

# gear

## TECHNOLOGY INDIA

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### Heat Treatment

*Thermal Effect of Gear Grinding through Process Parameters Responsible for Grinding Burn & Detection using Barkhausen Noise Analysis*

### Tech Innovation

*Two Newly Revised AGMA Standards*

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**Anitha Raghunath**  
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Dear Readers,

We are delighted to present Volume 2, Issue 2 of Gear Technology India, a collaborative effort with the American Gear Manufacturers Association (AGMA). This issue explores the dynamic synergy between manufacturing and design software, a theme that underscores the technological advancements shaping the gear industry.

In our cover story, "Deciphering the Technological Symphony: Exploring the Nexus of Manufacturing and Design Software in Gear Engineering," we have explained how integrated software solutions are revolutionising gear manufacturing. Our exploration continues with a look at cloud-based software solutions, enhancing gear design in unprecedented ways. This volume also brings you innovative insights into gear heat treatment, with articles like "Thermal Effect of Gear Grinding through Process Parameters Responsible for Grinding Burn & Detection using Barkhausen Noise Analysis" and "Enhancing Performance: The Science Behind Gear Heat Treatment," offering in-depth analysis on the thermal processes crucial to the gear industry.

We spotlight the latest advancements in design, from CAD automation tools in SolidWorks to direct metal laser sintering (DMLS) for spur gears, showcasing the innovative strides in gear manufacturing and design.

Our "Tech Innovation" section highlights newly revised AGMA standards, and we provide a glimpse into the future with articles on the evolving trends in gear manufacturing and an analytical evaluation of hob life. Manufacturing ambitions are a focal point, with articles like "From Smartphones to Semiconductors: India's Strategic Manufacturing Ambitions," presenting India's drive towards becoming a manufacturing powerhouse. Moreover, we cover the highlights from Hannover Messe 2024, a significant event for industrial technology and innovation.

The interviews in this issue offer personal perspectives on the gear industry's growth and challenges. Notably, AGMA scholarships are empowering the next generation of engineers, and experts provide insights into India's transmission sector and Molemab's vision for industrial evolution. We also address the environmental considerations in gearbox design and proactive maintenance strategies for gearboxes, emphasising sustainability and efficiency in our industry.

Join us on this comprehensive journey. We hope this issue inspires you to explore new horizons in manufacturing and design software, driving the gear industry forward.

Warm regards

Gear Technology India is a quarterly publication created in collaboration between the American Gear Manufacturers Association (AGMA) and Virgo Communications & Exhibitions. It serves as the premier platform in the industry, offering latest innovations, information, interviews and technical articles related to gears.

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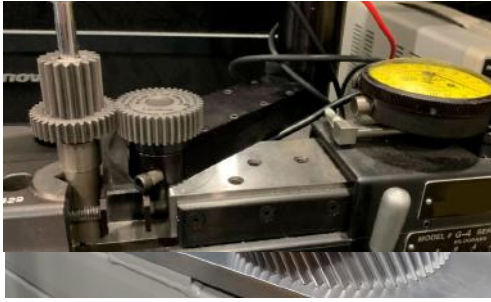
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# Thermal Effect of Gear Grinding through Process Parameters Responsible for Grinding Burn & Detection using Barkhausen Noise Analysis

By: K P Soundararajan

## Introduction:

One of the key aspects of the gear-grinding process is to focus on how best the stock allowance is removed.

This is important for controlling the grinding process time management, proportionate stock removal roughing and finish cuts to target towards the quality in grinding and most relevantly in the grinding process heat transfer into the cooling medium and managing the thermal stock in the tooth flank as the latter can cause grinding burn on the surface.

The excess heat on account of the chosen grinding parameters can penetrate into the flank surface to a shallow depth to induce unfavourable stress impact while the gear is in service.

The distortion of the flank besides radial but axial run-outs too in heat treatment renders its tooth flank topography non-uniform on the stock distribution.

The better stock is laid over the flank across the contact line evenly as well as balanced between the left and the right flanks of the tooth, the better the grinding forces on the tooth surfaces. This provides a uniform grinding structure below the surface and a burn-free flank.

With the above provisions targets towards precise quality of ground surfaces suitable for applications in the energy, aerospace, turbine class and speed-reduction including marine gearings is possible.

Such requirements on tooth quality in grinding attempts towards productivity by new practical concepts using power dressing, variants in grinding strategy adaptation of new cooler grinding wheels, quick stock divisions of hardened tooth flanks for wheel entry and so on have been implemented,

We have also seen in practice for quality orientation -twist-free grinding in two flank grinding method

with multiple axes control, roughing and finishing with grinding wheels of choice, the least unbalanced management and surface finish oriented dressing have become useful and applied methods.

## Tooth Flank heating and parameters:

While exercising roughing and pre-finish grinding with relevant specific material removal rate-  $Q_w'$  in mm<sup>3</sup>/mm/second, the selection of appropriate.

1. Depth of radial or infeed cut in the desired form of flank directional quantity.
2. Axial grinding feed rate to get the required  $Q_w'$  is important.

While rough grind phases are dependent on the material removal rate and in accordance with the selected volume removal parameters such as  $v_t$  and  $V_f$  (infeed based on stock allowance uniform removal rate and axial feed rate) the quality of gear before finishing cut is important to where it has brought the work gear.

So the finish cycle is properly managed to balance the effect of previous cuts by the parameters.

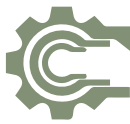
This alone gets the finish stage gear for its dressing frequency of dressing to connect the surface grinding finish.

Therefore, measurement or interpretation of the surface temperature of finished ground gear is important.

## Thermal characteristics:

With the evaluation of heat flux, depth of cut, feed value used applying the Carslaw-Jaeger model with heat conductivity of gear material, and temperature conductivity of medium, one can estimate:

1. the temperature of the heating in the grinding



2. heating time
3. cooled Surface temperature
4. cooling time

to figure out the relationship between evaluated parameters on the grinding process parameters, equation (1) for the TH and Tc is shown, which is self-explanatory:

$$T_H(x, \tau_H) = \frac{2q}{\lambda} \sqrt{a\tau_H} \operatorname{ierfc} \frac{x}{2\sqrt{a\tau_H}} + T_0, \quad (1)$$

**Where**

- T<sub>H</sub> the heating temperature
- q is the rate of heat flux
- λ is the heat conductivity
- α is the temperature conductivity
- X is the radial depth increment
- τ<sub>H</sub> is the Heat energy
- T<sub>0</sub> is the ambient temperature

Out of the total generated heat, much goes into the cooling oil / grinding oil / its volume, flow rate through convection rate and conductivity. A portion of heat flux gets into the material.

**The relationship is:**

$$q(r_x) = e_c \psi \frac{dQ}{dS_c} = \frac{P}{V_f S_{cc}} \psi \frac{V_f t_n(r_x)}{\sqrt{Dt_v(r_x)}}, \quad (2)$$

**Where**

- q(r) is the rate of heat flux penetrating at radius rx with reference to the gear axis
- Q is the total energy
- ψ is the portion of heat energy penetration into the gear tooth
- D is the grinding wheel instantaneous diameter
- tn, tv, are the depth cut value of the material relative to the normal direction of the tooth and across the grinding allowance direction respectively.

Therefore, with a known type and method of applying coolant to control the temperature at the cooling time interval, it is possible to control the convection

coefficient, magnitude of the outlet oil temperature, grinding method, regulating its depth tv and feed Vf.

1. The value of the tv affects the maximum heating temperature.
2. The value of vf determines the time for heating and cooling.

**The grinding temperature growth can be seen in the following Figure 1**

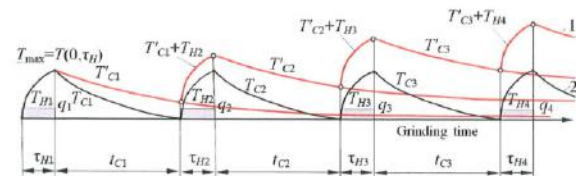


Figure 1 – Grinding temperature changing with accumulation heat energy (line 1) and without it (line 2)

The behaviour of the rate of heating, attained temperature, rate of cooling and attained cooling temperature have been connected in relation to the feed by choosing the parameters such as depth of cut, dressing and climb or convectional mode of grinding and monitoring the coolant regulation.

**Grinding and Barkhausen Test:**

The fact that the heat content is absorbed into the flanks and allowed to accumulate can result in:

1. Tensile stress at the surface and to a small shallow depth in the substrate, other than compressive stresses of the residual stress content.
2. A change in hardness.
3. A possible structural change depending on the extent of exposure to thermal gain.

The surface integrity in essence can alter at different depths and manifest in the form of tensile residual stresses as a result of grinding burn.

The change in structure is usually tested by Nital Etching. This method uses the effect of component material vulnerability to acids. As the green effect is taking an important stage in production this method is facing limited use, another fact is that Nital Etch testing is applicable to surface and below-surface structures are not fully/efficiently handled.

The alternative method is the Barkhausen Noise method. The basic features are:

- The material's microstructure alters the Barkhausen Noise.
- The inclusions in the material, vacancies created by the departure of non-metallic inclusions, impurity atoms and mechanical stress state all affect the magnetisation process.



- The ferromagnetic properties include mainly two, among others. These are domains without external magnetic field influence, These are Weiss Domains which carry a number of other domains as well which are separated by block walls allowing magnetic vectors. These vectors under the effect of external magnetic fields change the movement/rotation of these vectors that are orthogonal to block walls.
- The other property of the ferromagnetic field/domain is the Hysteresis loop.

## The Principle

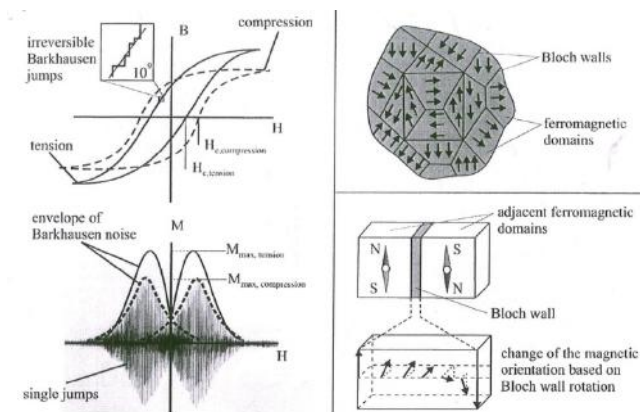


Figure 2 Characteristics of Ferromagnetic materials

- An external magnetic field initiates alternation of Weiss domain orientation along the line of least resistance when unfavourable magnetic orientation increases.
- The block wall movement increase takes place and the stepwise increase is discontinuous. The irregular changes of magnetisation are the reason for this stepwise behaviour. These discontinuous jumps are audible and can be made audible.
- The change in magnetic structure by the wall movement is due to basic mechanical stresses in the substrate. The resistance to the mobility of the wall decreases with the increase in tensile residual stresses. This causes the Barkhausen signal amplitude  $M_{tensile}$  to grow.
- Electromagnetic fields influence the Barkhausen signal as well, which gives rise to the need for signal calibration.
- The application was first introduced in the 1980s and increasingly used since then.
- It is possible nowadays to adopt solutions to gear surface measurements for gear inspection.
- A proper handling procedure for a proper calibration is required, lest the result can contain errors.

## Conclusion:

1. In order to attain signal up to thermal damage, the material removal rate proportionately increases. After grinding, the gears were tested with Nital Etching.
2. The test using BNA (Barkhausen Noise Analysis) shows: that some of the gears checked with Nital Etch for grinding burn required further testing. This was due to the fact thermal damage could have occurred in rough grinding and finish grinding could have induced fresh compressive stresses in its external zone. This can be due to the sub-surface grinding burn.
3. In some gears, the residual stresses suddenly change to tensile residual stresses under the surface of its tooth flank. The thermally affected parts that tempered zone evolve deeper, at times 250 to 300 microns from the surface. Unlike Nital etching, the Barkhausen signal increases at changing residual stresses. This can allow the process to be used for controlling the grinding operation by interrupting and taking corrective action to avoid errors.

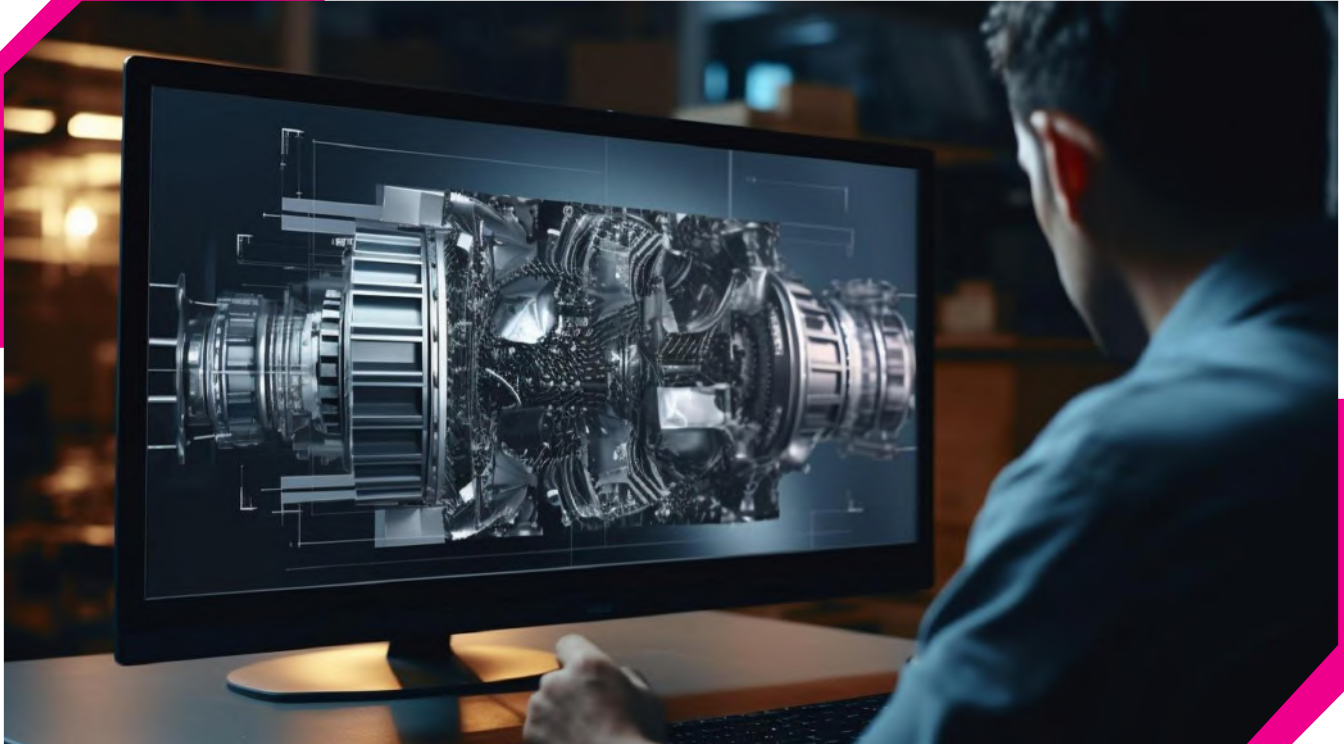
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# Deciphering the Technological Symphony: Exploring the Nexus of Manufacturing and Design Software in Gear Engineering

**By: Sushmita Das**

At the core of every mechanical entity, spanning from diminutive handheld devices to monumental industrial behemoths, resides an intricate network of gears. These ostensibly modest yet indispensable mechanisms serve as the silent architects of motion, adeptly transmitting power and torque with meticulous accuracy and efficiency.

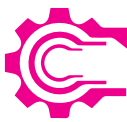
Concealed within the genesis of each gear lies a meticulously orchestrated amalgam of technological prowess, where the symbiotic interplay of manufacturing and design software conducts a choreographed ballet of form and function.

Designing software for industrial machinery is an essential aspect of mechanisation, which harnesses equipment and machinery to enhance productivity and output. This mechanization has been pivotal in driving industrial progress, with industrial machines

serving as fundamental components. Crafting machines that are swifter, cost-effective, and safer entails a complex engineering endeavour.

Design engineers are tasked with creating systems or devices tailored to specific manufacturing requirements. Typically involving moving parts that facilitate power transmission and specific motion patterns, these mechanical devices form integral parts of mechanical systems. However, designing machinery for manufacturing presents multifaceted challenges.

Once the objectives for machine development are outlined, extensive engineering is required. Given that a machine operates as a cohesive unit, addressing its elements in isolation is futile. The overarching objective of mechanical design is to deliver a functional product that not only meets



customer needs but is also safe, efficient, reliable, economical, and feasible to manufacture.

Engineers must consider these performance criteria for individual elements and their interfaces within the broader system or machine.

For instance, when designing gears, parameters such as tooth number, pitch diameter, tooth form, and material composition are crucial to ensure effective power transmission. However, gears are just one facet of the entire system, influencing and being influenced by components like mating gears, shafts, bearings, and housing.

With the advent of the Industrial Internet of Things (IIoT), manufacturers are demanding machines that not only enhance cycle speed and yield while minimizing defects but also integrate seamlessly with data analytics and predictive maintenance systems.

Consequently, modern machinery design must accommodate various sensors to leverage Big Data for enhanced operational insights.

Therefore, designing software for industrial machinery necessitates a holistic approach that considers the interplay of individual components within the broader system context.

This becomes increasingly complex in the era of IIoT, where machines are expected to be not only efficient but also data-driven and adaptable to evolving manufacturing demands.

## **Unravelling Innovation: The Metamorphosis of Manufacturing and Design Software in the Gear Sector**

Within these pages, we embark on an odyssey into the profound impact of manufacturing and design software on the gear industry.

From conceptualisation to fruition, these digital enablers have irrevocably transformed every facet of the gear production continuum, catalysing innovation and reshaping the boundaries of achievability.

### **The Digital Anvil: Revolutionizing Design**

The era of rudimentary hand-rendered schematics and iterative prototyping has yielded to the dominion of advanced CAD (Computer-Aided Design) software.

Present-day designers wield these technological marvels to sculpt gears with unparalleled precision. Leveraging functionalities such as parametric modelling and finite element analysis, engineers navigate a labyrinth of design permutations,

optimising performance and resilience before a single gear takes corporeal form.

Yet, the paradigm shift instigated by digitalisation extends beyond mere design; it permeates the very essence of manufacturing.

### **Precision Engineering: Transitioning from Virtual Blueprint to Tangible Manifestation**

Within the sanctified confines of contemporary machining facilities, CNC (Computer Numerical Control) apparatuses hum with deterministic intent, transmuting digital blueprints into palpable actuality.

Fuelled by CAM (Computer-Aided Manufacturing) software, these automaton craftsmen deftly carve, mill, and grind gears to submicron precision, transcending the frontiers of feasibility.

However, the apotheosis lies in the seamless amalgamation of design and manufacturing software. Through sophisticated CAD/CAM interoperability, engineers iteratively refine designs in real-time, harmonising manufacturability with performance optimisation.

### **The Ascendance of Simulation: Anticipating Performance**

In the relentless pursuit of perfection, uncertainty emerges as the primary antagonist. Enter simulation software—a formidable weapon in the arsenal of gear engineers.

By subjecting virtual gear assemblies to exhaustive stress, thermal, and kinematic analyses, engineers prognosticate performance with unprecedented fidelity.

Whether it entails ensuring seamless operation under onerous loads or mitigating wear over protracted durations, simulation software empowers designers to navigate the labyrinth of decisions with informed acumen.

### **Industry 4.0: Pioneering the Future of Gear Fabrication**

As humanity teeters on the cusp of the fourth industrial revolution, the gear industry stands at the precipice of an evolutionary leap.

From AI-driven design optimisation to IoT-facilitated predictive maintenance, the convergence of avant-garde technologies portends the dawn of uncharted frontiers in efficiency and reliability.

Yet amidst the profusion of possibilities, one immutable verity persists: the indispensable role of



manufacturing and design software in sculpting the destiny of gears.

As we cast our gaze toward the horizon, let us embrace this digital renaissance with a fervent embrace, for it is through the crucible of innovation that we forge the gears of tomorrow.

As the curtains draw on our exploration of the technological symphony orchestrating the gear industry, it becomes abundantly clear that we stand on the precipice of an era defined by unprecedented innovation and transformation.

Through the lens of manufacturing and design software, we have dissected the intricate interplay of digital tools that catalyse progress, redefine boundaries, and elevate standards within gear engineering.

From the genesis of conceptualisation to the fruition of physical manifestation, the omnipresent influence of CAD/CAM software has redefined the very fabric of gear design. No longer bound by the constraints of traditional methodologies, engineers wield the power of parametric modelling and finite element analysis to sculpt gears with precision and finesse previously unimaginable.

Yet, the zenith of technological prowess lies not merely in design, but in the seamless convergence of virtual blueprint and tangible reality within the confines of modern machining facilities.

Powered by CAM software, CNC machines emerge as the artisans of our digital age, transcending the limitations of human capability to craft gears with submicron precision and efficiency.

Furthermore, the ascendancy of simulation software heralds a new era of predictive engineering, where uncertainties are vanquished and performance is prophesied with unprecedented fidelity.

Through rigorous stress, thermal, and kinematic analyses, engineers navigate the labyrinth of design decisions armed with unparalleled insight, ensuring the seamless operation and longevity of gear assemblies under the most demanding conditions.

As we stand on the brink of Industry 4.0, the confluence of cutting-edge technologies promises to propel the gear industry into uncharted territories of efficiency and reliability.

From AI-driven optimisation to IoT-enabled predictive maintenance, the future brims with promise, poised to usher in a paradigm shift in gear fabrication.

Amidst the vast array of options, there's one constant truth: manufacturing and design software play an essential role in shaping the future of gears.

As we look ahead, let's wholeheartedly welcome this digital era, recognising that it's through innovation that we craft the gears that will drive tomorrow's progress.





# Cloud-Based Software Solutions: Taking Gear Design a Step Ahead

By: Nishant Kashyap



Cloud-based software solutions are applications or services that are hosted and accessed over the internet, rather than being installed and run locally on individual computers or servers. These solutions leverage cloud computing infrastructure to provide users with scalable, on-demand access to computing resources, storage, and software functionality. Cloud-based software solutions offer numerous advantages for gear design projects, including improved collaboration, mobility, version control, and integration with existing design tools. By harnessing the power of the cloud, gear design teams can work more efficiently, innovate more effectively, and bring their designs to market faster.

Let's have a look at how it can benefit the gear industry.

## Benefits of cloud-based solutions in gear design, focusing on collaboration and mobility:

**Collaboration:** Cloud-based solutions revolutionise collaboration in gear design by facilitating real-time interaction among team members, irrespective of their physical location. Here's how:

### Real-time Access:

These platforms provide a centralised repository where gear design files are stored securely. Team members can access these files instantly from anywhere with an internet connection, eliminating the need for physical file sharing or local storage.

