models in the vicinity of limiting water saturation. Eventually, the models' parameters were derived using the new approach incorporating optimization algorithm for both steady state and unsteady state experimental results and validated with observed data using 1-D numerical simulation. The results showed a remarkable influence of surfactant concentration on the mobility reduction factor of SAG (increased by 50%), notwithstanding, an insignificant impact of salinity (reduced by 7%). Although the modified model utilized a continuous function, it clearly revealed the foam coalescence phenomena. The results of models' parameters calculation (sfdry of 0.164) indicated that the unsteady state experimental data can be utilized to derive the model's parameter of foam flooding.

Jaber, Ahmed Khalil (2017) *Modeling and Optimization of Miscible CO2-WAG Flooding in Heterogeneous Clastic Reservoir using Proxy Model.* Doctoral thesis, Universiti Teknologi PETRONAS.

Developing an active alternative to reservoir simulation model has become a hot topic in petroleum engineering. The availability of data and the resources of computing are so far considered as limiting factors. Therefore, researchers are still searching for solutions to reduce the computational load related to the simulation studies. The aim of this research is to develop a new statistical proxy model to predict the performance of miscible CO2-WAG flooding in heterogeneous clastic reservoir. The proxy model is adequate to provide a rapid prediction of the reservoir performance during miscible CO2-WAG flooding. To realize a successful CO2-WAG flooding, it is necessary to optimize the main parameters affecting the whole process. The process entails conducting a large number of compositional simulation runs. In general, this process is costly and time-consuming and provides an evaluation of one parameter at a time, with no parameter interactions. The developed model was based on the results of a fullphysics compositional simulation model for a heterogeneous clastic reservoir of the Nahr Umr reservoir. The central composite design was employed to develop the model. Seven parameters have been identified to affect the performance of miscible CO2-WAG flooding and were included in the development of the proxy model. Three reservoir parameters and four are operating parameters. The reservoir parameters are permeability, porosity and ratio of vertical to horizontal permeability. The operating parameters are WAG ratio, cyclic time, slug size of CO2 and the bottom hole pressure. The ranges of the reservoir parameters are 0.1 to 0.35 for porosity, 50 to 1500 md for permeability and 0.1 to 0.6 for vertical to horizontal permeability ratio. The ranges of the operating parameters are 0.25 to 1.5 for WAG ratio, 0.2 to 1 HCPV for slug size, 3 to 18 months for cyclic length and 2221 to 2894 psia for the bottom hole pressure. With these wide ranges of parameters, the proxy model was able to predict recovery changes as compared with the simulation results within ± 95 % confidence. The new proxy model was applied to B oilfield. The prediction accuracy of results was within the ± 95 % confidence and maximum difference of 17.5 %.

Jumaah, Sundus Sameer (2017) *Experimental and Numerical Parametric Investigation for Performance Enhancement of Solar Chimney Power Plant.* Doctoral thesis, Universiti Teknologi PETRONAS.

The efficiency of the solar chimney power plants to generate electric power is less than 2% and incurs more than 50% thermal losses at the collector components, which is considered as a setback. On the other hand, there is no power production at night due to absence of sun which is another considerable setback. The objective of this research is to evaluate the performance enhancement of the solar chimney system by various enhancing methods of the solar collector, in particular. The proposed improvements have been accomplished, by experimental measurements, and numerical simulation at various design and operational parameters. The numerical simulation, using ANSYS FLUENT software, was validated by comparison with experimental data and the maximum difference was less than 10%, which was acceptable. To determine the enhancement of the solar collector by geometry optimization, experimental investigations were conducted at various canopy heights (0.05, 0.1, 0.15 and 0.2 m) and various collector diameters (3.0 and 6.0 m). The investigation was extended to 9.0 and 12.0 m diameters by numerical simulation. To enhance the mechanical conversion, four different wind turbines were characterized by independent experiments in the wind simulation Lab. They have a configuration compatible with radial in-axial out flow of air. A new correlation of optimum canopy inlet height-to-collector diameter ratio, equal to 0.0083±0.0001, was developed. Among four tested wind turbines, the one with 0.9 power coefficient and 1.2 m/s starting wind speed was selected and installed in the solar chimney model for outdoor experiments. To reduce the setback of the night situation, pebbles was selected to integrate the system with sensible energy storage. Results demonstrated that thermal energy storage considerably enhanced the performance and extend the functioning and production of the system after sunset, and even over the entire night. The measured enhancement due to the use of thermal energy storage, in terms of daily average efficiency was around 65.0%. Conical and cylindrical shaped flow guide controllers installed in the central part of the collector showed enhancement viii in the power generation by 39.1% and 7.3%, respectively compared to the case without flow guide.

Khan, Mohammed Yahaya (2017) *Investigation of Water in Bio Diesel Emulsions on the Microexplosion Behaviour and Engine Performance.* Doctoral thesis, Universiti Teknologi PETRONAS.

