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LUBRICATION
Friction in tooth flanks and its impact on various operating conditions in cylindrical gears - an Overview Part -1

FUTURE OUTLOOK
All You Need To Know About AI-Driven Gearbox Diagnostics in Gear Maintenance

TECH POLL
Insights from Gear Technology India's 2024 Polls

In Association

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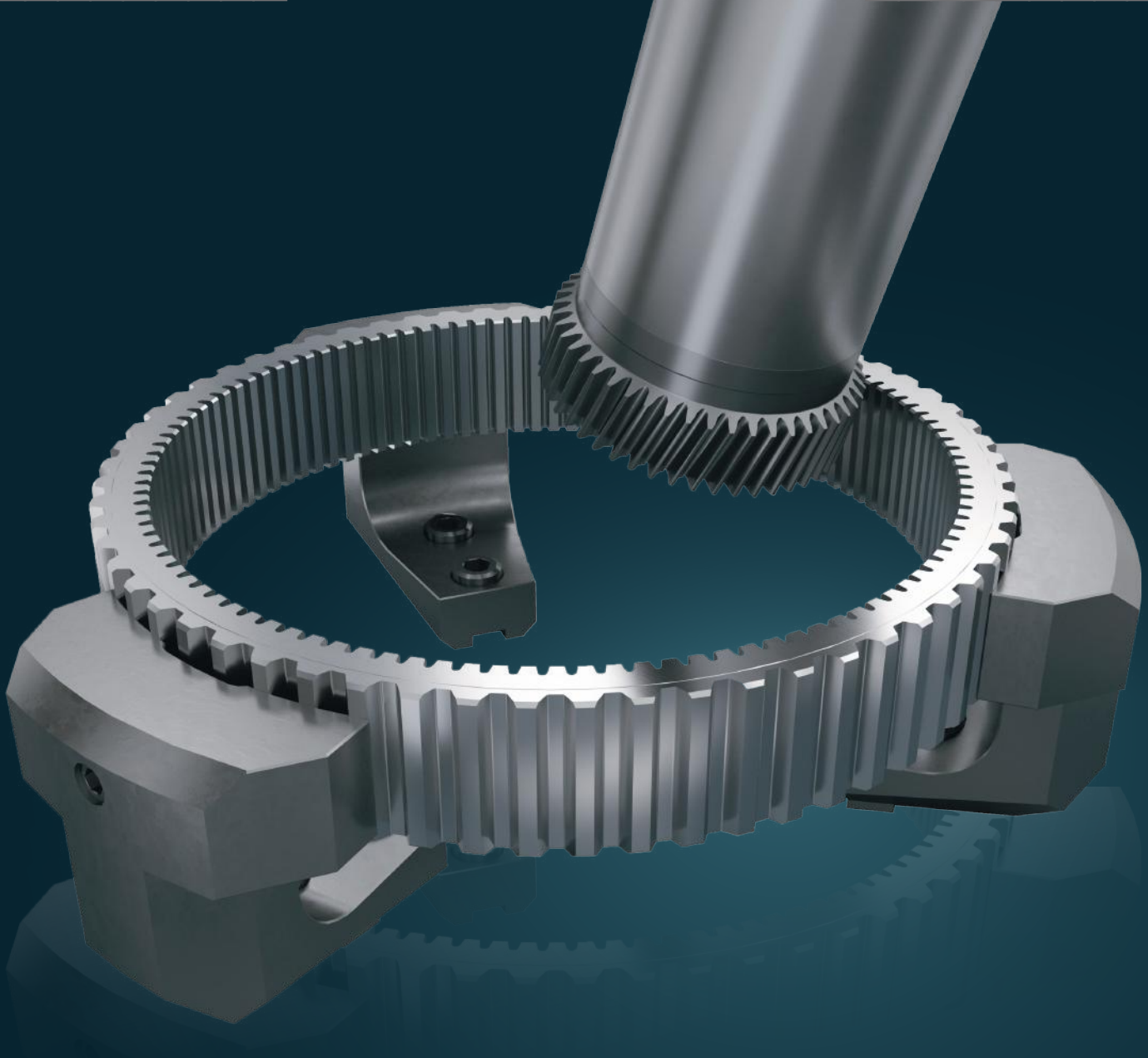

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Dear Readers,

As we step into 2025, the gear industry continues to evolve at a breathtaking pace, shaped by advancements in technology, materials, and manufacturing processes. The current edition of Gear Technology India Volume 3 Issue 1 is dedicated to exploring the future outlook of this dynamic sector, offering a comprehensive overview of where we stand and where we are headed in the domain of evolving technology.