### Simultaneous Editing:

Multiple team members can work on gear design files simultaneously within the cloud environment. This enables seamless collaboration, as designers, engineers, and other stakeholders can contribute their expertise in real time without waiting for file transfers or email exchanges.

### Version Control:

Cloud-based solutions often include robust version



control mechanisms. Every change made to a gear design file is tracked and documented, ensuring that team members are always working with the latest iteration. This minimises the risk of conflicts, errors, or data loss due to version discrepancies.

**Cross-functional Collaboration:**

Cloud-based solutions break down organisational silos by enabling cross-functional collaboration. Designers, engineers, manufacturers, and other stakeholders can collaborate seamlessly within the same digital environment, fostering interdisciplinary innovation and problem-solving.

**Mobility:** Cloud-based solutions empower gear designers to work anytime, anywhere, fostering flexibility and efficiency in the design process. Here's how mobility benefits gear design:

**Remote Access:** Gear designers can access and work on design files from any location with an internet connection. Whether they're at the office, at home, or travelling, they can seamlessly transition between devices and continue their work without interruption.

**Global Collaboration:** In today's interconnected world, many gear design projects involve collaborators spread across different geographic locations. Cloud-based solutions eliminate geographical barriers, allowing team members from diverse locations to collaborate effectively without the constraints of time zones or physical proximity.

**Flexibility:** Mobility offers designers the flexibility to adapt their work schedules to their personal preferences and lifestyles. Whether they prefer working during traditional office hours or outside conventional boundaries, cloud-based solutions enable them to design on their own terms, enhancing work-life balance and job satisfaction.

**Disaster Recovery:** By storing gear design files in the cloud, organisations can mitigate the risk of data loss due to unforeseen events such as hardware failures, natural disasters, or cyberattacks. Cloud-based backups ensure that critical design data remains accessible and secure, even in the face of adversity. By enabling real-time collaboration among team members regardless of their location and facilitating seamless access to gear design files from anywhere with an internet connection, cloud-based solutions promote teamwork, flexibility, and efficiency throughout the design process.

## Scalability and Cost Benefits of Cloud-based solutions:

Cloud-based solutions offer unparalleled scalability for gear design teams, enabling them to easily expand or reduce resources according to project requirements. With cloud computing platforms, teams can access on-demand resources such as

virtual machines, storage, and processing power, eliminating the need for costly hardware investments and infrastructure maintenance.

The elasticity of cloud-based solutions allows resources to be dynamically scaled up or down based on fluctuations in demand, ensuring optimal performance and resource utilisation.

Features like auto-scaling automate resource allocation, enabling gear design teams to respond quickly to changing needs without manual intervention. This scalability empowers teams to tackle projects of any size and complexity with flexibility and efficiency, while also supporting global collaboration and reducing time-to-market.

While talking about cost benefits, cloud-based solutions offer significant advancements for gear design teams compared to traditional on-premises software deployments.

By leveraging cloud resources, teams can eliminate the need for expensive hardware infrastructure and reduce operational overhead associated with infrastructure management.

Cloud-based solutions follow a pay-as-you-go pricing model, allowing teams to pay only for the resources they use on an hourly or monthly basis, without upfront capital expenditure. This transparent pricing structure and predictable billing cycles enable teams to forecast and budget expenses accurately.

Economies of scale achieved by cloud computing providers translate into cost savings for gear design teams, as cloud-based solutions leverage shared resources across multiple users and projects, maximising efficiency and minimising costs.

## Beneficial Features and Integrations for Gear Design:

Cloud-based solutions offer specific features and integrations that are particularly beneficial for gear design applications, enhancing productivity, collaboration, and innovation. Some examples include:

**Parametric Modelling:**

Cloud-based CAD platforms often support parametric modelling, enabling gear designers to create complex gear geometries and configurations efficiently. Parametric modelling allows for easy exploration of design variations, customisation, and optimisation, facilitating iterative design processes.

**Simulation and Analysis:**

Cloud-based solutions provide access to advanced simulation and analysis tools that are essential for optimising gear designs. Features such as finite element analysis (FEA), computational fluid dynamics



(CFD), and motion simulation enable engineers to evaluate the performance, durability, and efficiency of gear systems under various operating conditions.

#### Supply Chain Integration:

Cloud-based solutions can integrate with supply chain management systems, enabling seamless collaboration with suppliers, manufacturers, and partners. This integration facilitates communication, data exchange, and procurement processes, ensuring a smooth transition from design to production and delivery.

### Challenges & Limitations associated with Cloud-based solutions:

Cloud-based solutions offer plenty of advantages for gear design, promising streamlined collaboration, enhanced accessibility, and scalability.

However, their widespread adoption requires a nuanced understanding of the challenges and limitations involved. One significant concern is connectivity issues, particularly prevalent in regions with limited internet infrastructure or unstable connections.

Engineers may face disruptions in accessing design files or participating in real-time collaboration, hindering productivity and efficiency. Also, transitioning from traditional on-premises software to cloud-based solutions often entails a learning curve for engineers and design teams. Familiarising themselves with new user interfaces, workflows, and features can take time and effort, potentially leading to temporary decreases in productivity.

Another critical consideration is data ownership and security concerns associated with entrusting sensitive gear design data to third-party cloud providers.

Organisations may hesitate to migrate their intellectual property to the cloud due to fears of unauthorised access, data breaches, or vendor lock-in. Integrating cloud-based solutions with existing IT infrastructure, software systems, and workflows can be complex and time-consuming.

Compatibility issues, data migration challenges, and customisation requirements may arise during the integration process, necessitating careful planning and coordination between IT teams, vendors, and stakeholders.

Despite these challenges, the benefits of cloud technology for gear design are undeniable. Strategic planning and proactive measures are essential to navigate integration complexities and ensure a smooth transition.

With the right approach, businesses can harness the power of the cloud to revolutionise their gear design

processes while mitigating associated challenges and optimising efficiency in the long run.

### Future of Cloud-based Software in Gear Design:

The landscape of cloud-based software solutions for gear design is undergoing a transformative shift, driven by emerging trends and technologies that promise to revolutionise the industry. Among these trends, AI-driven design optimisation stands out, leveraging AI and ML algorithms to analyse extensive design data and predict performance outcomes swiftly.

This approach accelerates exploration within the design space, leading to the development of gear designs with superior performance characteristics. Augmented Reality (AR) interfaces represent another notable trend, enhancing visualisation and interaction with gear designs by overlaying digital models onto physical environments. This fosters real-time collaboration and decision-making, regardless of team members' locations, thereby boosting efficiency and innovation in gear design processes.

Cloud computing advancements, including edge computing for real-time data processing and serverless computing for simplified infrastructure management, further propel the evolution of gear design capabilities. The advent of quantum computing offers the promise of rapid and accurate optimisation solutions, addressing complex gear design challenges at unprecedented speeds. These trends collectively signal a new era of possibilities, empowering engineers to push the boundaries of gear design and achieve unprecedented levels of performance and efficiency.

The potential impact of these advancements in cloud-based software solutions on the future of gear design is profound. The convergence of these trends and technologies in cloud-based software solutions heralds a transformative era for gear design, characterised by increased efficiency, agility, and innovation.



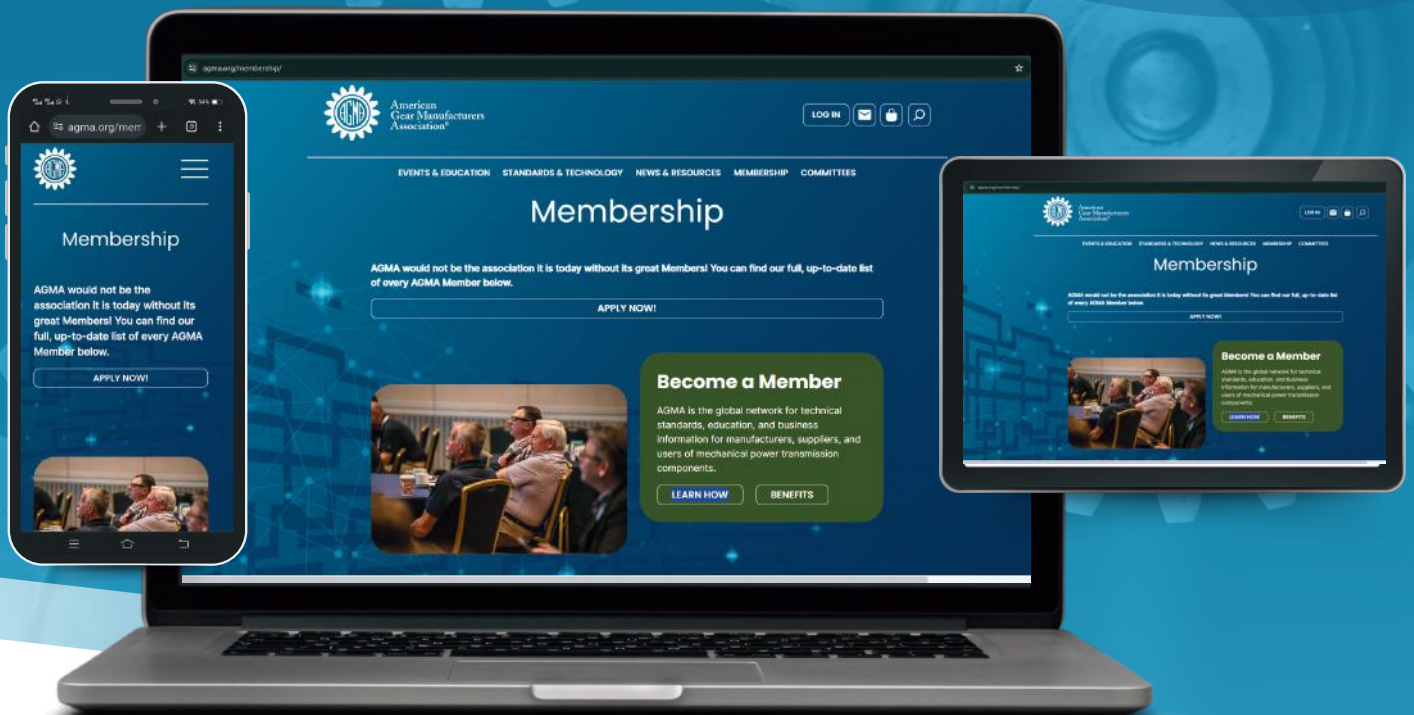
***Nishant Kashyap is a mechanical engineer with a passion for innovation in the manufacturing industry. With a strong background in machine tools, die mould, 3D printing, and the automotive sector, he leverages his expertise to craft insightful articles. He has authored over 600 articles and 200+ interviews with global industry leaders.***



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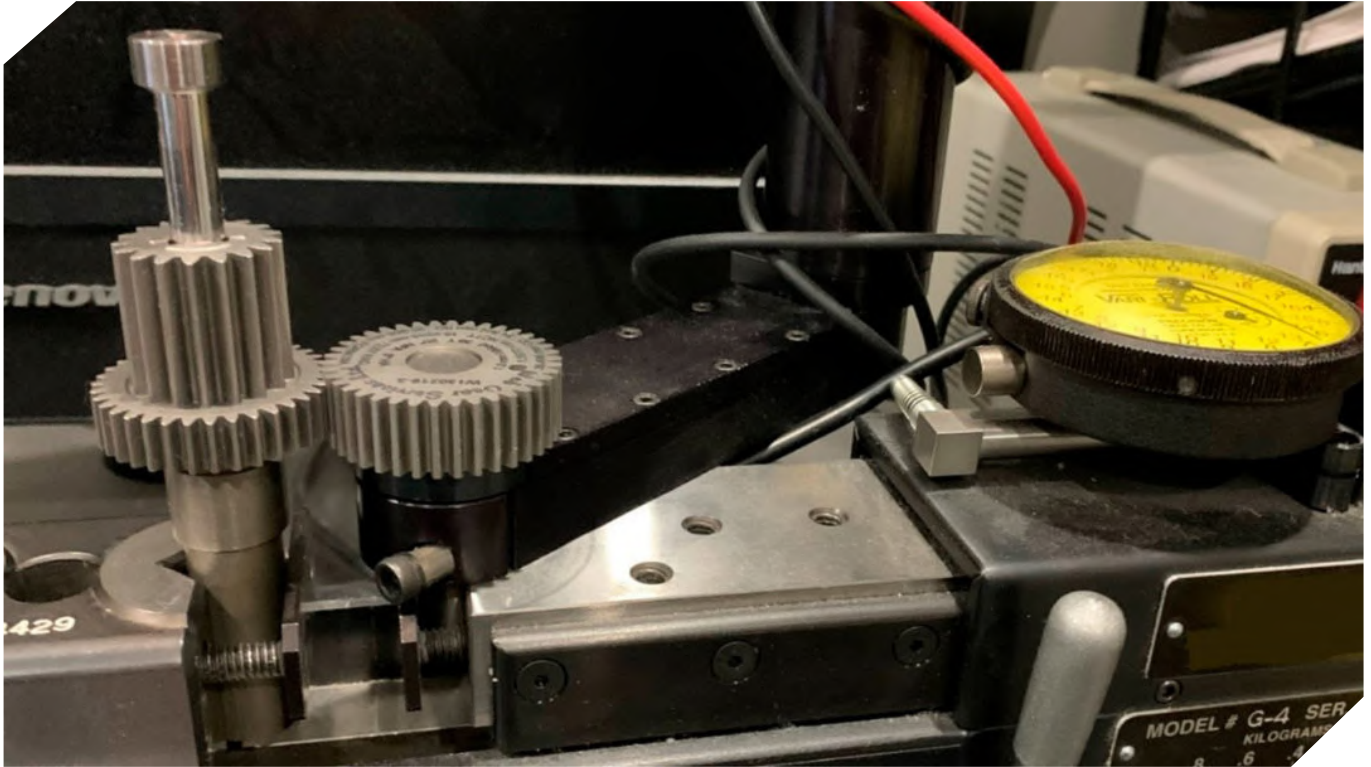
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# Two Newly Revised AGMA Standards

By: Phillip Olson



AGMA is pleased to announce the publication of two new revisions: ANSI/AGMA 2116-B24, Evaluation of Double Flank Testers for Radial Composite Measurement of Gears, written by the AGMA Gear Accuracy Committee, and ANSI/AGMA 6008-B24, Specifications for Powder Metallurgy Gears written by the AGMA Powder Metallurgy Committee.

## ANSI/AGMA 2116-B24

ANSI/AGMA 2116-B24 provides the evaluation criteria for double flank testers. It also recommends artifact sizes and geometry along with measurement system conditions. In Annex A of the standard a method for estimating calibration uncertainty is provided.

Between 1994 and 1998 the AGMA Calibration Committee published three standards on calibration of gear measuring instruments.

The AGMA documents were used as the basis to create ISO 18653:2003 Gears – Evaluation of instruments for measurement of gears, and ISO/TR 10064-5:2005, Cylindrical gears – Code of inspection practice – Part 5: Recommendations relative to evaluation of gear measuring instruments.

AGMA adopted the ISO standards, however the ISO standards did not cover evaluation methods of double flank testers. So the first edition of ANSI/AGMA 2116 was created in 2005 to fill in that gap.

This 2024 edition of ANSI/AGMA 2116 has incorporated information from an AGMA information sheet (AGMA 935-A05) into a new Annex A, titled Recommendations relative to the evaluation of radial composite gear double flank testers.

Information from the former Annex B, Calibration certificate requirements, has been moved into the body of the document. Other changes are general updates to the latest practices.

## ANSI/AGMA 6008-B24

ANSI/AGMA 6008-B24 provides comprehensive details for the design, processing, and specifications of powder metallurgy, PM, steel gears that need to be agreed upon between the PM gear supplier and the purchaser.

These include: definition of terms, gear tooth geometry considerations, inspection, PM gear materials, drawing specifications, heat treatment, and mechanical testing.





The AGMA Powder Metallurgy Gear Committee was organized in 1993 to work on this specification standard. The first edition of ANSI/AGMA 6008 was published in 1998. This 2024 edition is a major update from the 1998 edition. There are 70 pages in the new edition compared to 17 pages in the old edition, 29 Figures compared to 8 figures, and 7 tables compared to 5 tables. A new Annex with guidelines for specifying a PM gear has been added.

All sections from the 1998 edition have been greatly expanded including more details on how to specify, inspect, certify, and test PM steel gears and an extensive definitions section from ASTM B243-19 has been added.

On behalf of the gearing industry, AGMA would like to extend a sincere appreciation for the participation and the valuable contributions of the following experts. In addition, AGMA would like to especially thank the companies of these experts whose foresight and generosity made their participation possible.

### ANSI/AGMA 2116-B24— AGMA Gear Accuracy Committee

Stevn Lindley of Regal Rexnord Corporation, Committee Chairperson

John Rinaldo of Atlas Copco Comptec (Retired), Committee Vice Chairperson

Mark Cowan of Gleason Metrology Systems Corporation

Roger Layland of Precision Gage Company

Ernie Reiter of Web Gear Services Ltd.

Brandon Terry of Triumph Gear Systems

Kris Terry of Triumph Gear Systems

Frank Uherek of Regal Rexnord Corporation

Christopher Wanasek of Caterpillar Global Mining LLC

Timothy Woodruff of Jet Avion Corporation

### ANSI/AGMA 6008-B24— AGMA Powder Metallurgy Gearing Committee

Paul Crawford of PT Tech, LLC, Committee Chairperson

Ernie Reiter of Web Gear Services Ltd., Committee Vice Chairperson

Ian Donaldson of GKN Sinter Metals

Fred Eberle of Strattec Power Access

Robert Errichello of Geartech

Anders Flodin of Höganäs AB

Jacob Fritschle of Strattec Power Access

Jose Martinez Escanaverino of Atlantic Bearing Services

Ray Rupprecht of Metco Industries

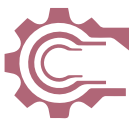
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# HANNOVER MESSE 2024: “Powerhouse for promising upswing”

## Event Report



HANNOVER MESSE 2024

More than 130,000 visitors from 150 countries, 4,000 exhibiting companies, 300 startups and over 300 economic and political delegations from all over the world, HANNOVER MESSE impressively demonstrated its ability to internationally synthesize the best of technology innovations, business trade fair and economic and political agenda-setting.

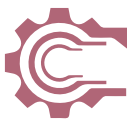
In other words, a veritable “powerhouse for the promising upswing” in Germany and Europe, as termed by German Economics Minister Robert Habeck.

Hannover, Germany. “HANNOVER MESSE 2024 was both an industrial powerhouse and a technology trade fair for the future,” remarked Dr. Jochen Köckler, Chairman of the Managing Board, Deutsche Messe AG, at the closing press conference for HANNOVER MESSE 2024. “It was an industrial powerhouse because

visitors found answers to how they can profitably take advantage of automation, artificial intelligence, hydrogen and many other high-tech solutions in their factories, thus making them fit for the future. And it has been a future-oriented technology trade fair, since the innovations that drive industrial competitiveness and sustainability were on display here.”

The more than 130,000 visitors from 150 nations traded ideas with some 4,000 exhibiting companies on ways of digitalizing their value chains and making them more resilient.

“This means we achieved our ambitious visitor target in a year where HANNOVER MESSE was smaller due to the biennial rotation of several of its component events,” said Köckler. More than 40 percent of visitors came from abroad. Apart from the host nation of



Germany, the top visitor nations were China, the Netherlands, South Korea, the United States and Japan.

Dr. Gunther Kegel, President of the ZVEI association and Chairman of the HANNOVER MESSE Exhibitor Advisory Board, stated: "In the current difficult economic environment, this year's Hannover Messe is a key morale booster.

Companies from the electrical and digital industry have impressively demonstrated how innovations, especially the use of artificial intelligence, are opening up new options for more climate protection and greater efficiency in energy consumption and the use of resources.

But also for more optimism. We can confidently take on major social challenges such as curbing global warming if we adopt the right measures and consistently pursue the path towards electrification, digitalization and automation.

Hannover Messe has once again made the innovative strength of our companies visible and thus made an important contribution to strengthening Germany as an industrial location," he concluded.

Thilo Brodtmann, Managing Director of the VDMA association, added, "Thinking far beyond day-to-day matters and developing solutions for digital and climate-neutral production – that is the goal of innovative mechanical engineering firms.

At this year's HANNOVER MESSE, they demonstrated how factories can be controlled more intelligently, how climate protection can be achieved more quickly with modern means of production and how autonomous systems can make production safer and more efficient on many levels.

In addition, biology and its processes will move into production – the first steps here have already been taken. Hannover Messe remains the best place for all these innovations and for a true spirit of optimism, because manufacturers, customers, political decision-makers and the media come together here in greater numbers than anywhere else."

From solutions such as the automation of entire production plants, the voice control of machines using AI, the efficient use of hydrogen in industry to the use of software to record and reduce the carbon footprint, HANNOVER MESSE offered a comprehensive picture of the technological opportunities for the industry of today and tomorrow.

New fields such as the "biologization" of the economy and carbon management were also brought into focus. And the initiative to create sovereign data spaces for small and medium-sized industrial enterprises under the "Manufacturing X" label is also gaining momentum.

This year's HANNOVER MESSE also offered an ideal platform for start-ups looking to break into industry with their solutions.

More than 300 young companies used the trade fair to network with representatives of industry. This was supported by the trade fair's targeted networking opportunities and master classes.

According to Köckler, his company's efforts to promote young companies bore fruit: "The exchange between start-ups, investors and industrial companies was much more intensive than in previous years, encouraging us to give this topic even more space at HANNOVER MESSE 2025," he said.

In a particularly unique way, HANNOVER MESSE served as a mainstay for economic policy agenda-setting this year. "HANNOVER MESSE made technological progress tangible for politicians," reported Köckler. "The potential of the technologies on show here is enormous. However, it can only unfold on condition that the overall political framework is correct."