This thesis presents the outcome from the experimental study in the development of stable water in biodiesel emulsions (WiBE) produced from a base fuel B5 diesel which contains 5% of palm oil methyl ester (POME), and the microexplosion behaviour of single droplets of the emulsions followed by engine testing. In the production of WiBE, parameters such as water content, surfactant dosage, HLB values and blending techniques were varied to comply with the emulsion fuel standard. The emulsions were then investigated to ascertain their impact on the evolution of microexplosion using high speed camera under Leidenfrost effect using hot plate as the heat source. As for the engine testing, a single-cylinder direct injection diesel was used to investigate the effects of WiBE on engine performance and exhaust gas emissions. Observation on the WiBE single droplet behaviour demonstrated that the coalescence process was the dominating factor in promoting the microexplosion phenomenon and the coalescence process can be either advanced or delayed by the surfactant dosage. All the unstable emulsions with wide range of distributed water droplets sizes developed microexplosion, while the homogenized emulsions with uniformly distributed with narrow sized water droplets did not develop microexplosion. The waiting time for the microexplosion was found to be delayed with increased surfactant dosage. The findings on the engine testing showed that the power produced using WiBE were reduced between 6 to 11.7% compared to base fuel. The specific fuel consumption increased up to engine load of 70% and comparable with base fuel for engine load of 70% to 100%. The in-cylinder pressure traces and the heat release rate attained by WiBE were found to be higher than the base fuel at high engine loads. The reduction in exhaust gas temperature, smoke opacity and the harmful emissions such as NOX were reduced significantly and CO reduced reasonable with WiBE compared to base fuel. viii At 80% engine load , WiBE st`abilized with 15% surfactant and an HLB of 9 reduced between 15 to 46% of NOX compared to the emulsions stabilized with 10% surfactant dosage with a HLB value of 6 at all engine loads.

Khan, Zahid (2017) *Interval Estimation and Bad Data Processing for Electric Power State Parameters.* Doctoral thesis, Universiti Teknologi PETRONAS.

State estimation (SE) in power engineering is used as a tool to find the point estimates of unknown state parameters from the hypothesized model using the specified information available about the system. In the presence of the short availability of the input data, these point estimates do not provide reliable estimates of the system state parameters. The SE algorithm should also have the capability to handle the gross errors which can considerably affect the accuracy of the estimated parameters. This current investigation, constructed confidence intervals for the unknown state parameters of the system. The results of the study show that the method is effective and practically applicable in the SE of power systems. In this thesis, the implementation of a new test, namely, the largest studentized residual (LSR) test is presented which combines both the results of the conventional approaches of the chi-square and largest normalized residual (LNR) tests for detection and identification of bad data in the form of a single test statistic. In addition, this research also develops another powerful procedure based on the generalized likelihood ratio (GLR) test to effectively detect the bad measurements in the SE algorithm. The proposed strategies have the ability to detect, identify, and estimate the size of gross errors. The obtained results confirm that the proposed algorithm has a greater power of detecting and identifying bad measurements compared to the estimator based on the conventional chi-square and LNR test statistics. The conventional SE algorithm is rooted in the weighted least squares (WLS) estimator which is not sufficiently robust to the gross errors in the measurements. This thesis also presents robust algorithms based on the quasi weighted least squares (QWLS) and modified least squares (MLS) estimators for power system SE environments. The performance analysis is evaluated on the ability of the state estimator for reducing the effects of bad measurements on the estimation results. The numerical results validate the performance of the proposed estimators in the power system SE.

Klufallah, Mustafa Mohammed Ahmed (2017) *Development of Construction Cost and Carbon Emission Assesment Model for Malaysia Office Buildings.* Doctoral thesis, Universiti Teknologi PETRONAS.

Construction projects have major impacts on the environment and are considered as one of the major consumes of naturally occurring and synthesized resources. In addition, changing its conventional practices to incorporate environmental performance as part of its decision making process is a gradually slow process. The management of carbon emission from construction projects is an important competitive advantage in businesses. The construction industry suffers from different kinds of market barriers and assessments measures to implement sustainable practices in developing countries including Malaysia. Therefore, the research was initiated to address the issues and aims at designing a methodology to enhance the competitive advantage throughout four objectives. It combines four methods from different areas of practices: social analysis; cost estimation; determination and assessment of carbon emission, in order to develop an environmental assessment foundation for construction projects. The results show that the major key barriers to sustainable construction are profession and capacity, design and technology, cost and finance and knowledge/culture considerations. A new benchmark and prediction models that provides a useful benchmarking and prediction opportunity for construction practitioners at the early project planning and design stages was introduced in the study. Moreover, the computational model for managing carbon emission and construction cost for Malaysian office projects was developed by integrating methods of assessment for carbon emission by using carbon emission inventory data, estimation of construction costs by considering cost databases and indices, and an application of Evolutionary Genetic Algorithm in MATLAB. The computational model was found to be effective when the results obtained from the computational process is compared with a reference value. The research bridges the gap between environmental management and project management within the construction industry context by application of ISO14040 LCA framework. It provides an assessment model for managing carbon emission based on evaluation of environmental and financial performances. The model was validated by an application to an office building and the findings obtained suggest that the model would be suitable for use in practice.

Lias, Mohd Rizal (2017) *Development of Bending Fatigue Life Mathematical Model For Spur Gear in Misalignment Conditions.* Doctoral thesis, Universiti Teknologi PETRONAS.

Misalignment phenomenon between gear teeth is well-known to affect the strength and bending fatigue life of the gears. Despite numerous research within this domain, investigations of the strength and bending fatigue life of a gear in misalignments condition are infrequent and limited. In this study, four types of misalignment known as axial, radial, yawing and yawing pitch were investigated. Their effects upon the strength properties of tooth surface contact stress and tooth root bending stress were discussed. Five mathematical models represent bending fatigue life of gear in pure and combine misalignments condition were developed. A three tooth computer-aided design model was constructed based on a physical problem of two involute spur gears with the same geometrical profiles. The model was then simulated according to quasistatics approach using a finite-element method. Comparison with different analysis, showed that the finite element model was verified to be extended for a parametric study of misalignments effect between the gears. In general, results showed that all misalignments do impact on the strength and bending fatigue life of the gears. Tooth surface contact stress and tooth root bending stress showed an incremental trend at different critical location while bending fatigue life was reducing simultaneously with the application of misalignments. Based on the four types of misalignments, yawing misalignment was found to give a major impact than the others. Using multiple regression methods, five bending fatigue life models of gear in misalignments condition were developed. The model successfully predicts the experimental data through the application of the miscellaneous fatigue factors. A high R-squares value more than 90%, indicates that all of these models are significance to predict the bending fatigue life of the gear in misalignments condition.

M. Qadrouh, Ayman Noor (2017) *Attenuation and Normal Move out Stretching Effect on the Seismic Response of a Bottom Simulating Reflector.* Doctoral thesis, Universiti Teknologi PETRONAS.

Gas hydrate will be an important energy source in the future. The seismic method has extensively been applied to detect gas hydrates based on the interpretation of bottom simulating reflectors (BSR), whose seismic response is characterised by low frequencies shadows (LFS). Moreover, the frequency content is offset dependent, with the BSR response having a lower dominant frequency at large offsets. Although studies on gas hydrate have been making significant progress during the last decades, still some issues are not clear such as the cause of the shadows. The objective of this study is to determine the cause of the low-frequency shadow. 1D and 2D synthetic seismograms were computed for a hypothetical high-loss BSR layer with varying quality factor and layer thickness. In addition, the shift of the centroid frequency of the power spectrum as a function of the travelled distance was computed. Then, stacking of the events were considered with and without the normal moveout (NMO) stretch correction. The 1D and 2D modeling use a spectrum of relaxation mechanisms and the differential equations were solved in the space-time domain by using a direct method based on the Fourier pseudospectral method. The media are described by a poroelastic model based on a generalisation of Gassmann's equation. In addition, real seismic data (case study) was processed using a standard seismic data processing sequence, tuned on this specific dataset and target. The results of 1D numerical seismograms and spectrograms show that attenuation affects the lower interface with minimum amplitudes for Q = 5. The centroid of the far traces decreases by 8 Hz compared to the near traces. Moreover, 2D spectrograms indicate that the attenuation increases, with increasing thickness, (e.g. h = 60 m) with values of the quality factor as low as 5. The maximum frequency loss is quantified as the shift of the centroid spectrum towards the low frequency. Furthermore, using the non-stretch NMO corrections improves the resolution of the top and bottom of the BSR layer in a stacked trace without loss of frequencies. Finally, the case study viii results show that a continuation of the BSR event and low frequency shadow below the BSR event are due to the use of a higher fold (fold 50), which was unobserved by other authors as they use a limited fold, namely, fold 2. Consequently, using a proper rock-physics methodology is essential to reach valid conclusions about the influence of the different parameters on the wave properties.

Mulubran, Freselam (2017) *Life Cycle Costing Framework Integration Probabilistic and Fuzzy AHP.* Doctoral thesis, Universiti Teknologi PETRONAS.

A proper decision making framework assist decision makers to make an optimum decisions. Failing to make accurate decision can lead plants for the loss of millions and billions of dollars. Even though there were different available decision models, the models consider either only quantitative factors (monetary) or only the qualitative factors for making decisions. The accuracy of a decision is improved if it incorporates fuzzy information, vague, imprecise, linguistic, or incomplete data. The objective of this research is therefore to develop a decision making framework that integrate quantitative and qualitative factors since there are a growing volume of qualitative data overwhelming decision makers in complex environments and yet containing valuable and vital information for accurate decisions. It emphasizes mainly on two issues, the first one is which method to use in order to appropriately model all the uncertainties and the second one is, on how to integrate the qualitative and quantitative models. Life-cycle costing (LCC) is generally recognized as a valuable tool for the assessment of quantitative factors on monetary terms. The deterministic method as one of the LCC model, which is used commonly in many plants is deficient in dealing with uncertainty factors due to their inherent focus on the economic issue alone and cannot practically and effectively utilize expert knowledge and handle ambiguous uncertainties. The cost elements of an asset are typically prone to uncertainty and subjectivity like time to failure, time to repair, interest rate, life span of equipment, cost of production loss per hour due to unexpected failure, number of personnel needed to repair a failure and labor cost per failure to name a few. These uncertainties are probabilistic and fuzzy in nature. Thus one needs to apply reliability and availability engineering principles to find when and how things fail by incorporating the probabilistic nature of the equipment life cycle. And fuzzy logic techniques were selected to enhance life-cycle cost analysis because they provide a formal approach for the effective treatment of these types of information. The proposed approach then uses viii vertex method, which is based on a combination of the λ-cut concept and standard interval. The decision making framework integrating Fuzzy Analytical Hierarchy Process (FAHP) and LCC is developed. The developed model was illustrated by applying it to a typical problem in amine pump of gas processing plant in Malaysia. The decision making framework investigates three options of decision alternatives these are, option one to continue with the existing pump system, option two to modify the existing pump system and option three to add new pumps to the existing system. FAHP is used to analyze the qualitative factors such as environmental effects, ease of operation, ease of installation, and flexibility considerations of all the three options. Finally, the research established a systematic approach to integrate the output of the two methods using weighted sum average method. The result indicated that the rank of the three options varies when using quantitative and qualitative analysis method and therefore the best decision was realized by integrating the results from the two analyses.