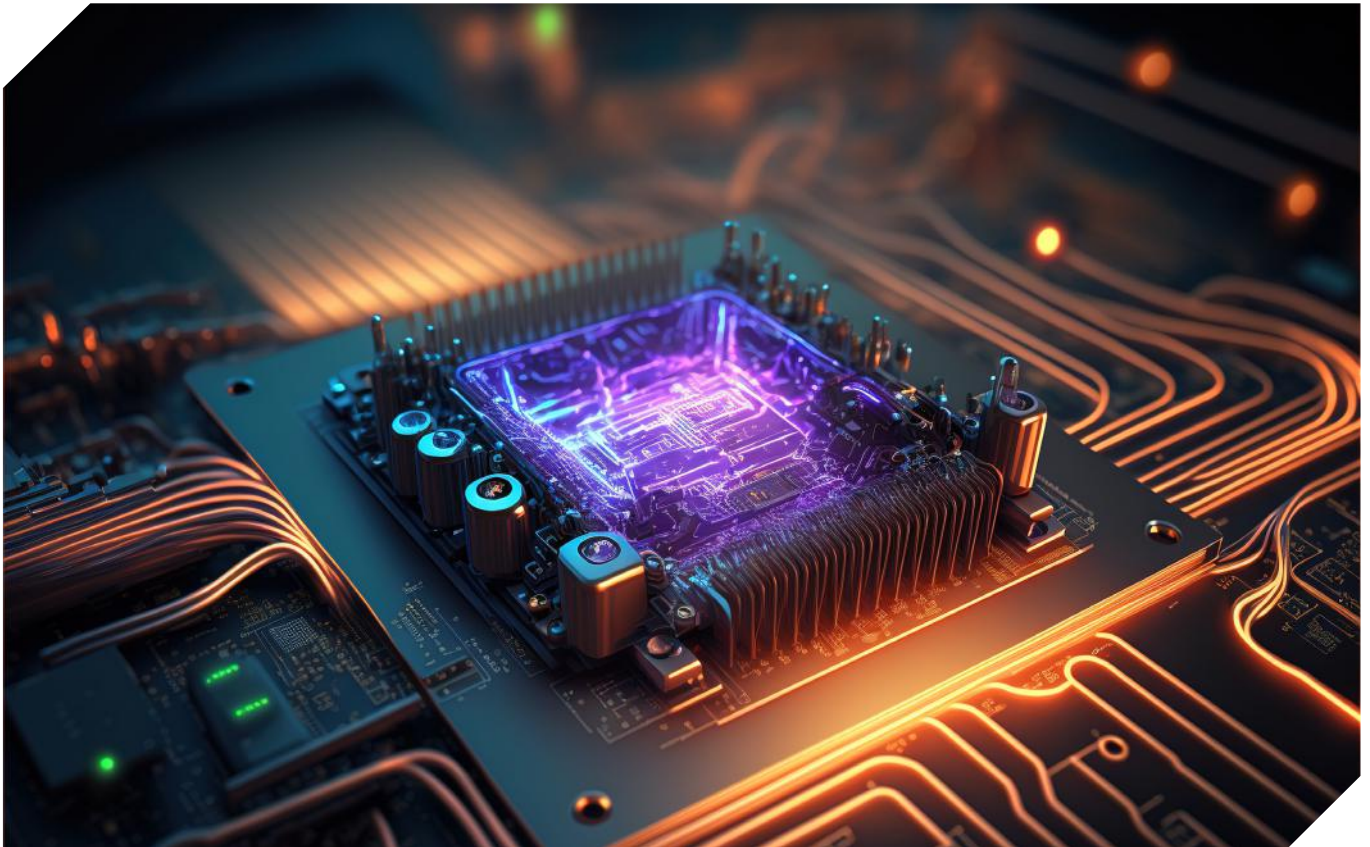
Competitive energy costs, the expansion of digital infrastructure, fast approval procedures, a reduction in unnecessary bureaucracy and the influx of qualified workers were at the top of the agenda for the more than 300 economic policy delegations that visited the trade fair.

As Köckler stated: "Here, too, there is ground for optimism. The discussions showed that Europe has the will and the capacity to fight for and maintain its competitiveness."

A prime example of pan-European cooperation was this year's partner country, Norway. On Tuesday at the trade fair, Federal Economics Minister Robert Habeck presented the roadmap for hydrogen cooperation together with Norwegian Energy Minister Terje Aasland.

Germany and Norway are planning to work together closely to enable large-volume hydrogen imports from Norway to Germany and create the necessary hydrogen infrastructure by 2030. At HANNOVER MESSE, companies from Norway and Germany signed contracts for the transportation of hydrogen and the storage of CO<sub>2</sub>, known as carbon capture and storage (CCS).

HANNOVER MESSE 2025 runs from 31 March to 4 April. Canada will be featured as the partner country.



# From Smartphones to Semiconductors: India's Strategic Manufacturing Ambitions

**By: Sushmita Das**

India's manufacturing sector has become a cornerstone of the nation's economic growth, showcasing remarkable performance across key industries such as automotive, engineering, chemicals, pharmaceuticals, and consumer durables. According to the India Brand Equity Foundation (IBEF) the pre-pandemic, the manufacturing industry contributed 16-17% to India's GDP and is poised to be one of the fastest-growing sectors in the coming years.

The machine tool industry can be said to be the mother machine industry as the backbone of the manufacturing sector; machines relevant to product and technology are part of the machine industry. Be it automotive or energy, textile machinery, printing or similar, while machines for each of these industries are specialised in product engineering. Digital transformation has become a critical component, driving innovation and providing a competitive edge

in the market. This shift towards more automated and process-driven manufacturing is set to enhance efficiency and boost productivity, positioning India as a significant player in global supply chains. Prime Minister Narendra Modi, in his recent address, emphasized the achievements and future goals of the NDA government. "We made India the second-largest smartphone manufacturer.

Now, we will increase work in semiconductors and electronics production sectors," he stated, highlighting the growth in the electronics and semiconductor industries.

This ambition is underpinned by the country's solid physical and digital infrastructure, enabling the manufacturing sector to expand its share of the economy and compete globally. The Indian government aims for the manufacturing sector to account for 25% of the GDP by 2025, up from the



current 17%. This goal is supported by the National Manufacturing Policy and the Production-Linked Incentive (PLI) scheme, which was launched in 2022. These initiatives are designed to elevate the core manufacturing sector to global standards, facilitating Industry 4.0's integration into the Indian economy.

With a workforce of over 27.3 million, the manufacturing sector is a significant employment generator.

The sector's growth is bolstered by various government programs, which aim to create long-term employment opportunities and skill development pathways for millions of people. India's potential in international markets is driven by its rich resources, industrial expertise, and entrepreneurial spirit.

Several market opportunities lie ahead for India's manufacturing sector, including expanding exports, localizing imports, catering to internal demand, and engaging in contract manufacturing. The country is on track to export goods worth US\$ 1 trillion by 2030, further solidifying its role as a global manufacturing hub.

The government plans to offer incentives worth up to Rs. 18,000 crore (US\$ 2.2 billion) to boost local manufacturing in six new sectors, including chemicals, shipping containers, and vaccine inputs.

This strategy aims to diversify and strengthen the manufacturing base, ensuring resilience and competitiveness. The mobile phone manufacturing industry, propelled by government incentives and rising global demand, is expected to create 150,000 to 250,000 jobs in the next 12-16 months. Major players like Apple and its contract manufacturers, along with Dixon Technologies, are scaling up their operations to meet this demand.

Prime Minister Modi also underscored the government's commitment to defence production and exports, emphasizing the goal of achieving self-reliance in the defence sector. "We have tried to increase defence production and exports. We will not stop till the time the defence sector becomes atmanirbhar (self-reliant)," he asserted. Additionally, the focus on green industrialization is set to transform India's manufacturing landscape. "Be it green energy or green mobility, we will take India to the forefront," PM Modi affirmed, indicating a strong push towards sustainable and eco-friendly industrial practices.

India's initiative in the manufacturing sector is expected to witness unprecedented growth. With a strategic focus on digital transformation, innovation, and global competitiveness, India is well on its way to becoming a leading global manufacturing hub, driving economic growth and job creation for years to come.

## INDIA'S EXCLUSIVE TECHNICAL SUMMIT TO BE HELD IN 2025

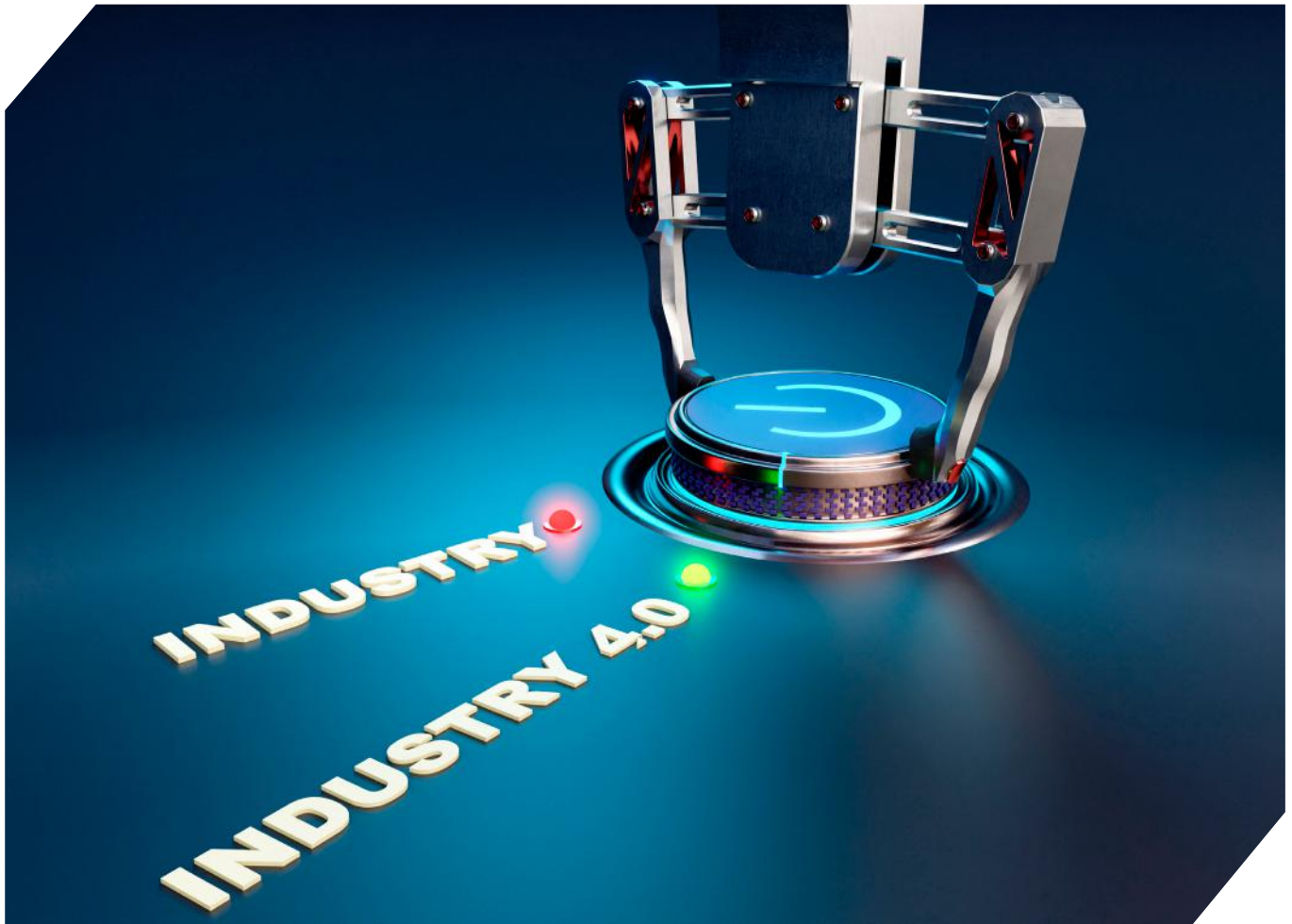


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# Exploring the Path Towards Innovations and Future Trends in Gear Manufacturing

By: Sudhanshu Nayak

Gear manufacturing is undergoing a profound transformation driven by technological advancements, shifting market dynamics, and evolving customer demands.

As industries strive for greater efficiency, reliability, and customization, gear manufacturers are embracing innovation to meet these challenges head-on. In this era of rapid change, exploring emerging trends and innovations in gear manufacturing is essential for staying competitive and meeting the needs of the future. Let's look into a few of them:

## Advanced Manufacturing Techniques

Gear manufacturing is benefiting from emerging technologies such as additive manufacturing (3D

printing), precision machining, and advanced casting methods. These techniques offer greater flexibility, precision, and efficiency, enabling the production of complex gear geometries with unprecedented accuracy and speed.

### Additive Manufacturing (3D Printing):

This allows for the creation of intricate gear geometries layer by layer, offering design freedom and enabling the production of lightweight yet robust gears.

This technology facilitates rapid prototyping and customization, reducing lead times and costs associated with traditional manufacturing methods. Complex internal structures and features can be easily incorporated into gear designs, optimising



performance and functionality for specific applications.

**Precision Machining:**

Techniques such as CNC milling and grinding ensure tight tolerances and high surface finishes, critical for gear performance.

Advanced machining capabilities enable the production of gears with precise tooth profiles, accurate dimensions, and smooth surface finishes, enhancing efficiency and minimising wear.

Computer-controlled machining processes offer consistency and repeatability, ensuring uniform quality across production batches.

**Advanced Casting Methods:**

Methods including investment casting and die casting, provide efficient and cost-effective means of producing complex gear shapes.

These techniques offer flexibility in material selection and enable the production of near-net shape gears with minimal machining required.

Advanced casting processes optimise material utilisation, reduce waste, and enhance production efficiency, making them attractive options for high-volume gear manufacturing.

## Digitalization and Industry 4.0

Digitalization enables precise design and simulation of gears, optimizing performance and reducing time-to-market. Integration of IoT devices and sensors allows for real-time monitoring, predictive maintenance, and enhanced productivity.

**Digital Twin Simulations:**

This creates virtual replicas of physical gear systems, allowing for real-time performance monitoring and predictive maintenance.

By analyzing data from sensors embedded in gear components, digital twins simulate operational conditions and predict potential failures before they occur. This proactive approach to maintenance reduces downtime and maintenance costs, ensuring optimal gear performance and reliability.

**Internet of Things (IoT) Devices and Sensors:**

IoT devices and sensors embedded in gear systems collect data on operating conditions, performance metrics, and environmental factors.

Real-time monitoring of gear health and performance enables condition-based maintenance, where maintenance activities are triggered based on actual equipment conditions rather than fixed schedules.

IoT-enabled gear systems are more responsive to changing operating conditions, optimising performance and extending service life.

**AI and Machine Learning (ML):**

AI & ML are driving the future of gear manufacturing by enhancing predictive maintenance, optimising production processes, and enabling smarter design. AI algorithms analyse vast amounts of operational data to predict gear failures before they occur, reducing downtime and maintenance costs.

ML models optimise manufacturing processes by identifying inefficiencies and suggesting improvements, leading to increased productivity and reduced waste. In gear design, AI-powered software can generate optimised gear geometries and profiles, ensuring maximum performance and durability.

By integrating AI and ML into gear manufacturing, companies can achieve higher efficiency, precision, and innovation, positioning themselves at the forefront of the industry.

## Materials Innovation

Advanced materials like high-performance alloys, composites, and ceramics are reshaping gear manufacturing, offering superior strength, durability, and wear resistance. These materials enable gears to operate under extreme conditions with minimal maintenance, meeting the demands of modern applications across industries.

**High-Performance Alloys:**

Alloys such as aerospace-grade steels and nickel-based alloys, offer superior mechanical properties and corrosion resistance, making them ideal for demanding gear applications. These alloys withstand high loads, temperatures, and harsh environments, ensuring reliable performance in aerospace, automotive, and industrial applications.

**Composites:**

Composite materials, including carbon fibre-reinforced polymers and ceramic matrix composites, offer lightweight yet durable alternatives to traditional metal gears. Composites combine high strength-to-weight ratios with excellent fatigue resistance, making them suitable for aerospace, marine, and sports equipment applications.

**Ceramics:**

Ceramic materials, such as silicon nitride and alumina, offer exceptional hardness, wear resistance, and thermal stability, making them ideal for high-speed and high-temperature gear applications. Ceramic gears exhibit low friction, minimal wear, and excellent dimensional stability, resulting in reduced maintenance and extended service life.

## Customisation and Mass Customisation

Manufacturing technology advancements enable gear customisation to meet specific application



requirements. Mass customisation allows for efficient production of gears in small batches or individual units, offering flexibility and responsiveness to customer needs.

#### **Flexible Manufacturing Processes:**

Processes, such as agile manufacturing cells and reconfigurable production lines, enable rapid adaptation to changing customer demands.

Modular equipment configurations and versatile tooling systems accommodate diverse gear designs and production requirements, allowing for efficient customisation. Flexible manufacturing systems optimise resource utilisation, minimise lead times, and enhance responsiveness to customer needs.

#### **On-Demand Manufacturing:**

These platforms leverage digital manufacturing technologies to produce custom gears in small batches or individual units.

These platforms offer online design tools, instant quoting, and rapid prototyping services, enabling customers to specify gear requirements and receive customised products quickly.

On-demand manufacturing reduces inventory costs, eliminates supply chain inefficiencies, and provides customers with tailored solutions for their unique applications.

## **Robotics and Automation**

Robotics and automation streamline gear manufacturing, reducing labour costs and improving efficiency and safety. Collaborative robots (cobots) handle tasks like material handling, assembly, and quality control, enhancing productivity and reliability.

#### **Collaborative Robots (Cobots):**

They work alongside human operators in gear manufacturing facilities, assisting with repetitive or physically demanding tasks.

Cobots enhance productivity, safety, and ergonomics, enabling workers to focus on higher-value activities while robots handle routine operations.

Collaborative robot systems are easy to deploy, flexible to reconfigure, and cost-effective for small-batch and high-mix production environments, driving efficiency and innovation in gear manufacturing.

#### **Automated Inspection Systems:**

These utilise machine vision, sensors, and artificial intelligence algorithms to perform quality control checks on gear components.

These systems detect defects, deviations, and dimensional variations in real-time, ensuring product quality and consistency. Automated inspection reduces inspection time, eliminates human error, and

improves defect detection rates, enhancing overall quality assurance in gear manufacturing.

Advanced inspection technologies, such as 3D scanning and optical metrology, enable high-speed and non-contact inspection of complex gear geometries, further improving inspection efficiency and accuracy.

## **Supply Chain Integration**

Advancements in supply chain management software and technologies facilitate seamless integration and collaboration between manufacturers and suppliers. Greater transparency, efficiency, and responsiveness across the supply chain optimise inventory management, reduce lead times, and enhance competitiveness.

#### **Digital Supply Chain Platforms:**

Digital supply chain platforms integrate manufacturing processes, supply chain operations, and customer interactions, enabling end-to-end visibility and collaboration.

These platforms leverage cloud-based software, IoT devices, and data analytics to optimise inventory management, production scheduling, and order fulfilment.

Digital supply chain platforms enable real-time monitoring of supply chain performance metrics, facilitating proactive decision-making and continuous improvement.

Integrated supply chain systems enhance agility, resilience, and responsiveness to customer demands, driving efficiency and competitiveness in gear manufacturing.

#### **Supplier Collaboration Networks:**

Supplier collaboration networks connect gear manufacturers with their suppliers, fostering communication, transparency, and cooperation across the supply chain. These networks enable real-time exchange of information, such as inventory levels, production schedules, and quality data, ensuring alignment of supply and demand.

Supplier collaboration platforms streamline procurement processes, reduce lead times, and mitigate supply chain risks, enhancing operational efficiency and customer satisfaction.

Collaborative supplier relationships enable shared goals, mutual benefits, and long-term partnerships, driving innovation and value creation in gear manufacturing.

## **Globalisation and Market Trends**

Gear manufacturing trends are influenced by globalisation, emerging markets, changing customer





demands, and the need for agility and adaptability. Strategic navigation of these trends enables manufacturers to leverage growth opportunities and mitigate risks.

**Emerging Markets:**

Emerging markets, such as Asia-Pacific and Latin America, offer significant growth opportunities for gear manufacturers due to increasing industrialisation and infrastructure development.

Rising demand for automotive, aerospace, and renewable energy applications drives investment in gear manufacturing capabilities in emerging economies.

Gear manufacturers are expanding their presence in these markets to capitalise on growth opportunities and access new customer segments, driving globalisation and market expansion strategies.

**Changing Customer Demands:**

Changing customer demands, such as shorter product lifecycles and customisation requirements, are reshaping gear manufacturing trends.

Customers seek innovative gear solutions tailored to their specific applications, driving demand for customisation and agility in manufacturing operations.

Gear manufacturers are leveraging digital technologies and flexible production systems to meet evolving customer needs while maintaining cost competitiveness and quality standards.

Customer-centric approaches enable gear manufacturers to differentiate themselves in competitive markets and build long-term customer relationships.

**Agility and Adaptability:**

Agility and adaptability are critical for gear manufacturers to navigate market uncertainties, supply chain disruptions, and changing regulatory environments.

Flexible manufacturing processes, responsive supply chains, and strategic partnerships enable gear manufacturers to quickly adjust production capacities and respond to shifting market dynamics.

Agile manufacturing practices, such as lean manufacturing and continuous improvement, foster operational excellence and innovation, enhancing competitiveness and resilience in volatile market conditions.

Gear manufacturers that embrace agility and adaptability can capitalise on emerging opportunities and mitigate risks, positioning themselves for long-term success and growth in dynamic global markets.

**The Road Ahead**

The gear manufacturing industry is rapidly evolving with advancements in technology and changing market demands. Innovations such as additive manufacturing, precision machining, and advanced casting techniques are enhancing production flexibility and precision.

Digitalization and Industry 4.0 are revolutionising the field with real-time monitoring and predictive maintenance powered by IoT, AI, and ML. Advanced materials and precision design tools are improving gear performance and efficiency.

Customization and automation are becoming increasingly important, enabling manufacturers to meet specific needs and streamline production processes.

Enhanced supply chain integration and responsiveness are crucial for navigating market uncertainties and leveraging global opportunities.

Staying informed about these trends is essential for maintaining a competitive edge and achieving long-term success in the dynamic gear manufacturing industry.




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# Empowering Engineering Futures: How AGMA Scholarships Fuel Success in the Gear Industry

By: Sushmita Das

## Making an Impact on Students by Advancing Education

The American Gear Manufacturers Association (AGMA) Foundation awards scholarships to outstanding engineering students at the Associate/Technical, Undergraduate, and Graduate levels.

This scholarship program addresses the industry's pressing need for skilled employees, thereby ensuring a well-prepared workforce for the gear and power transmission sector.

## Geared for Success

The success of the AGMA scholarship program is evident in its impressive outcomes.

A follow-up with scholarship recipients revealed that 86% of graduates are currently employed in the gear/power transmission industry, showcasing the program's effectiveness in fostering industry-ready professionals.

## Avail the Financial Support for Your Career



The AGMA Foundation's scholarships provide crucial financial support to students pursuing engineering careers in the gear industry. The awards are structured across three educational levels:

- **Associate/Technical Level**

Students at the Associate/Technical level can receive up to \$2,500 annually to support their education.

- **Undergraduate Level**

Undergraduate students are eligible for annual scholarship awards of up to \$5,000.

- **Graduate Level**

Graduate students can also receive annual scholarship awards of up to \$5,000.

### How to apply?

The AGMA Foundation Board of Trustees establishes guidelines for the distribution of funds and criteria for selecting recipients, which are implemented by the Scholarship Committee.