Osman Mukhtar, Mohammad Abdalla (2017) *Enhanced Audience-Driven Web Engineering Methodology using Model-Driven Architecture.* Doctoral thesis, Universiti Teknologi PETRONAS.

> Model Driven Web Engineering (MDWE) methodologies are highly used in web application development. Through these methodologies, web applications are developed using well-designed models that enable developers to automatically generate runnable implementation from high-level models. Currently, besides the well-known web applications domains, MDWE methodologies have been applied in several other domains such as Rich Internet Applications (RIA) and data validation. The Model-Driven Architecture (MDA) that has been applied into the web engineering field comprises of well-defined abstraction levels (components) and each abstract level has a standard set of specified models. During the web application development life cycle, these set of models are expected to be instantiated individually at the different abstraction levels by applying transformation from one level to another. However, the existing MDWE methodologies are not able to cover the complete transformation process between all MDA components. This deficiency has a direct effect to the required MDA components-based transformability and interoperability between these methodologies. Despite the fact that users (audiences) are considered as a critical part of web application development process, most of the existing MDWE methodologies are built according to the designer's perspectives only. In fact, the existing MDWE methodologies are not developed based on Audience-Driven philosophy. By following the audience-driven philosophy, web applications are developed to capture the users' navigation activities based on well-defined and standard functionalities. Within the field of web application development, Web Site Design Method (WSDM) is the only available method that employs audience-driven philosophy. WSDM is well-structured, however, it is not MDA-based, as such, it cannot be considered as an MDWE methodology.

Raju, S. Suresh Kumar (2017) *Unsteady Natural Convective Boundary Layer Flow of a Nanofluid Past a Vertical Plate For Various Thermal Boundary Conditions.* Doctoral thesis, Universiti Teknologi PETRONAS.

The unsteady two-dimensional natural convection boundary layer flows of a nanofluid past a vertical surface at various thermal boundary conditions such as constant/ variable surface temperature, heat flux, convective heating, sudden and ramped heating have been studied numerically. This study provides new insight into the role of nanofluids with regards to thermal engineering applications. A twocomponent non-homogeneous equilibrium model for nanofluid transport is extended in this study. The effects of Brownian motion and thermophoresis are incorporated in the mathematical model. A more physically realistic boundary condition for nanoparticle volume fraction has been used in this study, which is passively rather than actively controlled nanoparticle volume fraction on the boundary. The governing equations are non-dimensionalised by using the suitable dimensionless quantities and the resulting coupled non-linear partial differential equations are solved by using an efficient finitedifference technique of Crank-Nicolson method which is stable and convergent. A comparative study between the present numerical results and previously published results is conducted for the limiting case and the comparisons of results are found to be in good agreement. The analysis of the flow characteristics is performed for different values of the pertinent parameters such as time, Brownian motion parameter, thermophoresis parameter, buoyancy ratio parameter, Prandtl number, Lewis number, power-law variation of the wall temperature and wall heat flux, and Biot number. The computed results for the dimensionless velocity, temperature, nanoparticle volume fraction, local as well as average skin-friction and Nusselt number are displayed graphically and the physical aspects of the problem are discussed. It is found that the velocity, temperature and nanoparticle volume fraction increases with respect to time and a steady state of value is attained as the time progresses. The local Nusselt number is found to decrease with increasing thermophoresis parameter while it increases slightly with increasing Brownian motion parameter. The average Nusselt number decreases with increasing time and a steady state of value is attained as time progresses.

MD YUSOF, MUHAMMAD ASLAM (2016) *EXPERIMENTAL STUDY AND MODELLING OF CO2 INJECTIVITY IMPAIRMENT BY SALT PRECIPITATION AND FINES MIGRATION.* Doctoral thesis, Universiti Teknologi PETRONAS.

Re-injection of carbon dioxide (CO2) into saline aquifer is highlighted as an effective technique to permanently secure anthropogenic gas produced from high CO2 gas fields in Malaysia. Unlike typical gas injection for oil recovery, reactive interactions between CO2, brine, and rock minerals during the continuous injection of CO2 would trigger injectivity-related issues due to salt precipitation and fines migration mechanisms initiated in the aquifer. However, the existing models to predict CO2 injectivity change are limited to porosity change by salt precipitation alone, without considering other CO2, brine, and rock parameters. Moreover, there have been limited systematic experimental studies to understand the impact of these parameters on the CO2 injectivity change. This research work explored the application of neural network (NN) and response surface method (RSM) models to predict the CO2 injectivity change resulting from the combination of salt precipitation and fines migration. The impacts of independent and combined interactions between CO2, brine, and rock parameters were also evaluated by injecting CO2 into brine saturated sandstone. The core samples were saturated with NaCl brine with salinity between 6,000 ppm to 100,000 ppm. The 0.1, until 0.5 wt.% of different-sized hydrophilic silicon dioxide particles (0.005, 0.015, 0.03, 0.045, 0.06 and 0.07 µm) were added to evaluate the effect of fines migration on CO2 injectivity alteration. The experimental results showed that brine salinity has a greater individual influence on permeability reduction as compared to the influence of particles (jamming ratio and particle concentration) and CO2 injection flow rate. Moreover, the presence of both fines migration and salt precipitation during CO2 injection was also found to intensify the permeability reduction by 10%, and reaching up to threefold with increasing brine salinity and particle size. The evidence of permeability alteration has been examined through FESEM-EDX analysis of the rock physical changes and collected particles. It was both statistically found that the NN model gives better CO2 injectivity change prediction than RSM model for training, validation and testing data sets. NN model as overall is considered as efficient statistical tools in predicting the CO2 injectivity change of the sandstone rock after exposed with dynamic injection of scCO2 at different brine salinity, injection flow rate, particle size and particle concentration

Aziz Al-Wakeel, Haitham Behnam (2016) *Investigation Of Localized Rapid Soot Oxidation Using Metalassiste High Frequency Electromagnetic Heating.* Doctoral thesis, Universiti Teknologi PETRONAS.

Soot is a black carbon, produced from the incomplete combustion of diesel fuel, seen as a black smoke when it is emitted from diesel engines. Soot has dangerous impacts on the environment and human health. Hence, there are many regulations to reduce soot emissions. Current measures include the use of particulate matter filters to trap the soot from the exhaust gas. However, the increasing trapped soot in the filter leads to blockage of the filter, resulting in reducing of the engine efficiency and may lead to the engine damage. Therefore, filter regeneration strategies are used to oxidize the soot. One of the efficient strategies is high frequency electromagnetic or microwave heating. The drawbacks of microwave heating for soot filter regeneration are nonuniform regeneration, non-effective on soot of a small thickness, and excessive heating in the presence of a thick soot layer, which damages the filter. Hence, this research introduced a new means to generate a high electric field to attain the soot oxidation temperature locally and rapidly while saving the consumed microwave energy for unlimited soot thickness by using metal-assisted microwave heating. The behavior of the soot temperature with time was investigated computationally using a metallic rod inserted in the soot, positioned inside a mono-mode and modified multimode microwave cavities. The multi-mode cavity was attached with a waveguide, supplied with power of 800 W and frequency of 2.45 GHz at the incident port of mode TE,o. The investigation methodology was based on the conversion of the electromagnetic energy to thermal energy. The electromagnetic energy was calculated from the electric tleld, which was determined from Maxwell's equations. The soot temperature was found from the heat transfer equation. The comparison showed a good agreement between the results of computational and experimental investigations, which proved that the time of microwave heating to attain soot oxidation (temperature rise of about 555 K) was reduced from 8.5 to 0.3 second. This demonstrates that metallic pieces can be installed on the soot filter surfaces to enhance the regeneration process by localized rapid microwave heating.

Adebayo, Johnson Olufemi (2016) *Waste Cooking Oil as a Binder for Building Bricks and Immobilization of Petroleum Sludge.* Doctoral thesis, Universiti Teknologi PETRONAS.

Increasing depletion of material resources and concern for the environment has led to the great quest for degradable and environmentally sustainable material in various industries in recent years. This study explores the effectiveness of waste cooking oil as a novel binder in the production of non-structural building and paving block. Application of waste cooking oils as a renewable and biodegradable binder material was explored in this work. Also, this study investigated the feasibility of immobilizing petroleum sludge in building and paving block using waste cooking oil as a binder. Building block samples were prepared with 10% liquid binder of waste cooking oil and thermally cured in oven at temperature ranges of 170-200°C. Important parameters such as optimum binder content, optimum curing temperature, and optimum curing age were established. The mechanical and physical properties of the products were examined, the result shows that the compressive strength of 30 MPa was achieved in block manufactured with waste cooking oil whilst block with 50% petroleum sludge content in the binder matrix exhibit compressive strength of 21 MPa which are of greater values compared to conventional block, the normalized mean compressive strength is 26 and 18 MPa respectively. Initial rate of absorption (IRA), water absorption, efflorescence, freeze/thawing test and wet/dry durability of the products exhibit acceptable values within the threshold ofrequired standards. Flexural strength of 18 and 5 MPa was achieved for wastevege and petrovege masonry units respectively. The behavior of the blocks as the unreinforced masonry wall was assessed; the characteristic compressive strength ofthe masonry prisms is 8.0 and 3.1 N/mm2 for wastevege and petrovege blocks, respectively. This research work established an economically useful alternative to waste cooking oil disposal and provides a novel approach ofimmobilizing petroleum sludge

Rehman, Mobashar (2014) *Fostering Knowledge Sharing Among Software Engineers- A Case Of Malaysian Software Industry.* Doctoral thesis, Universiti Teknologi PETRONAS.