The Committee, comprising experienced members of the gear industry with a background in workforce education, reviews applications and makes recommendations to the Board of Trustees for final approval.

The next round of scholarships is now available. Applications for the 2024 Scholarship Awards are due by July 1, 2024.

*For any questions, contact at [Scholarship@AGMA.org](mailto:Scholarship@AGMA.org)*

## Interview with Suhas Gupta Thunuguntla, Graduate Research Assistant, Oakland University Upon Receiving the Scholarship



### Team Gear Technology India congratulates you on receiving the AGMA scholarship! Can you share with us how you found out about this opportunity and the application process?

Thank you very much! I would like to express my sincere gratitude to AGMA and its board members for awarding me the 2023 scholarship. I learned about this opportunity through my professor/advisor Christopher Cooley, who recommended it to me.

The AGMA scholarship application is available on their website, where you can also find detailed eligibility criteria.

This scholarship is open to any student interested in a career in the gear industry and/or power transmission related to the gear industry, including international students studying in the U.S. The application process requires basic information about the applicant and details about the education being pursued.

Additionally, applicants must submit several supplemental materials, including a signed personal statement outlining their interest in gears and their goals during the scholarship period, a study plan during the scholarship period, details of previous work experiences, official transcripts, and two letters of recommendation.

I would like to thank Mary Ellen Doran, the AGMA Foundation Executive Director, who provided invaluable assistance with any questions I had throughout the application process and continues to do so.

Furthermore, AGMA requires a mid-year report by January 31 and a final report by October 1. These reports should detail the progress made towards the goals stated in the personal statement and include a financial accounting of the scholarship funds.



## **Your research focuses on the in-depth analysis of damage-induced dynamics of geared transmissions with localized defects. Can you explain the significance of your work in the field of mechanical engineering and its potential impact on the industry?**

Definitely! The health and usage monitoring of geared transmissions, particularly in rotorcraft, is crucial for ensuring safety, reliability, and efficiency.

Gearbox failure during flight operations poses significant risks to both occupants and the vehicle. To mitigate these risks, Health and Usage Monitoring Systems (HUMS) are employed to record and analyze the vibrations of geared transmissions.

My research focuses on the in-depth analysis of damage-induced dynamics in geared transmissions, particularly those with localized defects.

By analyzing the vibrations caused by damage to components such as planets, rings, and sun gears, my work aims to detect early indicators of failure.

Initially, I evaluated the damage-induced dynamic response at the gear pair level to understand how damage affects vibrations and condition indicator values.

Subsequently, I applied this knowledge to the vibrations of entire geared transmissions, identifying critical condition indicators.

The significance of my research lies in its potential to enhance the development of HUMS sensors, enabling them to detect damage at an early stage, thereby preventing catastrophic failures.

This contributes to the overall safety and reliability of rotorcraft and other vehicles that rely on complex geared transmissions. By advancing the understanding of damage-induced dynamics, my work supports the design of more effective methodologies in monitoring systems, ultimately leading to improved maintenance practices and reduced operational risks in the mechanical engineering industry.

## **You've utilized advanced software like Calyx Transmission3D for your research. Can you discuss how this tool has been instrumental in your analysis and the specific benefits it has provided to your findings?**

Certainly! Calyx Transmission3D, developed by Dr. Sandeep Vijayakar at Advanced Numerical Solutions, LLC, has been instrumental in my research.

This software employs a combined finite element and contact mechanics (FE/CM) approach, which is highly effective for analyzing the accurate contact between gear teeth. The method capitalizes on the small size of the contact zone, where two mating gear teeth mesh, compared to the overall dimensions of the gear teeth.

It assumes that beyond a certain distance from the contact zone, the deformations of the gear teeth can be accurately predicted using the finite element method.

Near the contact zone, relative deflections are precisely captured using an analytical formula derived from elastic half-space approximations.

By combining these two solutions, the software provides accurate full-field approximations of the total displacements on the tooth surface, including areas near the contact zone.

The FE/CM formulation utilizes high-precision finite elements along the involute tooth surfaces, which are captured using specialized finite elements with high nodal resolution along the tooth profile and continuous shape functions.

This ensures that local curvatures are accurately represented without requiring highly refined finite element meshes within the tooth surface.

Conventional finite element approaches often necessitate excessively refined meshes for convergence, which compromises computational efficiency. The FE/CM approach circumvents this issue.

Furthermore, the FE/CM approach allows for the calculation of elastic contact pressure distribution and elastic deformations, accounting for changing contact conditions due to gear positioning within the mesh cycle, as well as elastic deformations throughout the gear and potential damage.

Calyx Transmission3D is capable of performing both static and dynamic simulations of gear pairs and geared transmissions, with or without localized defects.

The specific benefits this tool has provided to my findings include enhanced accuracy in predicting gear tooth deformations and contact pressures and the ability to simulate the models both statically and dynamically without depending on analytical models like lumped-parameter models.

This has significantly enhanced the depth and reliability of my research.



## One of your achievements is the development of closed-form expressions for condition indicators. Could you elaborate on how these expressions enhance predictive capabilities for fault detection in gear pairs?

Yes. I have derived closed-form expressions for condition indicators such as RMS, FM4, and M8A of the damage-induced dynamic response of gear pairs. The dynamic response of a damaged gear pair within a certain speed range resembles that of a damped linear oscillator.

Leveraging this phenomenon, the damage-induced dynamic response of the gear pair is approximated using the response model of a damped linear oscillator. The amplitude of this model signal depends on the severity of the damage, while the natural frequency and damping ratio are dynamic properties of the gear pair.

By substituting the expression of this phenomenon-based model into the condition indicator formulas, I derived expressions that depend on the properties of the gear pair. I explored amplitude domain formulas, which require a probability density function.

This function was derived based on the assumption that the phenomenon-based model response is constructed from different numbers of half-sine waves, utilizing the known probability density function of a sine wave. Consequently, the probability density function for  $n$  half-sine waves was derived and used in the amplitude domain formulas for the condition indicators, enabling the determination of closed-form expressions.

For a crack on the pinion of the gear pair, and crack lengths less than half of the tooth thickness, there is a very good agreement between the condition indicators of the damage-induced dynamic response calculated numerically and those of the phenomenon-based model calculated using closed-form expressions.

However, for crack lengths greater than half the tooth thickness, the condition indicators of the phenomenon-based model serve as a lower bound estimate for the actual condition indicators of the damage-induced dynamic response of the gear pair.

These closed-form expressions for condition indicators enhance predictive capabilities by allowing the prediction of condition indicator values for different damping ratios and natural frequencies, assuming the gear pairs exhibit similar responses to the damage-induced dynamic response of existing

gear pairs. Extending this derivation to condition indicators of geared transmissions is the next step in this research.

Unlike gear pairs, geared transmissions have multiple natural frequencies, but it should be possible to approximate the damage-induced dynamic response of geared transmissions and derive closed-form expressions for their condition indicators.

## Could you elaborate on the current challenges you are facing in your research on geared transmissions?

My research journey has been filled with challenges, each providing valuable learning opportunities. These include calculating mesh stiffness for gear pairs with or without damage, deriving dynamic responses of gear pairs, approximating damage-induced dynamic responses using phenomenon-based models, and deriving condition indicators for geared transmissions.

One of the ongoing challenges I am working to overcome is identifying the optimal construction of the vibration signal.

The goal is to maximize the damage content and minimize the healthy portion of the signal. This approach aims to ensure that the condition indicator values exceed threshold levels, thereby reliably detecting damage in the system with a high degree of accuracy.

## Looking ahead, how do you plan to leverage the knowledge and experience gained from your PhD research and the AGMA scholarship in your future career? What are your long-term professional goals?

I plan to make significant contributions to the field of mechanical engineering, particularly in the areas of gear dynamics and health monitoring systems.

My research has provided me with a deep understanding of the complexities involved in geared transmission systems and the techniques required to detect and analyze damage.

After my Ph.D graduation, I want to pursue a career in the automotive or aerospace industry, where I can continue to advance my learning in this field.

*Suhas Gupta Thunuguntla, Ph.D Candidate,  
Department of Mechanical Engineering, Oakland  
University*



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# Integrated Software Solutions for Gear Manufacturing: Streamlining the Production Process

By: Nishant Kashyap



Software solutions in manufacturing encompass a broad spectrum of tools and platforms designed to streamline processes, enhance productivity, and ensure quality at every stage of production. From design conception to final product delivery, these digital systems offer unprecedented levels of control, insight, and automation, revolutionising traditional manufacturing paradigms.

The utilisation of software solutions in manufacturing is not merely a trend but a strategic imperative. By harnessing the power of computational algorithms, simulation, and data analytics, manufacturers can navigate the complexities of modern supply chains, address strict quality standards, and meet the dynamic demands of global markets with agility and precision.

From CAD/CAM software facilitating intricate design

processes to simulation and analysis evaluating performances, we examine how these digital innovations are reshaping the industry landscape, driving efficiency, and empowering manufacturers to thrive in an era of rapid technological advancement.

## Advantages of integrating software solutions in CAD/CAM:

Integrating software solutions into the gear production process offers a multitude of advantages. These solutions enable precision in design through sophisticated CAD tools, ensuring that gear geometries meet exact specifications with minimal error. By facilitating seamless communication between design and manufacturing stages, software solutions streamline the production workflow, reducing lead times and minimising costly errors





associated with manual data transfer.

Simulation and analysis tools allow for virtual testing of gear designs, optimising performance and durability while minimising material waste and prototyping expenses. While software-enabled automation enhances productivity by orchestrating machine operations, scheduling tasks, and managing inventory with unparalleled accuracy. Last but not least, by providing real-time visibility into production metrics and quality parameters, integrated software solutions empower manufacturers to make informed decisions, proactively address issues, and continuously improve processes, ultimately driving sustainable growth and profitability in gear manufacturing operations.

CAD/CAM software plays a pivotal role in gear design and the generation of toolpaths, offering indispensable capabilities that significantly enhance efficiency, accuracy, and innovation in the manufacturing process. In gear design, CAD software provides engineers with powerful tools to create precise and intricate gear geometries, allowing them to explore various configurations, tooth profiles, and specifications with ease. The ability to visualise and manipulate designs in a digital environment facilitates rapid iteration and optimisation, enabling engineers to achieve optimal performance and functionality while meeting stringent tolerances and quality standards.

Moreover, CAD software enables seamless integration with simulation and analysis tools, allowing engineers to conduct virtual testing and validation of gear designs before physical prototyping or production. This not only reduces the time and cost associated with traditional trial-and-error methods but also minimises the risk of design flaws and manufacturing

defects, ensuring that gears perform reliably under real-world conditions. On the manufacturing side, CAM software complements the design process by translating CAD models into precise toolpaths that guide machining operations. By leveraging advanced algorithms and machining strategies, CAM software optimises toolpaths for efficiency, tool life, and surface finish, maximising the productivity of CNC (Computer Numerical Control) machining centres and other manufacturing equipment. Additionally, CAM software incorporates features such as automatic tool selection, collision detection, and adaptive machining, further enhancing process reliability and reducing the need for manual intervention.

The integration of CAD/CAM software in gear design and manufacturing not only accelerates the product development cycle but also enables engineers to push the boundaries of innovation, creating gears that are lighter, stronger, and more efficient than ever before. By harnessing the power of digital design and automated manufacturing, companies can stay ahead of the competition, deliver superior products to market faster, and drive sustainable growth in the dynamic landscape of gear manufacturing.

### Role in Simulation and Analysis Tools:

Integrated software solutions play a crucial role in the simulation and analysis of gear manufacturing processes by providing engineers with sophisticated tools and capabilities to optimise designs, evaluate performance, and mitigate risks before physical production begins. These solutions enable engineers to create detailed virtual models of gears and their associated manufacturing processes, allowing for accurate prediction of behaviour under various operating conditions.

Through advanced finite element analysis (FEA) and gear tooth contact analysis, engineers can assess factors such as stress distribution, load-bearing capacity, and tooth meshing characteristics, ensuring that designs meet performance requirements and withstand real-world demands. Integrated software solutions facilitate virtual prototyping, enabling engineers to iterate and refine designs quickly and cost-effectively, minimising the need for costly physical prototypes and accelerating time-to-market. By leveraging simulation and analysis capabilities, manufacturers can optimise gear designs for efficiency, durability, and reliability, ultimately enhancing product quality, reducing development costs, and maximising customer satisfaction.

### Software solutions in the context of Industry 4.0. & IoT:

In the context of Industry 4.0, software solutions play a central role in driving the digital transformation of manufacturing processes, facilitating the



*Moving from point solution to integrated workflows in product development so that they can transfer the information downstream and bring analytics from the production. This approach helps the companies to connect the complete value chain and make communications easier between departments giving it the flexibility of change and easy adoption of new products.*

- By Vipul Agarwal



integration of cyber-physical systems and enabling unprecedented levels of connectivity, automation, and data-driven decision-making.

These solutions serve as the backbone of smart factories, providing the infrastructure and tools necessary to orchestrate and optimise complex manufacturing operations in real time.

By leveraging advanced technologies such as artificial intelligence, machine learning, and big data analytics, manufacturers can harness the wealth of data generated by IoT-enabled devices and sensors to gain actionable insights into production performance, identify opportunities for efficiency improvements, and predict and prevent potential disruptions. Moreover, software solutions enable seamless communication and collaboration across various systems and stakeholders, breaking down silos and fostering agility and responsiveness in the face of changing market demands.

IoT integration further enhances the capabilities of software solutions by enabling machine connectivity and remote monitoring, thereby transforming traditional manufacturing equipment into intelligent, networked assets capable of autonomous operation and self-optimization.

Through IoT-enabled sensors and actuators embedded within machinery and production systems, manufacturers can capture real-time data on equipment status, performance metrics, and environmental conditions, allowing for proactive maintenance, predictive maintenance, and condition-based monitoring.

This not only minimises downtime and maintenance costs but also extends the lifespan of equipment and ensures consistent product quality. IoT integration enables manufacturers to implement closed-loop control systems, wherein data insights are used to dynamically adjust production parameters and optimise processes in response to changing conditions, ultimately driving continuous improvement and competitiveness in the era of Industry 4.0.

### Final Takeaway:

The integration of software solutions into gear manufacturing processes offers a multitude of benefits while presenting certain considerations for successful implementation.

Key benefits include enhanced precision and efficiency in design and production, facilitated by CAD/CAM software, leading to reduced lead times and minimise errors. Simulation and analysis tools enable virtual testing and optimization, ensuring that gears meet performance requirements and withstand real-world conditions.

Additionally, integration with Industry 4.0 principles and IoT connectivity empowers manufacturers with real-time insights, enabling proactive maintenance, predictive analytics, and dynamic process optimisation.

However, implementing such solutions requires careful consideration of factors such as initial investment costs, compatibility with existing infrastructure, and workforce training needs. Ensuring data security and privacy in the age of interconnected systems is paramount.


Nevertheless, by overcoming these challenges and leveraging the transformative potential of integrated software solutions, manufacturers can unlock new levels of productivity, agility, and innovation, positioning themselves for success in the rapidly evolving landscape of gear manufacturing. Ultimately, embracing digitalisation and investing in software-driven technologies will not only drive operational excellence but also enable manufacturers to thrive in an increasingly competitive global market.

*As quoted by Vipul Agarwal, Technical Specialist - Autodesk Fusion, Autodesk India*

Global consumer behaviour is driving a change in product development companies to build better products in less time. To cater for these changes, companies are making their design to manufacturing processes more robust and collaborative using integrated CAD CAM CAE and MES tools.



***Nishant Kashyap is a mechanical engineer with a passion for innovation in the manufacturing industry. With a strong background in machine tools, die mould, 3D printing, and the automotive sector, he leverages his expertise to craft insightful articles. He has authored over 600 articles and 200+ interviews with global industry leaders.***



# The Evolution and Impact of Gear Transmission in Aerospace Engineering

By: Sudhanshu Nayak

Gear transmission systems are vital in aerospace engineering and crucial for converting engine power into mechanical motion in aircraft and spacecraft. Their design directly affects reliability, precision, and efficiency, making them crucial components.

Gear transmission systems are primary in both terrestrial automobiles and aerospace engineering, yet their application and design diverge significantly in these domains.

While automotive gears prioritise factors like speed and torque for ground vehicles, aerospace gears must contend with extreme conditions of temperature, vacuum, and high loads, demanding precision, reliability, and lightweight construction.

This article delves into the evolution and impact of gear transmission in aerospace, exploring how advancements in materials, design, and

manufacturing have shaped the future of aerospace power transmission systems.

## Historical development in Gear transmission in Aerospace:

In the beginning, gear transmission had to deal with tough conditions in the aerospace field. The first gears were basic and strong, made for moving power but not very efficient or precise. Problems like big changes in temperature, high-speed use, and the need for materials that were both light and tough made engineers come up with new ideas. Important progress happened during big events in aerospace history.

In World War I, there was a big push in gear technology to help with aircraft engines, which led to the use of helical gears that ran more smoothly and could carry more weight. In the mid-1900s, we saw



big steps like planetary gears, which could handle lots of force and change gear sizes, important for complicated aerospace machines.

The growth of gear transmission technology sped up with the start of the computer era. Computer-aided design (CAD) and simulations changed the way gear systems were made better. New materials like titanium alloys and composites, along with 3D printing, changed what could be done with gear design. These changes not only made things work better but also solved problems like making things lighter, stable in heat, and resistant to wear.

Now, gear transmission in aerospace is known for its exactness, trustworthiness, and lasting quality. History shows us how new ideas and hard work have pushed gear technology forward to support the amazing things modern aircraft and spacecraft can do.

## Types of Gears Used in Aerospace Engineering and Their Properties

In aerospace engineering, the selection of gears is critical for optimal system performance.

**Spur gears** are known for their simplicity and straight teeth, making them efficient for handling high loads.

**Helical gears**, with their angled teeth, provide a smoother and quieter operation, which is perfect for systems that operate at high speeds and under heavy loads. Their design allows for a larger contact area, which enhances their load-bearing capabilities and addresses noise issues, making them a standout choice for high-speed, high-load aerospace systems.

**Bevel gears** have a conical shape that is essential for changing the direction of the rotation axis, typically at a 90-degree angle. They are often used in differential drives and are crucial for directional changes in aerospace systems. However, they may have a lower load-bearing capacity when compared to helical gears.

**Planetary gears** consist of multiple gears, including central sun gear and surrounding planet gears, which allow for high torque density and a variety of gear ratios.

This configuration is ideal for compact spaces and is necessary for aerospace applications that require both compactness and the ability to bear significant loads, such as engine starters and rotor systems.

The process of choosing the right gear involves a thorough understanding of the advantages and limitations of each gear type to ensure that the aerospace systems perform efficiently, effectively, and reliably.

## Applications of Gear Transmission in Aerospace Engineering

Gear transmission is integral to diverse aerospace applications, ensuring smooth and efficient operations across aircraft, helicopters, spacecraft, UAVs, drones, and satellites. In aircraft, gears convert engine power into rotational motion for propellers or jet turbines, handling high speeds and variable loads with precision. Helicopter rotor systems rely on gears for lift and control, necessitating stability and manoeuvrability.

Spacecraft mechanisms utilise precise gears for deploying solar panels, antennas, and scientific instruments, functioning flawlessly in the vacuum of space amid extreme temperatures and radiation. UAVs and drones depend on compact and lightweight gears for propulsion, stabilisation, and agility, essential for their versatile aerial manoeuvres. Satellites employ gears for accurate antenna positioning, solar array orientation, and payload deployment, ensuring mission success and longevity in space operations. The versatility and reliability of gear transmission play a critical role in advancing aerospace engineering capabilities and supporting essential functions across various aerospace platforms.

## Materials used in aerospace gear systems and their properties

Aerospace gears rely on high-strength alloys like titanium, nickel-based superalloys, and advanced steels, ensuring exceptional mechanical properties such as high tensile strength, fatigue resistance, and corrosion resistance. These materials maintain gear integrity under extreme conditions, that are crucial for passenger safety. Superior thermal stability from heat-resistant alloys and ceramic composites prevents deformation and material degradation during temperature variations, ensuring consistent gear performance. Advanced coatings and treatments like diamond-like carbon (DLC) coatings and self-lubricating materials minimise friction, reduce wear, and enhance longevity, vital for reliable gear operation.

Lightweight materials such as aluminium alloys and composites optimise weight without compromising strength, contributing to fuel efficiency and structural reliability. Rigorous quality assurance through non-destructive testing ensures gear components meet precise standards, guaranteeing safety and reliability in aerospace gear systems, paramount for passenger well-being during air travel.

## Challenges in Aerospace Gear Systems

Aerospace gear systems navigate a spectrum of challenges within their operational environments.



One of the foremost hurdles is the dramatic temperature shifts encountered, from sub-zero in space to intense heat during re-entry. These extremes induce thermal stresses and fatigue, demanding materials capable of withstanding such conditions. Nickel-based superalloys are a prime choice, offering exceptional strength and high-temperature resistance. Advanced thermal barrier coatings further fortify gear systems against thermal fatigue, ensuring prolonged reliability. Lubrication poses another critical challenge, particularly in space's vacuum where traditional liquid lubricants falter. Engineers have innovated with solid lubricants and self-lubricating materials, ensuring consistent and reliable lubrication without reliance on liquid forms.

This development is pivotal for maintaining smooth gear operation even amidst space's harsh conditions. Wear resistance is important for aerospace gears enduring extended usage and high loads. Surface engineering techniques like ion implantation and diamond-like carbon (DLC) coatings bolster the wear resistance of gear components, prolonging their lifespan and reducing maintenance frequency.

These challenges, met with sophisticated engineering solutions, not only guarantee the reliability and longevity of aerospace gear systems but also significantly contribute to the overall success and safety of aerospace missions.

## Recent Developments in Gearbox Designs

A study on aerospace gear and gearbox designs stressed thorough design, manufacturing, and installation for fail-safe operation, highlighting their crucial role in aerospace applications.

- **Materials Development:** Aerospace gear materials have seen significant advancements. Ferrium steels, such as Ferrium S53<sup>®</sup> and FerriumM54<sup>®</sup>, offer enhanced strength, toughness, fatigue resistance, and corrosion resistance compared to traditional gear steels like AISI 9310. Pyrowear 53, known for its high surface durability and bending strength even at high temperatures, has become a preferred material in aerospace gear applications.
- **Surface Treatments:** Surface treatments play a crucial role in improving gear performance. Hard coatings like tungsten carbon carbide (WC/C) and boron carbide (B4C) provide increased resistance to wear and scuffing, while superfinishing techniques create smoother surfaces, reducing friction and improving efficiency. These treatments are vital for aerospace gears operating under high loads and harsh conditions.