Software Engineering is a booming industry and has huge impact on world economy. This profe"ion is highly knowledge intensive for which knowledge sharing is critical. Importance of knowledge sharing can he imagined from the findings that only Fortune 500 companies lose US $31.5 billion annually because of failure to share knowledge. Due to the importance of knowledge sharing for overall industries and especially for Software Engineering. there i"i always a need to look more rigorously into this aspect. Solhvarc Engineering itself is not a 1nature field yet and most of the studies done so far in this field have focused on the technical aspects. However. to encourage knowledge sharing, non-tcchnicaJ aspects (e.g. organizational, work environment. personality) are very crucial as well. Therefore. this study focused on work design characteristics. personality traits and their relationship with knowledge sharing behavior for Software Engineers. In addition. perception (Perceived Ease of Use and Perceived Usefulness) towards knowledge sharing technology was also used to see how it affects knowledge sharing behavior of Software Engineers. Justification for focusing on these factors is that kno\vledge sharing is a behavior or behavioral outcome and working environment. personality traits and perception, influences behavior. Work design characteristics. which were focused in this study includes motivational (task and knowledge characteristics): social and contextual characteristics. These work design characteristics were adopted and adapted from Morgcson and Humphrey (2006). Personality traits of Software Engineers were measured through Big Five Personality traits. which are so far considered to he the most comprehensive set of traits to assess the personality. Both online and offline questionnaire methods were used to collect the feedback from Software Engineers. In total. 384 responses were used for analysis. Research was conducted in a nonexperiment way in order to collect the actual feedback from respondents. Multiple hierarchical regression method \vas used to see the impact of each variable on knowledge sharing behavior. Re-,ults indicated that work de~ign characteristics (motivationaL ..,ocial and contextual) do affect knowledge sharing behavior of VII Software Engineers. Similarly, personality traits of Software Engineers also have an impact on knowledge sharing behavior. However, results showed that PEOU do not play a significant moderating role whereas PU has a significant moderating role.

Zaini, Dzulkarnain (2013) *Development Of Inherently Safer Design Approaches To Prevent Or Minimize Toxic Release Accidents At The Preliminary Design Stage.* Doctoral thesis, Universiti Teknologi PETRONAS.

Inherent safety has been accepted as one of the best techniques to prevent or minimize major accidents in process plants. The best implementation is during the preliminary design stage. Even though it has been acknowledged as an attractive benefit in terms of safety and cost performance, the actual implementation of inherent safety in the process design stage is not widely implemented in the industries. The unavailability of a user friendly tool due to the lack of integration between process design simulators with inherent safety quantification is one of the difficulties for designing an inherently safer design process. Current research and development are focusing specifically for the case of explosion and fire only. None of these techniques were developed to prevent or minimize the major accidents due to toxic release accidents. Therefore, this work develops and proposes a new technique that can quantify the level of inherent safety for process routes, streams and evaluate the inherent risk for toxic release accidents. The combination of the above techniques provides the best solution which is known as 3-Tier Inherent Safety Quantification (3- TISQ). The 3-TISQ allows for risk reduction through the implementation of inherent safety principles during the preliminary design stage. A new concept of inherent risk based on a 2-region risk matrix that is suitable during the preliminary design stage is developed and used in the 3-TISQ.

Gebretsadik, Biruh Shimekit (2013) *Development Of Pol Yphenylene Oxide-Silicoaluminophosphate Mixed Matrix Membranes For Gas Separation.* Doctoral thesis, Universiti Teknologi PETRONAS.

This present research has developed new flat sheet dense mixed matrix membranes (MMM) that were comprised of poly (2,6-dimethyl-1,4-phenyleneoxide) (PPO) as polymer matrix and three different silicoaluminophosphates (SAPO) namely pure SAPO, sodium glycinate drived SAPO (GlyNa-SAPO) and aminopropyl triethoxysilane modified SAPO (APTES-SAPO) as molecular sieves via the solution casting method. Morphological analysises have shown that the newly developed MMMs provide evidence for good interfacial contact between the PPO polymer and the particles (SAPO, GlyNa-SAPO and APTES-SAPO) loadings at 2 wt.% and 5 wt.%. It was also found out that the introduction of the aforementioned molecular sieves into the PPO matrix improved the thermal stability of the newly developed MMMs over the PPO homogenous membrane. The differential scanning calorimetry (DSC) results showed that when the loadings of the (SAPO, GlyNa-SAPO and APTES-SAPO) molecular sieves increased from 2 wt.% to 10 wt.%, the glass transition temperature (T g) of MMMs also increased from 223.29°C to 225.83°C indicating the presence of rigidification effect. It was also found out that the annealing treatment has improved the thermal stability (thermal degradation temperature) and the Tg of the newly developed MMMs over unannealed membranes. The Fourier transform infrared (FTIR) analysis has also showed that the introduction of the SAPO, GlyNa-SAPO and APTES-SAPO functional groups and their specific interactions present in the PPO matrix. The gas permeation studies of the newly developed MMMs (SAPO-PPO, GlyNa-SAPO-PPO and APTES-SAPO-PPO) showed better gas separation performance in terms of ideal selectivity (C02/CH4 and C02/N2) over the homogenous PPO membranes. However, it was found that the addition of2 wt% to 10 wt% loading of the SAPO, GlyNa-SAPO and APTES-SAPO molecular sieves decreased the permeance of the tested gases over the PPO homogenous membrane. Within a pressure range of (2-1 0) bar, the permeation of C02 across the MMMs increased in the order of APTES-SAPO-PPO MMMs followed by GlyNa-SAPO-PPO v MMMs and SAPO-PPO MMMs, respectively. However, the permeation slightly decreased in the order APTES-SAPO-PPO MMMs followed by GlyNa-SAPO-PPO MMMs and SAPO-PPO MMMs for N2 and CH4 gases, respectively. From the newly developed twelve MMMs, the best ideal selectivity of target gases was found in APTES-SAPO-PPO MMMs at 10 wt.% loadings and 10 bar as much as 23.90 and 5.65 for the respective gas pairs of C02/CH4 and COz/Nz system. It was also found out that the annealing treatment at temperature of 235 °C reduced the permeance of target gases but improved the ideal selectivity of target gases (COz/CH4 and COz/Nz) of the developed MMMs compared with PPO homogenous membrane. The highest ideal selectivity achieved was found in annealed APTES-SAPO-PPO MMMs at 10 wt.% loadings and 10 bar with the values of 26.89 and 7.54 for the respective gas pairs of COz/CH4 and COz/Nz system, respectively.. Based on the computation, AARE % was found less than I%. Hence, the present developed model proved that the permeability and the selectivity of gases through non-ideal MMMs, could be predicted accurately.

E-Amin, Fazal (2012) *Identification And Quantification Of Variability Measures Affecting Code Reusability In Open Source Environment.* Doctoral thesis, Universiti Teknologi Petronas.

Open source software (OSS) is one of the emerging areas in software engineering, and is gaining the interest of the software development community. OSS was started as a movement, and for many years software developers contributed to it as their hobby (non commercial purpose). Now, OSS components are being reused in CBSD (commercial purpose). However, recently, the use of OSS in SPL is envisioned recently by software engineering researchers, thus bringing it into a new arena. Being an emerging research area, it demands exploratory study to explore the dimensions of this phenomenon. Furthermore, there is a need to assess the reusability of OSS which is the focal point of these disciplines (CBSE, SPL, and OSS). In this research, a mixed method based approach is employed which is specifically 'partially mixed sequential dominant study'. It involves both qualitative (interviews) and quantitative phases (survey and experiment). During the qualitative phase seven respondents were involved, sample size of survey was 396, and three experiments were conducted. The main contribution of this study is results of exploration of the phenomenon 'reuse of OSS in reuse intensive software development'. The findings include 7 categories and 39 dimensions. One of the dimension factors affecting reusability was carried to the quantitative phase (survey and experiment). On basis of the findings, proposal for reusability attribute model was presented at class and package level. Variability is one of the newly identified attribute of reusability. A comprehensive theoretical analysis of variability implementation mechanisms is conducted to propose metrics for its assessment. The reusability attribute model is validated by statistical analysis of I 03 classes and 77 packages. An evolutionary reusability analysis of two open source software was conducted, where different versions of software are analyzed for their reusability. The results show a positive correlation between variability and reusability at package level and validate the other identified attributes. The results would be helpful to conduct further studies in this area.

E. Gumah, Mohamed (2011) *Off-Line Arabic Handwriting Recognition System Using Fast Wavelet Transform.* Doctoral thesis, Universiti Teknologi PETRONAS.

In this research, off-line handwriting recognition system for Arabic alphabet is introduced. The system contains three main stages: preprocessing, segmentation and recognition stage. In the preprocessing stage, Radon transform was used in the design of algorithms for page, line and word skew correction as well as for words slant correction. In the segmentation stage, Hough transform approach was used for line extraction. For line to words and word to characters segmentation, a statical method using mathematic representation of the lines and words binary image was used. Unlike most of current handwriting recognition system, our system simulates the human mechanism for image recognition, where images are encoded and saved in memory as groups according to their similarity to each other. Characters are decomposed into a coefficient vectors. Using fast wavelet transform, then, vectors, that represent a character in different possible shapes, are saved as groups with one representative for each group. The recognition is achieved by comparing a vector of the character to be recognized with group representatives. Experiments showed that the proposed system is able to achieve the recognition task with 90.26% of accuracy. The system needs only 3.41 seconds a most to recognize a single character in a text of 15 lines where each line has 10 words on average.