- **Design Innovations:** Recent gear designs focus on optimizing load-sharing, reducing stresses, and improving overall performance. High contact ratio (HCR) gears distribute loads more evenly, reducing wear and enhancing durability. Asymmetric tooth and root gears redistribute stresses, increasing bending load capacity and reducing stress concentrations. Face gears, with their unique geometry, are effective in handling large reduction ratios with improved reliability.
- **Manufacturing Advances:** Modern manufacturing processes have evolved to produce more precise and reliable gears. Skiving processes and molecular decomposition grinding (MDP) achieve higher accuracy and surface quality, crucial for aerospace applications. Advanced inspection methods like magnetic Barkhausen noise detection and heat flow density evaluation ensure that gears meet stringent quality standards before deployment.
- **Industry 4.0 Integration:** The integration of Industry 4.0 technologies in gear manufacturing represents the future of production. Systems like Gear Engine facilitate seamless communication between design, manufacturing, and inspection processes, improving productivity, quality control, and data management. This integration enables real-time monitoring, analysis, and optimisation of gear production processes for enhanced efficiency and reliability.

These developments collectively contribute to a new era of aerospace gear technology, characterized by improved performance, durability, and manufacturing precision, all crucial for ensuring the safety and reliability of aerospace power transmission systems.

## Way Forward

Gear transmission systems are indispensable in aerospace engineering, enabling aircraft and spacecraft to convert engine power into motion. Their ongoing evolution is marked by significant advancements in materials, manufacturing, and design, leading to lighter, stronger, and more intelligent gear systems. This evolution is not just about incremental improvements but transformative leaps that redefine aerospace capabilities.

The integration of emerging technologies like additive manufacturing and AI accelerates this progress, pushing the boundaries of performance and efficiency. Gear transmission's significance in aerospace is profound, supporting space exploration, commercial aviation, and defence operations. As the industry continues to evolve, gear technology remains a vital pillar of innovation and excellence, driving aerospace engineering towards new horizons with ingenuity and precision.



# Advancements in Gear Manufacturing: Design and Analysis of Spur Gears via Direct Metal Laser Sintering (DMLS)

**By: Sushmita Das**

The evolution of manufacturing processes has revolutionised various industries, including automotive, aerospace, and robotics.

Among these advancements, Direct Metal Laser Sintering (DMLS) stands out as an innovative technology for producing intricate metal parts with high precision.

Continue reading to get insights on the design and analysis of spur gears manufactured through DMLS, exploring its benefits, challenges, and applications.

## Understanding Spur Gears

Spur gears are among the most common and basic types of gear used in the gear industry. They consist of cylindrical gears with teeth that are parallel to the axis of rotation.

This straightforward design facilitates efficient power transmission between parallel shafts while maintaining constant speed ratios.

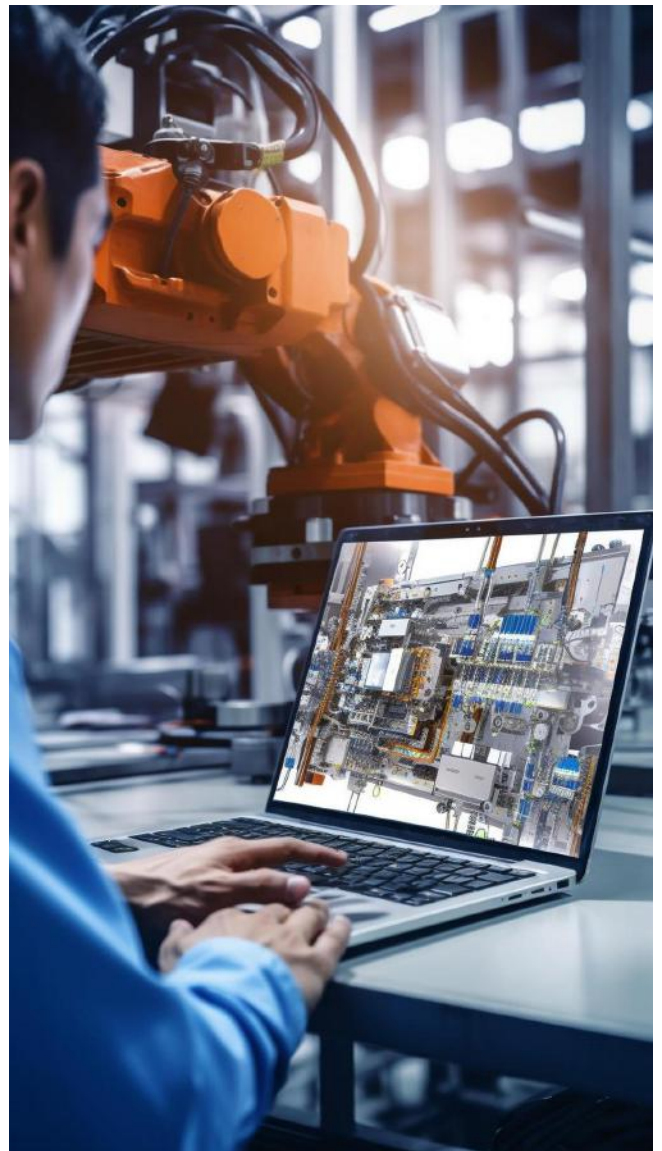
One of the key advantages of spur gears is their simplicity, making them relatively easy to manufacture and maintain.

They are also highly versatile and find application in a wide range of industries, including automotive, aerospace, machinery, and more. Spur gears are used in various mechanisms like gearboxes, drivetrains, and conveyor systems.

Despite their widespread use, spur gears do have limitations. Their design can result in higher noise levels and vibration, particularly at high speeds, due to the sudden engagement of teeth. Additionally, they are susceptible to axial thrust forces, which may require additional components or design considerations to mitigate.

## Direct Metal Laser Sintering (DMLS)

Direct Metal Laser Sintering (DMLS) is a cutting-edge additive manufacturing technology used in the production of complex metal parts. It operates on the



principles of selective laser sintering, but instead of using powdered polymers, it uses metal powder.

In DMLS, a high-powered laser selectively fuses powdered metal particles, layer by layer, according to a 3D digital model.

This process allows for the creation of intricate geometries and precise, fully functional metal components with minimal material waste. The laser



heats the metal powder to just below its melting point, ensuring strong metallurgical bonds between particles.

DMLS offers several advantages over traditional manufacturing methods, including the ability to produce parts with complex geometries without the need for expensive tooling or machining. It also enables rapid prototyping and shortens the production cycle, making it ideal for industries such as aerospace, automotive, and medical where customised, lightweight, and high-performance parts are in demand.

However, DMLS also presents challenges such as post-processing requirements for achieving desired surface finishes and mechanical properties, as well as material limitations concerning the types of metals that can be used.

Despite these challenges, DMLS continues to advance, pushing the boundaries of what is possible in metal fabrication and driving innovation across various industries.

## Design Considerations for DMLS Spur Gears

Designing spur gears for Direct Metal Laser Sintering (DMLS) requires careful consideration of several factors to ensure optimal performance and manufacturability. Following are some key design considerations:

**Geometry Optimization:** Spur gear geometry should be optimized for additive manufacturing processes like DMLS. This involves selecting appropriate tooth profiles, such as involute or cycloidal, and ensuring that the gear design allows for efficient material deposition and laser sintering.

**Tolerance and Clearance:** Designing appropriate tolerances and clearances is crucial for ensuring proper meshing and functionality of the gear teeth. Since DMLS typically produces parts with tight dimensional accuracy, designers should account for this in their designs to avoid issues such as interference or binding.

**Material Selection:** The choice of metal powder for DMLS spur gears is critical and should be based on the specific application requirements, including mechanical properties, wear resistance, and thermal conductivity. Common materials used for DMLS gears include stainless steel, titanium, and cobalt chrome alloys.

**Heat Treatment Considerations:** Depending on the material used, DMLS parts may require post-processing heat treatments to improve their mechanical properties and reduce residual stresses. Designers should consider these heat treatment

requirements in their design to ensure that the final gears meet performance specifications.

**Surface Finish Requirements:** DMLS parts typically have a rough surface finish due to the layer-by-layer additive manufacturing process.

Designers should specify the required surface finish for the gear teeth and account for any necessary post-processing steps, such as machining or polishing, to achieve the desired surface quality.

**Support Structures:** Since DMLS builds parts layer by layer, support structures are often required to prevent distortion and ensure dimensional accuracy during printing. Designers should consider the location and design of support structures to minimize their impact on the final part and facilitate their removal after printing.

By cautiously considering these design factors, engineers can optimize the performance, durability, and manufacturability of spur gears produced using Direct Metal Laser Sintering technology.

## Analysis of DMLS Spur Gears

Analysing spur gears manufactured using Direct Metal Laser Sintering (DMLS) involves assessing various aspects of their performance and characteristics. Here are some key points to consider in the analysis of DMLS spur gears:

**Dimensional Accuracy:** Evaluate the dimensional accuracy of the gears to ensure that they meet the specified tolerances and geometric requirements. DMLS typically offers high precision, but variations may occur due to factors such as thermal gradients and powder characteristics.

**Surface Finish:** Assess the surface finish of the gear teeth to determine if additional post-processing steps, such as polishing or machining, are required to achieve the desired smoothness. Surface roughness can impact gear meshing, efficiency, and wear characteristics.

**Material Properties:** Examine the mechanical properties of the DMLS material used for the gears, including strength, hardness, and fatigue resistance. Conduct material testing and analysis to ensure that the selected material meets the performance requirements of the application.

**Meshing Behaviour:** Analyze the meshing behaviour of the gear teeth to ensure smooth operation and minimize noise, vibration, and wear. Evaluate parameters such as tooth profile, backlash, and tooth contact patterns to optimize gear meshing efficiency and load distribution.

**Stress Analysis:** Perform finite element analysis (FEA) or other stress analysis techniques to assess



the structural integrity of the gears under operating conditions. Identify areas of high stress, potential failure modes, and fatigue concerns to optimize the gear design and ensure reliability.

**Wear and Friction:** Evaluate the wear and friction characteristics of the gear teeth to assess their durability and performance over time.

Consider factors such as material properties, lubrication, operating conditions, and contact patterns to minimize wear and friction losses.

**Dynamic Performance:** Analyze the dynamic behavior of the gears under various loading and operating conditions, including speed, torque, and acceleration.

Consider factors such as dynamic tooth load distribution, vibration, and resonance to optimize gear design for smooth and reliable operation.

## Benefits of DMLS Spur Gears

DMLS offers several advantages for spur gear manufacturing, including:

**Customisation:** DMLS allows for the production of gears with custom geometries tailored to specific applications, enabling optimization of performance and efficiency.

**Material Flexibility:** DMLS supports a wide range of metal materials, including stainless steel, titanium, and aluminium, offering flexibility in a material selection based on mechanical properties and environmental conditions.

**Complexity:** DMLS eliminates many of the design constraints associated with traditional manufacturing methods, enabling the production of complex gear geometries with internal features and cooling channels.

**Rapid Prototyping:** DMLS enables rapid prototyping and iteration of gear designs, reducing time-to-market and facilitating design optimization through iterative testing and analysis.

## Challenges and Limitations

Despite its numerous benefits, DMLS spur gear manufacturing also presents some challenges and limitations, including:

**Surface Finish:** DMLS parts may exhibit rough surface finishes, requiring post-processing techniques such as machining or grinding to achieve desired surface quality.

**Material Properties:** The mechanical properties of DMLS-produced parts, including strength, hardness, and fatigue resistance, may vary from those of conventionally manufactured gears, necessitating thorough material characterisation and testing.

**Cost:** DMLS can be expensive compared to traditional manufacturing methods, particularly for small batch production, due to equipment and material costs.

## Applications of DMLS Spur Gears

DMLS spur gears find applications in a wide range of industries, including aerospace, automotive, robotics, and medical devices. Some specific applications include:

**Aerospace:** DMLS spur gears are used in aircraft engines, landing gear systems, and satellite mechanisms, where lightweight, high-strength components are essential.

**Automotive:** DMLS spur gears are employed in transmissions, differential systems, and engine components, where compact size, precise tolerances, and high torque transmission are critical.

**Robotics:** DMLS spur gears are utilised in robotic arms, actuators, and motion control systems, where reliability, accuracy, and compactness are paramount.

## Way Ahead

The evolution of manufacturing processes has ushered in a new era of innovation across various industries, with Direct Metal Laser Sintering (DMLS) emerging as a transformative technology in the production of intricate metal parts, particularly spur gears.

Through this article, we have explored the design, analysis, benefits, challenges, and applications of DMLS spur gears, shedding light on the dynamic landscape of advanced manufacturing.

Spur gears, renowned for their simplicity and efficiency in power transmission, have found a new dimension with DMLS, enabling the creation of custom geometries tailored to specific applications.

This technology offers unparalleled design freedom, material flexibility, and the ability to produce complex geometries with high precision. Moreover, the rapid prototyping capabilities of DMLS facilitate iterative design optimization, reducing time-to-market and fostering innovation.

However, DMLS spur gear manufacturing is not without its challenges. Surface finish, material properties, and cost remain significant considerations, necessitating post-processing techniques, thorough material characterization, and careful cost analysis.

Despite these challenges, the benefits of DMLS spur gears outweigh the limitations, especially in industries where lightweight, high-strength components and precise tolerances are paramount.

The applications of DMLS spur gears span across aerospace, automotive, robotics, and medical





devices, driving advancements in aircraft engines, transmissions, robotic arms, and more.

As industries continue to embrace additive manufacturing technologies like DMLS, the potential for innovation and advancement in mechanical systems is limitless.

In essence, DMLS represents a paradigm shift in spur gear manufacturing, offering unprecedented opportunities for design optimization, performance enhancement, and technological advancement.

As we move forward, it is imperative to leverage the capabilities of DMLS responsibly and innovatively, pushing the boundaries of what is possible in the realm of advanced manufacturing.



*Sushmita Das is an accomplished technical writer. Holding a degree in Electrical Instrumentation and Control System Engineering, she brings a wealth of technical expertise to her writing.*

## HIGHLIGHT

Direct Metal Laser Sintering (DMLS) is an advanced additive manufacturing technology that enables the production of intricate metal parts with high precision, significantly impacting industries like automotive, aerospace, and robotics.

There are several benefits of DMLS: Such as customization that allows for custom geometries tailored to specific applications. Material Flexibility supporting a wide range of metals like stainless steel, titanium, and aluminium. Creation of complex geometries and internal features. Rapid Prototyping that facilitates quick design iterations and reduces time-to-market.

DMLS represents a paradigm shift in spur gear manufacturing, offering opportunities for design optimisation, performance enhancement, and innovation across various industries.

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# Navigating the Gears: Challenges and Opportunities in India's Transmission Sector

By: Nishant Kashyap



## An Exclusive Interview with Mr Rajesh Nath, the MD of VDMA India

**Q1. Could you share your perspective on the recent growth trends within the gear transmission industry in India, and what factors have been driving this growth?**

According to Transparency Market Research, the global industrial gear market is expected to grow at around 5% CAGR and reach a value of 111 billion USD by 2030. In India, Government investments in the expansion of the power-generating industry especially wind energy and the rapid industrialization in the country are driving the demand for the industrial gearbox. Application of industrial gearbox in sectors including agriculture machinery, machine tools, construction and mining equipment, material handling, transportation and food processing are other key industrial segments driving the growth.

**Q2. What new opportunities have emerged in the Indian gear transmission sector, especially with advancements in technology and government initiatives like Make-in-India?**

Advancements in technology and initiatives like Make-in-India have ushered in a wave of new opportunities in the Indian gear transmission sector.

These include the integration of smart technologies for enhanced efficiency and performance, the rise of eco-friendly and sustainable gear manufacturing processes, and the bolstering of domestic production capacities.

Moreover, initiatives such as Make-in-India have spurred investment and innovation, fostering partnerships and collaborations both domestically and globally, thus broadening the sector's horizons for growth and development.

**Q3. What are the most significant challenges currently facing the gear transmission industry in India, and how can they be addressed?**

The gear transmission industry in India grapples with multifaceted challenges, including the continuous technological evolution to remain competitive globally, coupled with the need to uphold quality standards and comply with international regulations.

Tackling these demands involves substantial investments in research and development, as well as bolstering skill development initiatives to ensure a proficient workforce capable of meeting market expectations. Moreover, infrastructure deficiencies, such as inadequate transportation and power supply, pose operational hurdles, compounded by regulatory complexities that hinder industry expansion.

Addressing these challenges mandates collaborative efforts between the public and private sectors to invest in infrastructure upgrades, streamline regulatory processes, and cultivate a conducive business environment, thus empowering the gear transmission sector to navigate obstacles and flourish sustainably.

**Q4. How do you envision the future of the gear transmission industry in India, and what role will innovation play in shaping it?**

The gear transmission industry in India is poised for a promising future, driven by technological advancements and supportive policies. Innovation will be instrumental in shaping this future, with a focus on smart and sustainable solutions. These



innovations include digital integration for efficiency, eco-friendly manufacturing, and collaborative efforts under initiatives like Make-in-India.

Overall, innovation will drive growth and competitiveness in the sector, ensuring a prosperous and sustainable future for gear transmission in India.

**Q5. In terms of India-Germany trade relations, can you provide how many German companies are operating in India, and what could be the approximate trade between the two nations in the gear transmission industry?**

Currently, approximately 1,800 German companies are operating in India across various sectors. The bilateral trade between India and Germany touched record figures of around 31 billion Euros. The machinery sector contributes almost 30% to the bilateral trade between the 2 countries.

In 2023, the German exports of machinery attained a value of around 4.2 billion Euros whereas the Indian machinery and component exports reached around 1.3 billion Euros. The export of power transmission (mechanical) from Germany to India was around 450 million Euros

**Q6. Can you elaborate on the role of VDMA in fostering Indo-German collaboration within the gear transmission industry?**

VDMA plays a pivotal role in fostering Indo-German collaboration within the gear transmission industry through its extensive network and initiatives, VDMA facilitates dialogue and partnerships between Indian and German companies, promoting knowledge exchange and business cooperation.

One of VDMA's key functions is providing a platform for industry players to connect and explore potential collaborations.

It organizes trade fairs, seminars, and business matchmaking events, where Indian and German companies can showcase their products, discuss industry trends, and explore partnership opportunities.

Moreover, VDMA offers support and guidance to companies seeking to enter or expand their presence in the Indian market.

It provides valuable insights into local regulations, market dynamics, and business practices, enabling German companies to navigate the Indian business landscape more effectively.

Overall, VDMA catalyses Indo-German collaboration in the gear transmission industry by facilitating interactions, fostering relationships, and supporting mutual growth and development.

**Q7. Where does India stand in the global gear transmission market, and what steps are necessary to elevate its position?**

India holds a significant position in the global gear transmission market, buoyed by its expanding industrial base and skilled workforce. To elevate its global standing, India needs to invest in R&D for innovation, forge partnerships with international players for knowledge transfer, enhance infrastructure to boost efficiency and ensure adherence to quality standards. These measures will strengthen India's position in the global gear transmission market, opening avenues for growth and expansion.

**Q8. How is the integration of digital technologies like AI and IoT transforming the gear transmission industry?**

AI algorithms enable predictive maintenance, optimizing gear performance and reducing downtime by detecting potential issues before they occur. IoT connectivity allows real-time monitoring of gear systems, providing valuable data for analysis and decision-making.

Additionally, digital twin technology creates virtual replicas of gear systems, facilitating simulation and testing for improved design and performance optimization. Overall, these digital innovations enhance efficiency, reliability, and productivity in the gear transmission industry, driving advancements and transforming traditional manufacturing processes.

**Q9. What role does research and development play in the gear transmission industry, and how is VDMA India contributing to it?**

R&D is vital for innovation and competitiveness in gear transmission. It advances materials, designs, and manufacturing processes for more efficient, reliable gears. Integrating AI, IoT, and digital twin simulations keeps manufacturers ahead, meeting evolving market needs.

VDMA India fosters R&D in the gear transmission sector through collaboration, knowledge exchange, and technology transfer between Indian and German companies. It hosts events and workshops and partners with academic institutions, often organising delegation visits, thus facilitating industry stakeholders' engagement and sharing of insights. Overall, the aim rests on bolstering R&D and innovation, enhancing the sector's competitiveness in India.



# Wings of Intelligence: Learn How AI is Shaping the Future of Indian Air Force Operations

By: Sushmita Das

In the context of modern warfare, technological progress has consistently held a crucial position. Among these advancements, Artificial Intelligence (AI) emerges as a transformative force, particularly within the aerospace domain.

The Indian Air Force (IAF), demonstrating a dedication to leading-edge innovation, has actively adopted AI technologies to overhaul its operational strategies. At the core of the IAF Centre lies a sophisticated Big Data Analytics and AI Platform, facilitating the adoption of cutting-edge AI applications and their integration into the IAF's platforms and systems.

Within the IAF's AI centre, applications are undergoing infusion with elements of Analytics, Machine Learning, Neural Networks, and Deep Learning algorithms. This concerted effort signifies AI's potential to redefine air combat and broaden the scope of Command, Control, Communications, Computers, and Intelligence (C4I). Furthermore, the IAF is enthusiastically embracing various decision

support systems, thus propelling advancements within the aerospace industry.

This piece of write-up explores the impact of AI on reshaping aerospace practices and the notable advancements achieved by the IAF in this pursuit.

## AI in Aerospace: Transforming Operations

The integration of AI in aerospace has ushered in a new era of efficiency, precision, and strategic superiority. One of the most notable applications of AI in aerospace is in autonomous systems.

Unmanned Aerial Vehicles (UAVs), equipped with AI algorithms, can now perform a wide array of tasks, including reconnaissance, surveillance, and even combat missions, with minimal human intervention. This capability not only reduces the risk to human pilots but also enables round-the-clock operations and enhances situational awareness





on the battlefield. Moreover, AI-driven predictive maintenance has revolutionised aircraft maintenance practices. By analysing vast amounts of data from sensors and historical maintenance records, AI algorithms can accurately predict equipment failures before they occur, allowing for timely maintenance and minimising aircraft downtime. This predictive approach not only saves costs but also improves fleet readiness and mission availability.

## Enhancing Decision-Making with AI

In the fast-paced environment of aerial combat, split-second decisions can often mean the difference between victory and defeat. Here, AI-powered decision support systems are proving to be invaluable assets for pilots and command centres alike.

These systems analyse real-time data from various sources, including radar, satellite imagery, and electronic warfare sensors, to provide pilots with actionable insights and recommendations during missions. By leveraging AI, pilots can make informed decisions faster, adapt to dynamic situations more effectively, and maintain a competitive edge over adversaries.

Furthermore, AI is reshaping mission planning and optimisation processes. Advanced algorithms can generate optimal flight paths, taking into account factors such as weather conditions, terrain characteristics, and threat scenarios, to maximise mission success while minimising risk. This level of precision and optimisation not only enhances operational efficiency but also conserves valuable resources and reduces collateral damage.