Zafar, Saeed (2009) *Design and Implementation of the Quadrature Voltage Controlled Oscillator for Wireless Receiver Applications Utilizing 0.13 {Lm and 0.18 {Lm Deep Sub-Micron RF CMOS Technology.* Doctoral thesis, Universiti Teknologi PETRONAS.

The field of high-frequency circuit design is receiving significant industrial attention due to variety of radio frequency and microwave applications. This work proposes the low power, low phase noise and low phase error quadrature voltage controlled oscillator (LP3 - QVCO) for wireless receiver applications. An enhanced investigation and design of the low power, low phase noise and low phase error quadrature voltage controlled oscillator (LP3 - QVCO) is carried out in comparison to conventional LC- QVCO. The design, implementation and characterization of the complementary LP3 - QVCO is carried out with the integration of 40 S1 source damping resistor (Rdmp), tail biasing resistor (Rtait) and multifinger gate width configuration of the pMOS varactors and 50 S1 impedance of common drain output buffers. The LP3 - QV CO implementation is carried out using 0.18 p,m, 6 metal, 1 poly, 1.8 V and 0.13 p,m, 8 metal, 1 poly, 1.2 V deep sub-micron CMOS and RF CMOS process technologies. The three different designs with the center frequencies of 2.8 GHz, 3.1 GHz and 3.8 GHz are implemented using 0.18 p,m CMOS and RF CMOS process technology. The remaining four designs with the center frequencies of 4.35 GHz and 5 GHz are implemented using 0.13 p,m RF CMOS process technologies. The LP3 - QVCO design exhibit the measured phase noise of -110.13 dBc/Hz and -108.54 dBc/Hz at the offset frequency of 1 MHz, with multifinger gate width configuration of pMOS varactor (3.125 p,m x 64 = 200 p,m) and (8 p,m x 25 = 200 p,m), respectively. The phase noise im- provement of 1.63 dB is achieved in LP3 - QVCO design implemented with (3.125 I'm x 64 = 200 I'm) mult.ifinger gate width configuration of pMOS varactor in comparison to (8 f.tm x 25 = 200 f.tm). The measured center frequency of the LP3 - QVCO is 4.35 GHz with the frequency tuning range of 4.21 GHz to 4.44 GHz. Both LP3 - QVCO core power dissipation is 3.36 m W from 1.2 V de power supply. The measured phase error is less than 0.2'. The calculated figure of merit (FOM) is -177.6 dBc/Hz. The symmetrical spiral inductor is also used with patterned ground shield (PGS). The quality (Q) factor of inductor is 18.6 and is implemented using 0.13 f.tm RF CMOS process technology.

Sayed, Khalid *Enhancement of Tapis Light Crude Oil Biodegradation in Polluted Seawater Using Palm Oil Mill Effluent Final Discharge as Biostimulant.* Doctoral thesis, Universiti Teknologi PETRONAS.

Petroleum hydrocarbon pollution in marine waters has been an extremely significant environmental and health issue worldwide. Crude oil spill is a common issue during offshore oil drilling, transport and transfer to onshore. A biological treatment method using bacteria, fungi and algae has recently gained a lot of attention due to its efficiency in petroleum hydrocarbons biodegradation. This study aims at constructing an efficient indigenous bacterial consortium to biodegrade tapis light crude oil (TLCO). The local agro-industrial wastewater of palm oil mill effluent final discharge (POME FD) was used as biostimulant to further enhance the biodegradation efficiency. POME FD was selected as biostimulants (nutrient) by comparing the elemental analysis results with raw POME. In this study, three TLCO degrading bacteria were isolated from seawater samples collected. Molecular identification using 16S rRNA genes sequencing was done and results show that these isolated strains belong to: Bacillus tropicus, Bacillus licheniformis and Bacillus subtilis. Bacterial consortium tested using four different concentrations of POME FD (0.1, 0.25, 0.5, and 1%) as biostimulant and TLCO (0.5 and 1.0%) degradation capability was investigated. The residual TLCO in culture medium after 40 days was analyzed. The results confirmed that POME FD dosage (0.25%) for the bacterial consortium gave maximum biodegradation of 99.85% with TLCO (0.5%) and 95.23% biodegradation with TLCO (1.0%). To further enhance the biodegradation process of TLCO, response surface methodology (RSM) was used to optimize the parameters such as TLCO concentration, POME FD dosage, and incubation time in order to obtain optimal biodegradation. The central composite design (CCD) was employed, and it predicted that with a POME FD dose of 0.2% and 1.5% TLCO, the percentage of biodegradation could be maximized to achieve 86.605% in 10 days. Validation experiments confirmed that this projected value was achievable and reproducible. This study is the first reports on TLCO biodegrading bacterial strains by using POME FD as biostimulant. This study can be used for treatment such as emulsified residual spilled oil in seawater with floating oil spill containment booms as an enclosed basin such as a bioreactor.