## The IAF's Leap into AI

Recognising the transformative potential of AI in aerospace, the Indian Air Force has embarked on a journey to harness these technologies to bolster its capabilities further. Through strategic partnerships with leading tech firms and research institutions, the IAF is actively developing and deploying AI solutions tailored to its operational needs.

One such initiative is Project Garuda, aimed at integrating AI into various aspects of aerial warfare, from autonomous drones to intelligent decision support systems. Under this project, the IAF is collaborating with academia and industry experts to develop cutting-edge AI algorithms and platforms that will enhance its combat effectiveness and operational resilience.

Additionally, the IAF is investing in training its personnel in AI-related disciplines, ensuring that its workforce is equipped with the knowledge and skills needed to leverage these technologies effectively. By fostering a culture of innovation and continuous learning, the IAF is laying the groundwork

for sustained success in the AI-driven aerospace landscape.

## Challenges and Future Prospects

Despite the promising advancements in AI technology, challenges remain on the path to full integration and adoption in aerospace operations. These challenges include ensuring data security and integrity, addressing ethical concerns surrounding autonomous systems, and overcoming regulatory hurdles.

Looking ahead, the future of AI in aerospace looks incredibly promising. As AI algorithms become more sophisticated and capable, they will continue to enhance the IAF's operational capabilities across a wide range of missions, from aerial combat to humanitarian assistance and disaster relief. By embracing AI and pushing the boundaries of innovation, the IAF is poised to maintain its status as a formidable force in the global aerospace arena.

## What Lies Ahead?

The Indian Air Force's embrace of AI represents a significant leap forward in the evolution of aerospace warfare. By harnessing the power of AI-driven technologies, the IAF is not only enhancing its operational effectiveness but also redefining the boundaries of what is possible on the modern battlefield. As AI continues to evolve, the IAF remains committed to leveraging these technologies to stay ahead of emerging threats and safeguard the nation's interests in the skies above.

Artificial Intelligence (AI) has been advancing significantly within the aerospace sector, showcasing its relevance in the Indian Air Force (IAF). The pioneering effort to establish the IAF Centre of Excellence for Artificial Intelligence (CoEAI) under the UDAAN (Unit for Digitisation, Automation, Artificial Intelligence and Application Networking) at Air Force Station Rajokri demonstrates a commitment to developing cutting-edge applications in this field.

Within the Indian Air Force, the integration of AI into diverse platforms and systems is anticipated to bolster operational capabilities, enhance situational awareness, and elevate the effectiveness of air operations. Moreover, the ongoing research and development endeavours are likely focused on uncovering novel AI applications in aerospace, intending to preserve India's air supremacy and safeguard the sovereignty and integrity of its airspace.

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# Transforming Industrial Landscapes: Molemab's Vision for India's Industrial Evolution

By: Nishant Kashyap

"In recent times, perceptions of India have shifted positively. With a stable government prioritising GDP growth, the country's image has transformed significantly.

Over the past few years, India has gained recognition for its technological advancements and cultural diversity," said Amit Kumar Singh, Business Development Associate – India, Molemab in conversation with Nishant Kashyap during a recently held IPTEX GRINDEX 2024 exhibition, at Auto Cluster Center, Pune, Maharashtra, India.

**Q1. To start the conversation, could you talk about your company, your product range, and the application areas you cover?**

Molemab, a 60-year-old Italian company, operates four plants globally and is excited to announce our fifth plant in India. This expansion will cater to the Asian market while also exporting products to Europe.

Our speciality lies in producing grinding wheels for various applications, offering a comprehensive product range. Our diverse clientele spans from tooling industries to automotive, gear grinding, transmissions, and engine crankshaft applications.

Notably, we have introduced the innovative Titan X line, designed to increase production efficiency without the need for additional machinery. With our high-quality wheels, we aim to significantly enhance productivity for our customers.

**Q2. Grinding wheels are a crucial component of any grinding operation. Your comments...?**

Absolutely, grinding wheels are absolutely important in the final operation that adds significant value. Manufacturers should focus on high-quality grinding tools because the machines, especially in automotive ID grinding, are costly. Using high-quality products can optimise machine life.

**Q3. You have been serving the Indian gear and transmission industry for quite some time. Can you please high some of the trends shaping up in the Indian gear transmission industry?**



*Amit Kumar Singh,  
Business Development Associate – India, Molemab*

In recent years, the Indian gear transmission industry has witnessed significant advancements, driven by both technological innovations and shifting market dynamics. One notable trend is the increasing adoption of automation and digitisation across manufacturing processes.

This shift towards Industry 4.0 principles has led to enhanced efficiency, reduced production times, and improved product quality.



Manufacturers are leveraging technologies such as robotics, artificial intelligence, and IoT-enabled devices to optimise operations and meet growing consumer demands for precision-engineered gear transmission systems.

Moreover, this digital transformation presents lucrative business opportunities for companies to capitalise on emerging markets and expand their product offerings.

Another noteworthy trend is the growing emphasis on sustainability and eco-friendly manufacturing practices within the gear transmission industry.

With increasing awareness about environmental conservation and regulatory pressures, manufacturers are investing in greener technologies and processes to minimise their carbon footprint.

This includes the adoption of energy-efficient manufacturing techniques, recycling initiatives, and the use of eco-friendly materials.

By aligning with sustainable practices, companies not only contribute to environmental preservation but also stand to gain a competitive edge in the market, as consumers increasingly prioritise sustainability when making purchasing decisions.

Overall, the convergence of technological innovation and sustainability efforts presents a promising landscape for the Indian gear transmission industry, offering abundant business opportunities while driving positive societal and environmental impact.

#### **Q4. You've mentioned a diverse and high-quality product range at Molemab. Could you please tell us more about the R&D activities at Molemab?**

In the grinding segment, continual product upgrades are paramount to staying competitive. At Molemab, we recognise that research and development (R&D) form the cornerstone of our business strategy.

We allocate substantial resources to R&D activities, investing in cutting-edge technologies and processes to drive innovation and product excellence. Our dedicated R&D division focuses on experimenting with bonding systems, with a particular emphasis on Cubic Boron Nitride (CBN).

This strategic focus on bonding technology differentiation enables us to continuously enhance our proprietary bonding technology, ensuring that our products remain at the forefront of industry standards.

Furthermore, customer satisfaction is our primary objective, and we maintain a close relationship with our customers to achieve this goal.

We actively seek feedback from our clients to understand their evolving needs and preferences, leveraging this insight to develop new and improved products that exceed expectations. All our R&D activities take place in Italy, Florida, & USA.

#### **Q5. Which sector is most important to you?**

In today's interconnected industries, automotive and transmission sectors lead in revenue. Over the next five years, especially in India, significant growth is expected.

As India advances, with a focus on sustainable development and innovation, demand in these sectors will soar, which will reflect positively on companies like ours. With India's promising direction, opportunities abound for those ready to seize them, fuelling economic growth and societal advancement.

#### **Q6. Why do you think the Indian economy is expanding, and FDI is growing?**

In recent times, perceptions of India have shifted positively. With a stable government that is also prioritising GDP growth, the country's image has transformed significantly.

Over the past few years, India has gained recognition for its technological advancements and cultural diversity.

This evolution reflects a newfound confidence and potential on the global stage.

As India continues to showcase its strengths in innovation and inclusivity, it emerges as a key player in the global economy. This positive narrative positions India as an attractive destination for investment and collaboration, fostering further growth and development.

#### **Q7. You have recently started manufacturing in India. Could you please share more details on that?**

We aim to sell solutions, not just products. Unlike European manufacturers in India, who mainly trade, Molemab wants to manufacture in India for Indians. As an Indian citizen, I believe it's important for our country if more and more companies invest in manufacturing in India. My goal was always to be in India to cater to Indian customers effectively. This approach also reduces transportation costs and helps us improve our delivery time – clearly benefitting the customers.

#### **Q8. Do you find it challenging to compete with low-cost alternatives from China and Taiwan?**

In recent years, there has been a notable shift in the mindset of Indian consumers. Quality now takes





precedence over price, signalling a growing emphasis on value and reliability. Unlike before, where Chinese and Taiwanese products posed stiff competition, Indian manufacturers now stand firm with their own quality standards.

To answer your question, we don't see Chinese and Taiwanese products as competition; we have our quality standards and the right customers for our products.

#### Q9. Any future plans for the Indian market?

We have ambitious plans for expansion in India, which include enlarging our manufacturing facilities, bolstering our workforce with skilled personnel, and introducing new product lines.

By bringing production closer to our customers and enhancing our offerings, we aim to meet their evolving needs more effectively.

With confidence in our capabilities and the conducive factors in place, we are poised for significant growth in the Indian market.

## HIGHLIGHT

#### **Molemab's Expansion in India:**

Molemab, a 60-year-old Italian company specialising in grinding wheels, is expanding its operations in India by opening its fifth plant. This expansion aims to cater to the Asian market and exporting products to Europe.

**Product Range:** Molemab offers a comprehensive range of grinding wheels for various applications, including tooling industries, automotive, gear grinding, transmissions, and engine crankshaft applications.

**R&D:** Molemab's focus areas include bonding technology, particularly Cubic Boron Nitride (CBN), to continuously enhance product quality and meet evolving customer needs.

# gear

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INTERVIEW



with

**Manish Khanna**

Business Development Head - India  
Hengst Filtration





# Forecasting the Trajectory of the Global Manual Gear Manufacturing Market

**By: Sushmita Das**

The manual gear manufacturing market is a crucial component of the automotive and machinery industries, providing the fundamental mechanisms for manual transmission systems. As technology advances and preferences shift, the global market for manual gear manufacturing undergoes continual evolution. Understanding the market dynamics, trends, and forecasts is essential for stakeholders to make informed decisions. In this article, you will get insights and forecasts for the global manual gear manufacturing market spanning from 2020 to 2030.

## **Market Overview:**

Manual gears play a vital role in various sectors, including automotive, aerospace, marine, and industrial machinery. Despite the rise of automatic transmissions, manual transmissions remain popular in certain regions and vehicle types due to their affordability, simplicity, and driver engagement. Consequently, the demand for manual gear manufacturing persists, albeit with fluctuations influenced by factors such as economic

conditions, regulatory standards, and technological advancements.

As per a Transparency Market Research report, spur gears offer numerous advantages, including a wide range of transmission ratios, easy processing, and efficiency in industrial equipment. However, issues such as increased vibration, deformation, and changes in involute shape lead to undesired outcomes during the production process. This explains why the industrial gear market is projected to grow at a CAGR of 5% during the forecast period. Consequently, companies are educating end-users to utilize spur gears for bearing radial loads instead of axial loads to establish better load distribution, thereby enhancing the operational life of gearboxes.

In addition to spur gears, helical gears also come with drawbacks, such as poor axial force distribution, which often results in increased manufacturing costs. To mitigate these challenges, end-users are adopting new strategies, such as implementing the compensation effect, to enhance the durability of helical gears.



## Insights and Trends:

**Regional Dynamics:** The manual gear manufacturing market exhibits regional variations influenced by economic growth, automotive production trends, and regulatory policies. Developing regions such as Asia-Pacific witness robust demand due to expanding automotive markets and industrialization efforts. In contrast, mature markets like Europe and North America experience stable but slower growth rates, partly due to the prevalence of automatic transmissions. **Technological Advancements:** Innovation in materials, manufacturing processes, and design technologies significantly impact the manual gear manufacturing landscape. Advancements such as lightweight materials, precision machining techniques, and computer-aided design (CAD) software enhance gear performance, durability, and efficiency, meeting evolving customer expectations for reliability and fuel efficiency.

**Sustainability Initiatives:** Environmental concerns drive sustainability initiatives across industries, including automotive and machinery. Manual gear manufacturers increasingly adopt eco-friendly practices, such as using recyclable materials, reducing waste generation, and optimizing energy consumption in production processes. Sustainability initiatives not only align with regulatory requirements but also enhance brand reputation and appeal to environmentally conscious consumers.

**Shift in Automotive Preferences:** While automatic transmissions dominate in urban areas and luxury vehicles, manual transmissions remain popular in compact cars, sports cars, and off-road vehicles. However, consumer preferences are gradually shifting, influenced by factors like traffic congestion, technological advancements in automatic transmissions, and the convenience of electric vehicles. Manufacturers must adapt their product offerings and strategies to cater to evolving consumer demands.

## Forecast 2020-2030:

The manual gear manufacturing market is projected to witness steady growth during the forecast period, albeit with regional variations and technological disruptions. Key forecast insights include:

**Market Expansion:** Despite the rise of automatic transmissions, the global manual gear manufacturing market is expected to expand, driven by sustained demand from emerging economies, niche vehicle segments, and industrial machinery applications. **Technological Integration:** The integration of advanced technologies such as robotics, automation, and digitalization will streamline manufacturing processes, improve product quality, and enhance production efficiency. Industry 4.0 principles will play a pivotal role in shaping the future of manual gear

manufacturing, enabling smart factories and agile production systems.

**Electric Vehicle Adoption:** The increasing adoption of electric vehicles (EVs) poses both challenges and opportunities for manual gear manufacturers. While traditional manual transmissions are incompatible with electric powertrains, specialized gear systems for hybrid and plug-in hybrid vehicles may emerge as a niche market segment. **Regulatory Landscape:** Stringent emissions regulations and fuel efficiency standards will drive innovation in manual gear manufacturing, prompting manufacturers to develop more efficient gear designs and lightweight materials to reduce energy losses and enhance vehicle performance.

## Way Ahead

The manual gear manufacturing sector serves as a fundamental component of the automotive and machinery industries, supplying the necessary components for manual transmission systems. As our comprehension of this sector deepens, it becomes apparent that its trajectory is intertwined with technological advancements, changing consumer preferences, and regulatory frameworks. Despite the dominance of automatic transmissions, manual gear manufacturing remains pertinent, driven by factors like cost-effectiveness, simplicity, and driver involvement. This enduring relevance is accentuated by the continual progress in gear technologies, with innovations such as helical gears and strategies like the compensation effect addressing inherent issues such as vibration and distortion.

Looking forward, the manual gear manufacturing industry is positioned for consistent growth, fuelled by increasing demand from emerging markets, specialized vehicle sectors, and industrial applications. However, this growth path comes with its own set of challenges. The integration of technology, particularly the embrace of Industry 4.0 principles, will transform manufacturing processes, ushering in an era of intelligent factories and flexible production systems.

Additionally, the emergence of electric vehicles presents both obstacles and opportunities. While traditional manual transmissions may face obsolescence, there exists a demand for specialized gear systems in hybrid and plug-in hybrid vehicles, potentially creating a niche market segment. Adapting to strict emissions regulations and fuel efficiency standards will further stimulate innovation, driving the advancement of more effective gear designs and lightweight materials.

By staying abreast of market dynamics, embracing technological progress, and promoting sustainability efforts, stakeholders can navigate this evolving landscape and seize emerging prospects.



# Environmental Considerations in Gearbox Design

By: Sudhanshu Nayak



The design of gearboxes holds significant implications for environmental sustainability, extending far beyond their mechanical function. Gearboxes are present in industrial machinery, vehicles, and renewable energy systems, and their design choices profoundly influence energy consumption, emissions, and resource utilisation throughout their lifecycle.

By prioritising environmentally-conscious design principles, engineers can mitigate the environmental impact of gearboxes, contributing to global efforts towards sustainability. From material selection to efficiency optimization and end-of-life considerations, every aspect of gearbox design plays a pivotal role in shaping its environmental footprint. This article explores the multifaceted relationship between gearbox design and environmental sustainability, shedding light on key considerations and innovative approaches driving progress in this vital field.

## Energy Efficiency:

Designing gearboxes to maximise energy efficiency is crucial for several reasons. Energy efficiency directly impacts operating costs, making it economically advantageous for industries to prioritise efficient gearbox designs. By minimising energy losses through

factors such as friction and inefficient gear meshing, manufacturers can reduce the amount of power required to drive machinery, resulting in lower energy bills and improved overall profitability.

In an era of increasing environmental awareness and concern over resource consumption, energy efficiency plays a pivotal role in reducing the carbon footprint of industrial operations.

Gearboxes are integral components in a wide range of applications, from automotive transmissions to industrial machinery and renewable energy systems. By optimising gearbox designs to minimise energy consumption, manufacturers can contribute to sustainability efforts by reducing greenhouse gas emissions and conserving finite energy resources.

Maximising energy efficiency in gearbox design goes beyond immediate cost savings and environmental benefits. It also enhances the reliability and longevity of machinery by reducing wear and tear on components.

Gearboxes operating with high efficiency experience less heat generation and mechanical stress, leading to decreased maintenance requirements and extended



equipment lifespan. This not only reduces downtime and maintenance costs but also improves overall productivity and operational reliability. In applications where space and weight are critical factors, such as automotive and aerospace systems, efficient gearbox designs allow for more compact and lightweight solutions without sacrificing performance, further enhancing their appeal in various industries.

## Material Selection:

The choice of materials in gearbox construction plays a pivotal role in determining its environmental sustainability. Traditional gearbox materials like steel and cast iron are durable and widely used but come with significant environmental drawbacks. The extraction and processing of these materials require substantial energy inputs and can result in high carbon emissions and environmental pollution. However, by exploring alternative materials and manufacturing processes, engineers can mitigate these environmental impacts and promote sustainability.

One approach is the adoption of lightweight materials such as aluminium, magnesium, and composites. These materials offer comparable strength and durability to traditional metals but with significantly lower weight, leading to reduced energy consumption during operation. Lighter gearboxes require less power to drive machinery, resulting in lower fuel consumption and emissions in applications such as automotive transmissions and aerospace systems. Additionally, lightweight materials can enable the downsizing of gearbox components, further reducing material usage and environmental impact.

The use of recyclable materials in gearbox construction can significantly enhance environmental sustainability. By incorporating recycled content or designing gearboxes for easier disassembly and recycling, manufacturers can reduce reliance on virgin materials and minimise waste generation.

For instance, the adoption of modular gearbox designs with standardised components facilitates efficient recycling at the end of the gearbox's life cycle. Exploring alternative materials with lower environmental footprints, such as bio-based plastics or biodegradable lubricants, offers promising avenues for reducing the environmental impact of gearbox manufacturing and operation.

## Lubrication Systems:

Lubrication plays a crucial role in ensuring optimal gearbox performance and longevity. Within a gearbox, lubricants serve multiple purposes, including reducing friction between moving parts, dissipating heat, preventing wear and corrosion, and maintaining sealing integrity.

Proper lubrication not only improves gear efficiency and reliability but also minimises energy losses and extends the lifespan of gearbox components.

Different lubrication systems can have varying impacts on environmental sustainability. Traditional lubrication methods, such as oil bath and grease lubrication, are effective but can contribute to environmental pollution if not managed properly. Oil leaks, spills, and improper disposal of used lubricants can contaminate soil, water bodies, and ecosystems, posing significant environmental risks.

To mitigate these environmental impacts, it's essential to prioritise the selection of environmentally friendly lubricants and implement efficient lubrication strategies. Environmentally-friendly lubricants, often referred to as bio-based or biodegradable lubricants, are formulated from renewable resources and break down more readily in the environment compared to conventional petroleum-based lubricants. These lubricants offer comparable performance while reducing the risk of environmental contamination and minimising the carbon footprint of gearbox operation.

## Life Cycle Analysis:

Life Cycle Analysis (LCA) is a comprehensive method used to assess the environmental impact of a product or system throughout its entire lifespan, from raw material extraction and manufacturing to use and disposal. In the context of gearbox design, LCA is a valuable tool for evaluating the environmental sustainability of gearbox systems and informing design decisions that minimise environmental impact across the entire lifecycle.

By considering the environmental impact of gearboxes holistically, from cradle to grave, engineers can identify areas of inefficiency and opportunities for improvement at each stage of the product life cycle. For example, during the raw material extraction and manufacturing phase, LCA can assess the energy and resource consumption associated with producing gearbox components, as well as the emissions and waste generated during manufacturing processes.

During the use phase, LCA can evaluate the energy consumption, emissions, and maintenance requirements of gearboxes in operation. This includes assessing factors such as energy efficiency, lubrication requirements, and durability, which directly impact the environmental footprint of gearbox systems over their operational lifespan.

By conducting life cycle analysis, gearbox designers can identify opportunities to reduce environmental impact at each stage of the product life cycle, leading to more sustainable design decisions. This may involve selecting materials with lower environmental footprints, optimising manufacturing processes to minimise waste and energy consumption, designing



for durability and ease of maintenance to extend product lifespan, and implementing end-of-life strategies that prioritise recycling and resource recovery.

Integrating life cycle analysis into gearbox design enables engineers to make informed decisions that prioritise environmental sustainability, reduce resource consumption, and minimise environmental impact throughout the entire lifecycle of gearbox systems.

### Future Trends:

Future trends and developments in gearbox design hold promising potential for further enhancing environmental sustainability.

Emerging technologies and research areas are poised to revolutionise gearbox systems, reducing their environmental impact while improving efficiency and performance.

One key trend is the continued advancement of lightweight materials and additive manufacturing techniques.

Innovations in materials science, such as advanced composites and 3D printing, enable the production of lightweight yet durable gearbox components. By reducing weight and improving strength-to-weight ratios, these materials can significantly decrease energy consumption and emissions in applications such as automotive and aerospace.

The integration of smart and connected technologies into gearbox systems offers new opportunities for optimization and efficiency.

Internet of Things (IoT) sensors and predictive analytics can enable real-time monitoring of gearbox performance, allowing for proactive maintenance and optimization to minimise energy losses and emissions. Predictive maintenance algorithms can detect potential issues before they escalate, reducing downtime and extending gearbox lifespan.

The development of alternative propulsion systems, such as electric and hybrid drivetrains, is driving innovation in gearbox design. Gearboxes for electric vehicles require different specifications and configurations compared to traditional internal combustion engine vehicles, presenting opportunities for optimization and efficiency improvements.

Additionally, advancements in renewable energy technologies, such as wind turbines and solar power plants, are driving demand for more efficient and reliable gearbox systems with reduced environmental impact.

Research into novel lubricants and tribological coatings is also promising for reducing friction and

wear in gearbox systems, further improving efficiency and durability while minimising environmental impact. Bio-based lubricants and environmental-friendly additives offer alternatives to conventional petroleum-based lubricants, reducing the risk of pollution and contamination.

Future developments in gearbox design are likely to focus on enhancing efficiency, reliability, and environmental sustainability through the adoption of lightweight materials, smart technologies, alternative propulsion systems, and advanced lubricants. By embracing these innovations, gearbox manufacturers can play a pivotal role in driving towards a greener and more sustainable future.

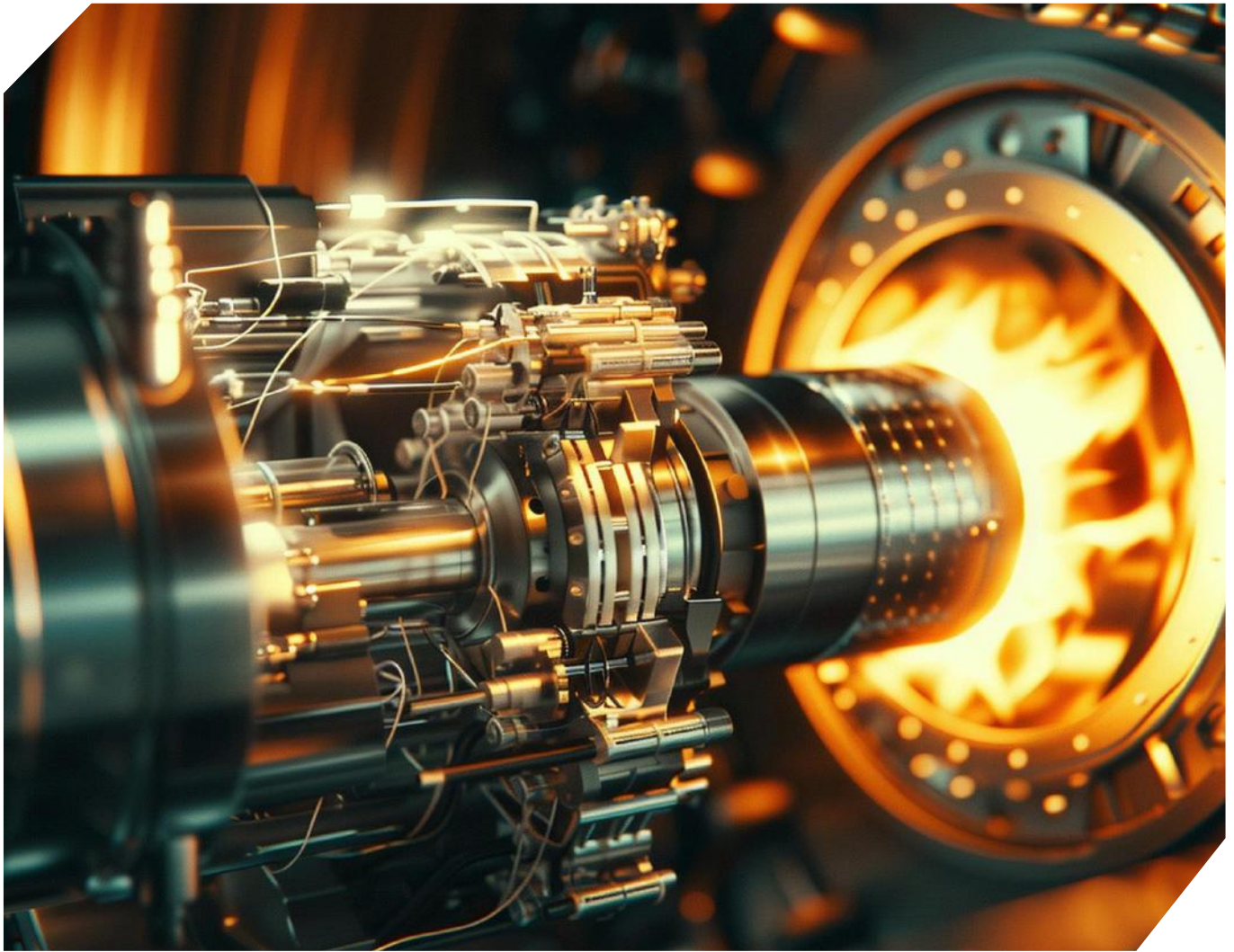
### Conclusion:

The article explores the vital relationship between gearbox design and environmental sustainability, emphasising the multifaceted considerations and innovative approaches driving progress in this field. It begins by highlighting the significance of energy efficiency in gearbox design, discussing how optimising gear designs and material selection can minimise energy consumption and greenhouse gas emissions.

The role of lubrication systems in reducing environmental impact is also explored, with an emphasis on selecting environmentally friendly lubricants and implementing efficient lubrication strategies. The article discusses the importance of lifecycle analysis in evaluating the environmental sustainability of gearbox systems, from raw material extraction to disposal.



***Sudhanshu Nayak, a dynamic mechanical engineer, is driven by a fervor for cutting-edge technologies like 3D printing, cloud manufacturing, & Industry 4.0. He has gained invaluable firsthand experience with 3D printing during his tenure at innovative startups. His youthful energy fuels a deep expertise in social media marketing, technical content creation, & market research.***



# Enhancing Performance: The Science Behind Gear Heat Treatment

By: Sushmita Das

Gears are the unsung heroes of machinery, silently transferring power from one component to another, enabling the smooth operation of everything from automobiles to industrial machinery. However, for gears to perform their duties reliably and efficiently, they must undergo a transformative process known as heat treatment.

Heat treatment is a critical step in the manufacturing process of gears, where controlled heating and cooling are applied to alter their microstructure, enhancing their mechanical properties. Among various components in a machine, gears are subjected to some of the most demanding

conditions, such as high loads, intense friction, and repetitive stress. Heat treatment not only ensures that gears withstand these harsh conditions but also prolongs their lifespan, by reducing wear and tear, and enhances their overall performance.

## Essential Steps Involved in the Process of Gear Heat Treatment

### Annealing:

Annealing is the initial step in gear heat treatment, where the gears are heated to a specific temperature and then cooled slowly to relieve internal stresses,



improve machinability, and refine the microstructure. This process helps in reducing hardness, making the gears easier to machine into their final shape.

**Normalizing:**

Normalizing involves heating the gears to a temperature above the transformation range, followed by air cooling. This process refines the grain structure and improves the uniformity of properties throughout the gear. Normalizing also enhances the machinability and dimensional stability of the gears.

**Quenching:**

Quenching is perhaps the most critical stage of gear heat treatment. During this process, the gears are rapidly cooled from a high temperature by immersion in a quenching medium such as oil, water, or polymer.

This rapid cooling hardens the gears by transforming the microstructure, typically forming martensite, a hard crystalline structure. The choice of quenching medium and cooling rate depends on the material composition and desired properties of the gears.

**Tempering:**

Tempering follows quenching and involves reheating the hardened gears to a specific temperature, typically below the critical point, and then cooling them at a controlled rate.

Tempering reduces the brittleness induced by quenching while maintaining the desired hardness and improving the toughness and ductility of the gears.

## The Significance of Heat Treatment in Gear Industry

**Improved Hardness:**

Heat treatment significantly increases the hardness of gears, making them more resistant to wear, deformation, and fatigue failure.

This enhanced hardness ensures that gears maintain their shape and integrity even under high loads and continuous operation.

**Enhanced Strength:**

By altering the microstructure of gears, heat treatment improves their mechanical properties, including strength, toughness, and fatigue resistance.

This enhanced strength allows gears to withstand heavy loads and shocks without failing prematurely, thereby increasing the reliability and durability of machinery.

**Dimensional Stability:**

Heat treatment minimizes internal stresses and distortion in gears, ensuring dimensional stability and precise gear tooth profiles.

This dimensional stability is crucial for maintaining proper gear meshing, reducing noise, and improving the efficiency of power transmission.

**Wear Resistance:**

The hardened surface layer resulting from heat treatment improves the wear resistance of gears, reducing friction and minimizing surface damage during operation. This extends the service life of gears and reduces the need for frequent maintenance and replacement, thereby lowering operating costs.

**Consistency and Control:**

Heat treatment processes can be precisely controlled to achieve desired properties consistently across batches of gears. This ensures uniformity in performance and quality, crucial for industries where precision and reliability are paramount.

## Key Takeaway

In the industrial sector, gears stand as silent but indispensable components, orchestrating the seamless transfer of power across various mechanisms. However, their unassuming nature belies the rigorous journey they undergo to fulfil their roles with unwavering reliability. At the heart of this journey lies heat treatment, a process that elevates gears from mere components to resilient and high-performing assets.

Through annealing, normalizing, quenching, and tempering, gears are sculpted into structures that defy the harshest conditions, exhibiting enhanced hardness, strength, and wear resistance. This metamorphosis not only extends their lifespan but also ensures consistent performance under the most demanding circumstances. The significance of heat treatment reverberates throughout the gear industry, underpinning the reliability and efficiency of machinery across sectors.

Beyond mere metallurgical processes, gear heat treatment embodies precision, consistency, and control, reflecting the exacting standards of modern manufacturing. It is a testament to human ingenuity, where science and engineering converge to unlock the full potential of gears, enabling the smooth operation of complex machinery.

As we navigated an era defined by technological advancement and relentless pursuit of efficiency, the importance of gear heat treatment remains undiminished. It stands as a crucial part of modern engineering, a testament to our ability to harness the forces of nature to drive progress. In the symphony of machinery, gears may remain unsung, but their resilience, forged through the crucible of heat treatment, ensures that they continue to power the wheels of industry for generations to come.





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# Proactive Gearbox Care: Strategies for Preventive Maintenance and Efficient Troubleshooting

By: Sudhanshu Nayak

Gearboxes play an important role in the smooth operation of machinery across various industries, from automotive to manufacturing and beyond. These complicated systems of gears, shafts, and bearings are the driving force behind power transmission, ensuring that machines function with precision and efficiency. And like any mechanical system, gearboxes require regular maintenance to operate at their best and avoid costly downtime. By understanding the importance of proactive maintenance, implementing preventive strategies, and knowing how to troubleshoot problems effectively, we will gain valuable insights into maximizing the reliability, efficiency, and safety of gearbox systems.

Let's dive into the world of gearbox maintenance and troubleshooting to keep your machinery running smoothly and your operations thriving.

## Common Gearbox Issues and Troubleshooting

Gearboxes are complex systems with various components that can experience issues over time. Identifying common problems and knowing how to troubleshoot them is essential for maintaining gearbox performance.

Let's explore some typical gearbox issues and their troubleshooting steps:

### Gearbox Noise:

Unusual noises coming from a gearbox, such as whining, grinding, or clicking, often signify underlying issues with gears, bearings, or lubrication systems.

When troubleshooting gearbox noise, it's crucial to conduct a thorough inspection of the gears to check



for signs of wear, chipped teeth, or misalignment, which can contribute to the noise. Additionally, inspecting the bearings for damage or inadequate lubrication is essential to ensure smooth operation and minimize noise. Maintaining proper oil levels and quality is another critical aspect, as insufficient lubrication can lead to increased friction and noise.

Adjusting gear meshing and alignment as needed can also help mitigate noise issues, ensuring optimal performance and minimizing disruptions in gearbox operation.

### Overheating:

Excessive heat buildup in a gearbox can stem from various factors such as inadequate cooling, overloading, or friction caused by poor lubrication. When addressing overheating issues, thorough troubleshooting steps are essential. Begin by checking the cooling systems for any blockages or malfunctions that could hinder proper heat dissipation. If the gearbox is overloaded, reducing the load can help alleviate heat generation and stress on components.

Verifying oil levels and quality is crucial, as insufficient or degraded lubrication can contribute to increased friction and heat. Improving ventilation around the gearbox and enhancing heat dissipation mechanisms can also aid in reducing overheating, ensuring optimal gearbox performance and longevity.

### Vibration and Shaking:

Vibrations and shaking in a gearbox can signal underlying issues such as imbalance, misalignment, worn components, or resonance within the system. Troubleshooting these vibrations requires a systematic approach.

Balancing rotating components like shafts and gears is crucial to reduce vibrations caused by imbalance. Using laser alignment tools helps ensure precise alignment of gearbox components, minimizing vibrations due to misalignment.

Inspecting and replacing worn bearings, gears, or couplings is essential to maintain smooth operation and minimize vibrations caused by wear. Addressing resonance issues may involve structural modifications or implementing damping measures to reduce the impact of vibrations and shaking on gearbox performance.

By addressing these root causes through effective troubleshooting, gearbox vibrations can be minimized, ensuring optimal performance and reliability.

### Gear Slippage or Engagement Problems:

Gear slippage or engagement problems in a gearbox, such as difficulty in gear engagement, slippage under load, or erratic shifting, can stem from issues with clutch systems, hydraulic actuators, or worn gear teeth.

Troubleshooting involves checking clutch systems for proper adjustment and wear, inspecting hydraulic systems for leaks or malfunctions, examining gear teeth for wear patterns or damage, and replacing worn components while adjusting gear engagement mechanisms as needed to ensure smooth and reliable gearbox operation.

### Oil Leaks:

Oil leaks in gearboxes, resulting from damaged seals, gaskets, or housing cracks, can lead to lubrication loss and component damage.

Troubleshooting involves identifying and replacing damaged seals or gaskets, repairing housing cracks, and regular monitoring of oil levels and quality to detect leaks early.

### Regular Maintenance Practices

Gearbox maintenance is not just a task to be performed when issues arise; it's a proactive approach to ensure optimal performance and prevent costly breakdowns. Regular maintenance practices form the foundation of a well-functioning gearbox system. Here's a closer look at some essential practices:

**Scheduled Inspections:** Implementing a regular inspection schedule is key to catching potential issues early. This includes visual inspections of gearbox components such as gears, bearings, seals, and lubrication systems. Inspections should be conducted according to manufacturer recommendations or industry standards.

**Oil Level and Quality:** Checking the oil level and quality is crucial for proper lubrication and heat dissipation within the gearbox. Low oil levels or degraded oil can lead to increased friction, overheating, and premature wear of components. Regularly monitor oil levels and perform oil analysis to ensure optimal lubrication properties.

**Lubrication Systems:** Proper lubrication is essential for reducing friction, wear, and heat generation within the gearbox.

Ensure that lubrication systems are functioning correctly, and use the recommended lubricants as specified by the gearbox manufacturer. Inspect lubrication lines, fittings, and reservoirs for leaks or blockages.

**Seals and Gaskets:** Inspect seals and gaskets for signs of wear, leaks, or damage. Faulty seals can lead to



oil leaks, contamination of gearbox internals, and reduced lubrication effectiveness. Replace worn seals and gaskets promptly to maintain the integrity of the gearbox enclosure.

**Bearings and Alignment:** Check bearings for wear, proper alignment, and smooth operation. Misaligned or worn bearings can cause excessive vibration, noise, and premature failure of gearbox components. Use laser alignment tools to ensure precise alignment of shafts and gears for optimal performance. By regularly following the above practices, one can keep their gearboxes healthy and efficient.

## Diagnostic Techniques

Diagnostic techniques play a crucial role in identifying gearbox issues accurately and efficiently. By utilizing advanced tools and methods, maintenance professionals can pinpoint problems early, allowing for targeted troubleshooting and timely repairs. Here are some essential diagnostic techniques for gearbox maintenance:

### Vibration Analysis:

Vibration analysis is crucial for detecting abnormal vibrations in gearboxes, indicating misalignment, imbalance, worn components, or gear meshing issues.

Utilizing vibration sensors or accelerometers, measure vibration levels and analyze signatures for frequency peaks linked to gearbox problems. Early detection enables corrective actions like realignment, balancing, or replacing worn parts, ensuring optimal gearbox performance and reliability.

### Temperature Sensors:

Temperature sensors play a vital role in monitoring gearbox operating temperatures, and detecting overheating from factors like inadequate lubrication or overloading.

By installing sensors at critical points, temperature variations are monitored, with threshold alarms set to alert abnormal temperature rises, prompting timely maintenance actions. This proactive approach prevents component damage and enables troubleshooting of cooling or lubrication issues, ensuring gearbox reliability and performance.

### Oil Analysis:

Oil analysis is instrumental in evaluating gearbox lubricants, and identifying contaminants, degradation, or wear particles that impact lubrication quality.

Regularly collect oil samples for analysis, assessing viscosity, contamination levels, wear debris, and chemical composition using laboratory tests or on-site kits.

This practice offers valuable insights into gearbox health, guiding maintenance decisions like oil changes, filter replacements, or investigating underlying issues for optimal performance.

### Gear Tooth Inspection:

Visual inspection of gear teeth serves to identify wear patterns, pitting, chipping, or damage impacting gear performance. Utilize tools like borescopes, magnifying lenses, or digital imaging systems to scrutinize gear surfaces, detecting wear, fatigue, or irregularities in tooth contact. Early detection enables proactive maintenance actions such as gear replacements or adjustments, enhancing gear meshing and load distribution for improved reliability and performance.

### Laser Alignment Tools:

Laser alignment tools are essential for achieving precise alignment of gearbox components and reducing vibration, noise, and wear.

Utilize laser alignment systems to accurately align shafts, couplings, and gears, measuring and adjusting parameters like parallelism, angularity, and offset. Proper alignment enhances gearbox efficiency, lowers energy consumption, and prolongs component lifespan, ensuring optimal performance and reliability.

## Preventive Maintenance Strategies

Preventive maintenance is a proactive approach crucial for gearbox systems, aiming to prevent equipment failures and minimize downtime by addressing potential issues before they escalate.

Key strategies include Condition-Based Monitoring (CBM), which involves real-time monitoring of gearbox parameters such as vibration, temperature, and oil quality using sensors and predictive analytics to detect early signs of potential issues.

Regular cleaning and inspection schedules are implemented to remove debris and contaminants, ensuring clean and efficient gearbox components while allowing for timely corrective actions.

Comprehensive training programs for maintenance personnel cover gearbox maintenance procedures, diagnostic techniques, safety protocols, and equipment handling, empowering teams to conduct effective preventive maintenance and identify potential problems early.

Lifecycle management strategies involve developing component replacement schedules based on manufacturer recommendations and upgrading gearbox components to enhance performance and reliability. Documentation and record-keeping of maintenance activities, inspections, and repairs support informed decision-making, continuous improvement, and compliance with regulatory



requirements, ultimately ensuring the reliability, efficiency, and longevity of gearbox systems.

### Final Takeaway:

Gearbox maintenance and troubleshooting are vital for ensuring the smooth operation and longevity of machinery in various industries.

Understanding the importance of proactive maintenance, implementing preventive strategies, and employing effective diagnostic techniques are key to maximizing gearbox reliability, efficiency, and safety.

Common gearbox issues such as noise, overheating, vibrations, gear slippage, and oil leaks require systematic troubleshooting approaches.

Regular maintenance practices like scheduled inspections, monitoring oil levels and quality, ensuring proper lubrication, checking seals and gaskets, and aligning components contribute to optimal gearbox performance.

Diagnostic techniques such as vibration analysis, temperature sensors, oil analysis, gear tooth inspection, and laser alignment tools help identify gearbox issues early, enabling targeted troubleshooting and timely repairs.

Preventive maintenance strategies, including Condition-Based Monitoring (CBM), regular cleaning and inspections, comprehensive training programs, lifecycle management, and documentation, are essential for preventing equipment failures, minimizing downtime, and ensuring gearbox reliability, efficiency, and longevity.



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## HIGHLIGHTS

### Proactive Maintenance Importance:

Gearboxes are critical for machinery across industries, demanding proactive maintenance to prevent downtime and ensure efficiency.

By adopting proactive maintenance strategies and leveraging advanced technologies such as predictive analytics and condition monitoring, organisations can optimise the performance and reliability of their machinery, thereby enhancing productivity and competitiveness in the market.

### Common Issues & Troubleshooting:

Identifying and troubleshooting common gearbox issues like noise, overheating, vibrations, and gear slippage is essential for maintaining performance.

### Regular Maintenance Practices:

Scheduled inspections, monitoring oil levels, proper lubrication, checking seals, and alignment are fundamental maintenance practices to uphold gearbox health.

### Diagnostic Techniques:

Vibration analysis, temperature sensors, oil analysis, gear tooth inspection, and laser alignment tools aid in early issue detection, enabling targeted repairs.

### Preventive Maintenance Strategies:

Strategies like Condition-Based Monitoring (CBM), comprehensive training, lifecycle management, and documentation ensure reliability, efficiency, and longevity of gearbox systems.

CBM utilises various techniques such as vibration analysis, oil analysis, thermography, and acoustic monitoring to assess the health of the gearbox components.

By implementing these preventive maintenance strategies, organisations can enhance the reliability, efficiency, and longevity of gearbox systems, ultimately reducing operational costs and enhancing overall productivity.



# Rationalising Spur Gear Design: The Development of a CAD Modelling Automation Tool in SolidWorks

By: Sushmita Das



In the domain of industrial engineering, efficient design processes are important for enhancing productivity and reducing time-to-market. Spur gears, omnipresent in mechanical systems, require meticulous design considerations.

Conventional Computer-Aided Design (CAD) methods for modelling spur gears often involve repetitive and time-consuming tasks. However, the emergence of automation tools presents an opportunity to transform this process. Continue reading to explore the development of a CAD modelling automation tool for spur gear design within SolidWorks, tailored to the requirements of industrial engineers.

## Emerging Need for Automation:

The emerging need for automation in spur gear design arises from several critical factors. Traditionally, engineers have relied on manual processes for designing spur gears using CAD

software. However, this approach has its limitations and inefficiencies:

**Complex Calculations:** Designing spur gears involves intricate mathematical calculations to determine parameters such as tooth size, pitch, and profile. Performing these calculations manually can be time-consuming and prone to errors, especially for gears with non-standard configurations or specific requirements.

**Manual Geometry Creation:** Creating the geometric profiles of spur gears manually within CAD software is a meticulous task. Engineers need to input dimensions accurately and ensure that the gear teeth mesh correctly to transmit motion smoothly. This process requires a significant amount of time and attention to detail.

**Repetitive Adjustments:** Iterative refinement is often necessary during the gear design process to achieve



optimal performance and durability. Engineers may need to make repetitive adjustments to parameters such as tooth profile, backlash, and pressure angle until the desired specifications are met.

Manually carrying out these adjustments can be tedious and prone to inconsistencies.

**Error Prone:** Human error is a significant risk in manual gear design processes. Even small mistakes in calculation or geometry creation can lead to substantial issues in gear functionality, resulting in costly rework or even equipment failure in industrial applications.

**Resource Consumption:** Manual gear design processes consume valuable human resources and time that could be allocated to more strategic and creative tasks.

As industries strive for efficiency and productivity, there is a growing recognition of the need to streamline design workflows and minimise resource expenditure.

To address these challenges, industrial engineers are increasingly turning to automation technologies. Automated approaches leverage algorithms and computational techniques to streamline the gear design process, reducing reliance on manual input and minimising the risk of errors.

By automating calculations, geometry creation, and iterative adjustments, engineers can expedite the design process while ensuring precision and consistency in the final product. This not only saves time and resources but also enhances the overall quality and reliability of spur gears, meeting the demands of modern industrial applications.

## Key Features and Functionality:

The CAD modelling automation tool developed for SolidWorks encompasses several key features to streamline spur gear design, which are as follows:

**Parameterised Input:** Users input gear specifications such as module, number of teeth, pressure angle, and profile shift coefficient, simplifying the customisation process.

**Algorithmic Calculations:** The tool integrates algorithms to compute gear dimensions, tooth profiles, and other critical parameters based on user inputs, eliminating the need for manual calculations.

**Dynamic Modelling:** Leveraging SolidWorks' parametric modelling capabilities, the tool generates gear models dynamically, enabling users to visualise design changes instantly.

**Customisation Options:** Engineers can customise gear designs by adjusting parameters such as

tooth profile modification, backlash, and clearance, ensuring compatibility with specific application requirements.

**Design Validation:** The tool incorporates validation mechanisms to evaluate gear performance based on criteria like tooth strength, contact ratio, and backlash, empowering engineers to optimise designs for reliability and efficiency.

## Development Process:

The development of the CAD modelling automation tool involved several key steps:

**Requirement Analysis:** Collaborating with industrial engineers to comprehend design requirements and challenges associated with spur gear modelling.

**Algorithm Design:** Designing algorithms to calculate gear dimensions, tooth profiles, and other parameters based on industry-standard formulas and design guidelines.

**Software Integration:** Integrating the automation tool seamlessly within the SolidWorks environment, utilising APIs and scripting capabilities for robust functionality.

**User Interface Design:** Designing an intuitive user interface within SolidWorks to facilitate ease of use and efficient interaction with the automation tool.

**Testing and Validation:** Conducting rigorous testing to ensure the accuracy, reliability, and performance of the automation tool across various design scenarios and parameters.

## Benefits and Impact:

The implementation of the CAD modelling automation tool in SolidWorks offers significant benefits to industrial engineers:

**Time Efficiency:** Automation reduces design cycle times, enabling engineers to iterate and refine designs rapidly.

**Accuracy and Consistency:** Automation eradicates human errors inherent in manual design processes, ensuring consistent and precise gear geometries.

**Design Optimisation:** Engineers can explore a broader range of design possibilities and promptly evaluate their impact on performance metrics, leading to optimised gear designs.

**Enhanced Productivity:** By automating repetitive tasks, engineers can focus on higher-value activities such as innovation and problem-solving, enhancing overall productivity.

**Knowledge Transfer:** The automation tool encapsulates domain knowledge and best practices,



facilitating knowledge transfer among engineering teams and expediting onboarding for new engineers.

## Way Ahead

The development of a CAD modelling automation tool for spur gear design in SolidWorks represents a significant advancement in rationalising design processes for industrial engineers.

By harnessing automation, engineers can expedite design iterations, enhance accuracy, and optimise gear performance, ultimately driving efficiency and innovation in mechanical systems design and manufacturing.

As automation evolves, its integration into CAD environments will empower engineers and redefine the landscape of engineering design.



*Sushmita Das is an accomplished technical writer. Holding a degree in Electrical Instrumentation and Control System Engineering, she brings a wealth of technical expertise to her writing.*

## HIGHLIGHT

### Complex Calculations:

Manual spur gear design involves intricate, error-prone calculations.

### Manual Geometry Creation:

Creating accurate gear profiles in CAD is labour-intensive.

### Repetitive Adjustments:

Refinements for optimal performance can be tedious and inconsistent.

### Error Prone:

Human errors in calculations or geometry can cause significant issues.

### Resource Consumption:

Manual processes consume valuable time and human resources.



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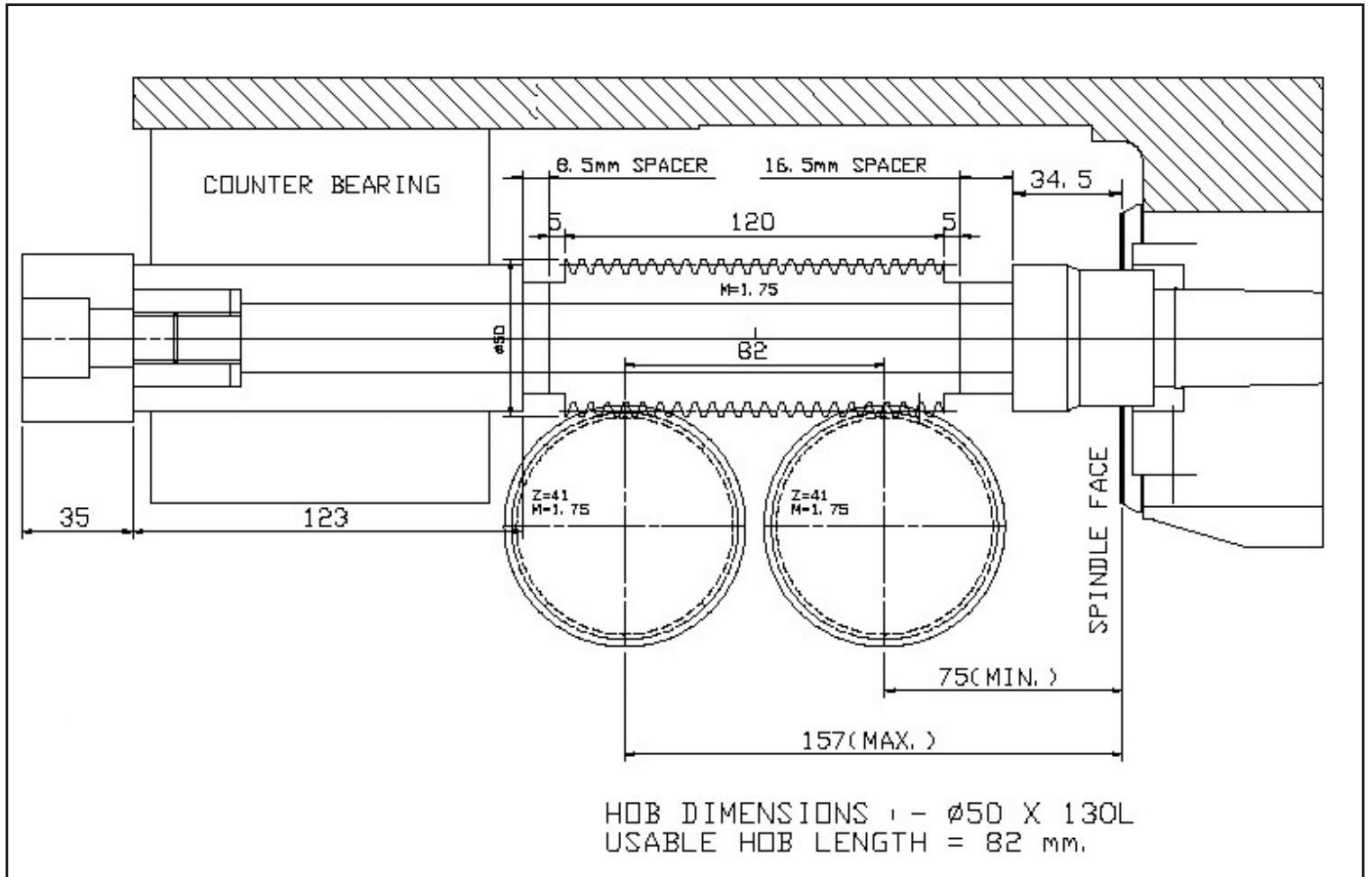
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# Analytical Evaluation of Hob Life

By: Vishwajit Kothari



Usually, it is always better to plan the use of a hob based on experience gathered in a gear production shop.

This, no doubt, is very important from effective utilization of hob, which ultimately results in lowering the tool cost per piece. The hob could be a new one or a re-sharpened one. However, it has to be coated for better performance. There are two ways to look at while estimating the hob life. One could be using the hob for the targeted batch production where the quantity of parts to be produced is a known figure.

Once the target is achieved, the hob is offered for re-sharpening and coating. The second could be to estimate the production volume with reference to the performance of each hob-tooth in terms of length of gear teeth can be cut.

## Hob Life Estimation Methods

Below is a simple methodology developed to estimate the hob life.

Hob life is expressed in terms of lineal inches / meter cut per hob tooth.

Knowing the hob parameters and specifications and utilizing life factors that have been developed through experience, it is possible to calculate tool life estimates with a certain degree of accuracy.

**The first step is to calculate the number of usable teeth in the hob.** To do this, it is necessary to determine the usable length of hob as follows:

$$\text{Usable Length} = HL - HB - NCP - RZ - GZ/2,$$

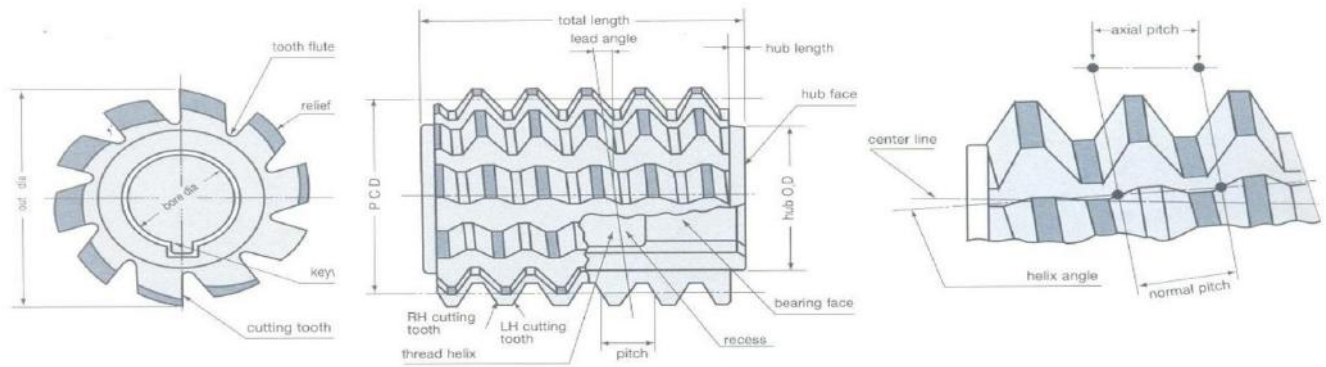
Where,

HL = Hob length

HB = Hub length (total of both sides)

NCP = Normal Circular Pitch

RZ = Roughing Zone =  $\text{SQRT}((\text{Gear OD} - \text{Whole Depth}) * \text{Whole Depth})$



$GZ = \text{Generating Zone} = (2 * ADD) / \text{TAN} (PA)$

Usable number of teeth =  $((\text{Usable Length}) / \text{NCP}) * \text{No of gashes}$

Once the usable number of teeth has been calculated, determine the total number of linear meter that can be cut per sharpening. The following example shows how above methodology can be used.

Hob OD: 100

Length: 200

No of Gashes: 14

Hub width: 5

NCP:  $\pi * Mn$

Work piece: 40 Teeth

Module: 4

Outer Diameter: 168

Whole Depth: 9

Face width: 40

Pressure Angle: 20

Usable Length =  $200 - (2 * 5) - (\pi * 4) - \sqrt{((168-9)*9) - (2 * 4) / \text{TAN} (20)} = 161.6$

Usable no of teeth =  $(161.6 / 12.56) * 14 = 180$

For a coated tool of 3.0 m length tooth life, hob life between re-sharpening will be =  $540 \text{ m length} = 338 \text{ parts}$

Knowing the usable length of hob, the hob shift amount will be  $161.6 / 338 = 0.478 \text{ mm amount / piece}$ .

With the modern CNC machines it is always possible to decide the strategy how to put hob in use so that there is uniform wear and tear across its face width, targeted production volume is achieved with consistent accuracy and planned numbers of resharping are achieved thereby giving the least

tool cost per piece over the total estimated life of the hob.

Let us implement above scientific approach for better effective utilization of hob.



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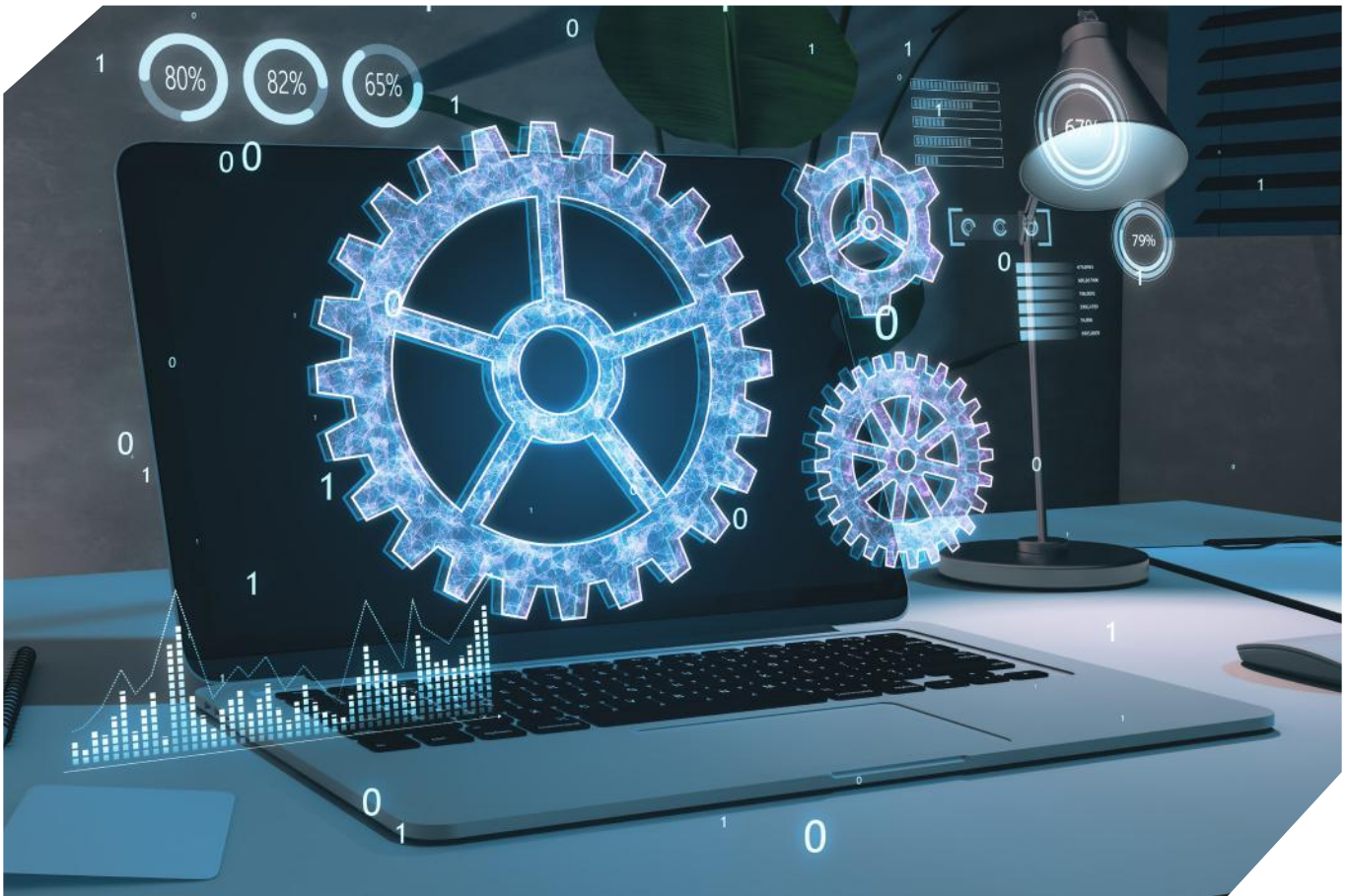
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# Streamlining Gear Manufacturing: The Vital Role of CAM Software in Optimizing Processes

By: Sushmita Das



Gear manufacturing stands as a cornerstone of numerous industries, supporting the functionality of essential machinery ranging from automotive transmissions to industrial equipment.

Within this domain, the demand for precision engineering is unwavering, with even the slightest deviation in gear tooth profiles or tolerances potentially resulting in catastrophic failures. Moreover, the pursuit of efficiency remains an enduring goal, as manufacturers endeavour to strike a balance between productivity and cost-effectiveness in an increasingly competitive landscape. Among all these challenges, Computer-Aided Manufacturing (CAM) software emerges as a transformative force,

revolutionising traditional manufacturing processes and unlocking new avenues for optimisation.

In this intricate sphere where precision and efficiency hold sway, CAM software serves as a catalyst for innovation, empowering engineers to navigate the complexities of gear manufacturing with unparalleled precision and agility.

The foundation of gear manufacturing is based on the intricate interplay of design, machining, and quality control. Each phase of the manufacturing process demands meticulous attention to detail, as engineers strive to translate digital designs into physical components that meet exacting specifications.



Yet, the transition from design to production is fraught with challenges, ranging from material selection and toolpath optimisation to CNC machining and quality assurance.

It is within this context that CAM software emerges as a linchpin of modern gear manufacturing operations. By seamlessly integrating with Computer-Aided Design (CAD) software and CNC machining platforms, CAM software bridges the gap between digital design and physical production, facilitating a smooth and efficient workflow from concept to completion.

Through a comprehensive suite of tools and functionalities, CAM software empowers engineers to optimise every facet of the manufacturing process, from toolpath generation and CNC programming to simulation and quality control.

### Understanding CAM Software:

In the intricate realm of modern manufacturing, Computer-Aided Manufacturing (CAM) software emerges as a pivotal tool, seamlessly bridging the gap between digital design and physical production.

At its core, CAM software serves as the conduit through which intricate CAD models are transformed into tangible products on the manufacturing floor. Within the domain of gear manufacturing, CAM software plays a multifaceted role, offering a comprehensive suite of tools and functionalities finely tuned to meet the unique challenges inherent in this specialized industry.

CAM software acts as the linchpin of the manufacturing process, orchestrating a seamless transition from the virtual realm of digital design to the physical reality of machined components. Through its sophisticated algorithms and intuitive interfaces, CAM software empowers engineers to translate complex CAD models of gears into precise instructions for CNC machines.

By generating optimized toolpaths, specifying machining parameters, and simulating the manufacturing process, CAM software ensures that every step of the production process is executed with precision and efficiency.

In the context of gear manufacturing, CAM software assumes additional significance due to the intricate geometries and tight tolerances inherent in gear design.

Gears, with their precisely machined tooth profiles and intricate shapes, demand a high degree of accuracy and repeatability in the manufacturing process.

CAM software rises to this challenge by offering specialized functionalities tailored specifically for gear manufacturing, such as gear profile generation,

tooth form optimization, and flank milling strategies. Moreover, CAM software facilitates the seamless integration of CAD and CAM workflows, enabling engineers to design gears in CAD software and then seamlessly transfer them to CAM software for manufacturing. This integration streamlines the design-to-production workflow, reducing manual errors and accelerating time-to-market.

Additionally, CAM software offers advanced features such as collision detection, material removal simulation, and toolpath optimization, which further enhance the efficiency and reliability of the manufacturing process.

### Toolpath Optimization:

At the core of CAM software lies toolpath optimization, a fundamental functionality crucial in gear manufacturing, where intricate geometries and tight tolerances are standard.

CAM software meticulously analyses the design geometry, material properties, and machining parameters to generate the most efficient toolpaths. By minimizing tool travel distance, reducing machining time, and mitigating tool wear, CAM software enhances productivity whilst upholding the desired quality standards.

### CNC Machining:

The nucleus of modern gear manufacturing processes is Computer Numerical Control (CNC) machining. CAM software seamlessly integrates with CNC machines, generating machine-readable code (G-code) that guides cutting tools with unparalleled precision.

Engineers utilise CAM software to fine-tune machining parameters, such as cutting speed, feed rate, and tool orientation, to optimize the manufacturing process for each specific gear geometry. Additionally, advanced CAM software provides simulation capabilities, enabling engineers to visualize the machining process and preempt potential issues, thus minimizing costly errors and downtime.

### Complex Geometry Machining:

Gears encompass a plethora of shapes and sizes, each presenting its own unique set of challenges. From straightforward spur gears to intricate bevel gears, machining complex geometries necessitates sophisticated CAM software adept at handling intricate 3D models.

CAM software employs advanced algorithms to generate toolpaths accurately reproducing the desired gear profile, tooth form, and surface finish. Leveraging multi-axis machining capabilities, CAM software enables the production of gears with



unparalleled accuracy and complexity, pushing the boundaries of traditional manufacturing methods.

### Automation and Integration:

In the contemporary fast-paced manufacturing milieu, automation is pivotal for maintaining competitiveness.

CAM software offers an array of automation tools, from automated toolpath generation to batch processing, streamlining the manufacturing process and reducing manual intervention.

Furthermore, CAM software seamlessly integrates with other software systems such as CAD, Product Lifecycle Management (PLM), and Enterprise Resource Planning (ERP) systems, creating a unified digital ecosystem spanning the entire product lifecycle.

This integration facilitates real-time data exchange, automated workflows, and enhanced collaboration between design, manufacturing, and supply chain teams, fostering efficiency and innovation across the organization.

### Quality Assurance:

Quality assurance is imperative in gear manufacturing, where even minor deviations can precipitate catastrophic consequences. CAM software assumes a pivotal role in ensuring the quality of the final product through in-process monitoring, inspection, and feedback mechanisms.

Real-time monitoring capabilities enable engineers to track key metrics such as dimensional accuracy, surface finish, and tool wear during the machining process.

By detecting deviations early and effecting real-time adjustments, CAM software mitigates the risk of defects and rework, ultimately enhancing yield and reducing scrap rates.

### Key Takeaway

Gear manufacturing is a linchpin of various industries, facilitating the functionality of essential machinery across automotive, industrial, and other sectors.

The unyielding demand for precision engineering underscores the criticality of achieving exacting standards in gear design and production.

Concurrently, pursuing efficiency remains paramount as manufacturers navigate a competitive landscape where productivity and cost-effectiveness are essential.

Amidst these challenges, Computer-Aided Manufacturing (CAM) software emerges as a transformative force, revolutionising traditional



manufacturing processes and opening new avenues for optimisation. Within the intricate realm of gear manufacturing, CAM software assumes a multifaceted role, seamlessly integrating with Computer-Aided Design (CAD) models and CNC machining platforms to facilitate a smooth transition from digital design to physical production.

CAM software's versatility is evident in its ability to address the unique challenges of gear manufacturing. From toolpath optimisation and CNC machining to handling complex geometries and facilitating automation and integration, CAM software offers a comprehensive suite of tools and functionalities tailored specifically to meet the demands of this specialized industry.

By leveraging CAM software, engineers can streamline the manufacturing process, enhance productivity, and maintain stringent quality standards.

Real-time monitoring and simulation capabilities enable proactive quality assurance, minimizing the risk of defects and rework while maximizing yield and reducing scrap rates.

Therefore, CAM software embodies the convergence of cutting-edge technology and manufacturing expertise, offering a holistic solution to the multifaceted challenges of gear manufacturing.

As the industry continues to evolve, CAM software will undoubtedly remain a vital tool in streamlining processes, driving efficiency, and fostering innovation across the manufacturing landscape.

# NEW ROLE NEW VISION



We extend our heartfelt

## CONGRATULATIONS

**To Shri. H D Kumaraswamy**

on his appointment as the new

**Union Minister of Heavy Industries & Minister of Steel**

We look forward to his dynamic leadership and the significant advancements he will bring to these sectors.

**gear**  
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