The **future outlook theme** explores transformative ideas and technologies in depth. From AI-driven diagnostics revolutionizing gear maintenance to the impact of regenerative braking on gear machining, we offer insights to help you stay ahead in this ever-evolving industry.

This issue also aligns with the excitement surrounding IMTEX 2025, one of the most anticipated exhibitions in the manufacturing domain, scheduled to take place at BIEC, Bengaluru, from 23rd to 29th January 2025.

Here's what you can look forward to in this edition:

- **Lubrication:** A deep dive into friction in tooth flanks and its impact on cylindrical gears, Part 1 of this series promises to unravel the complexities of this critical aspect of gear performance.
- **Future Outlook:** From AI-driven gearbox diagnostics to the implications of regenerative braking on gear machining and emerging trends in surface engineering, our features provide insights into how innovation is reshaping gear design, manufacturing, and maintenance.
- **Interviews:** An exclusive conversation with Mr. Parminder Singh of Autodesk sheds light on design and manufacturing advancements within the Indian and SAARC markets.
- **IMTEX Highlights:** Discover groundbreaking innovations such as GearSkiving with process-reliable simulation by LMT Fette, Grind Master's latest offerings, and CalibroMeasure's game-changing solutions in quality inspection.
- **Manufacturing:** Precision in motion takes centre stage with an exploration of gear generation and profile teeth grinding.
- **Materials:** Self-healing gears signal a new frontier in material science, promising enhanced durability and performance.
- **Tech Poll:** Reflect on the insights from our 2024 polls, highlighting industry trends and challenges.

As always, our goal is to inform, inspire, and ignite meaningful discussions about the future of the gear industry. We invite you to read this issue, explore the innovations showcased at IMTEX, and join us in envisioning a future of boundless possibilities.

Warm regards,

gear TECHNOLOGY INDIA

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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FOUNDER

Michael Goldstein founded Gear Technology in 1984 and served as Publisher and Editor-in-Chief from 1984 through 2019.
Thanks to his efforts, the Michael Goldstein Gear Technology Library, the largest collection of gear knowledge available anywhere will remain a free and open resources for the gear industry.
More than 38 years' worth of technical articles can be found online at geartechnology.com. Michael continues working with the magazine in a consulting role and can be reached via e-mail at michael@geartechnology.com.

Matthew Croson

DISCLAIMER

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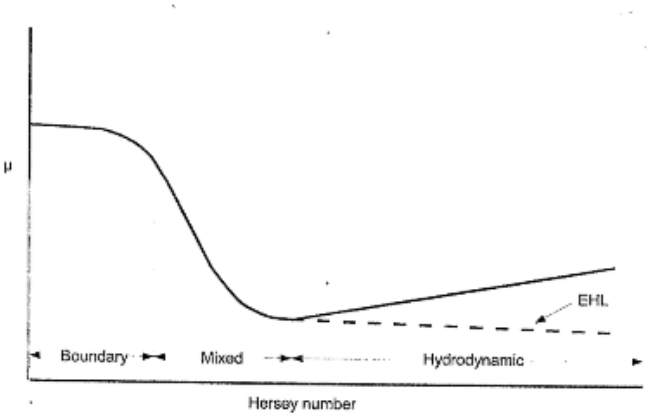
Friction in tooth flanks and its impact on various operating conditions in cylindrical gears - an Overview Part -1

- Soundararajan KP

Introduction:-

Typical Stribeck Curve represents basically different regimes of lubricated conditions. Consequently, the Hersey number on the abscissa can imply the Lubricant film thickness to show a higher Hersey number representing a thick film. This enables to find different Stribeck Curves in literature carrying a variety of parameters on the abscissa such as rolling speed of gear, entertainment speed, film thickness and similar parameters which can alter the value of friction.



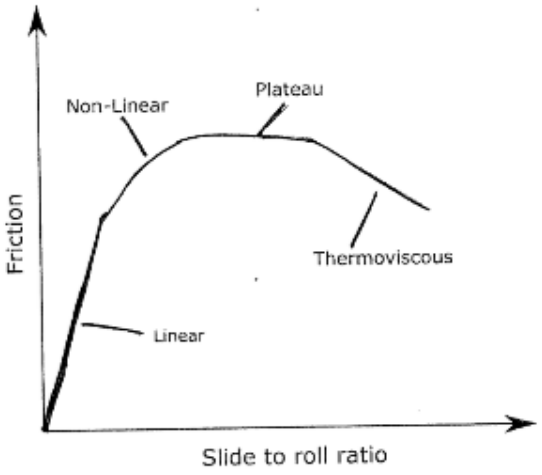
A smaller Hersey number can represent a boundary lubrication and a coefficient of friction at a higher value. When the number increases, there is a rapid decrease in friction coefficient. This is accompanied by a transition from boundary conditions to mixed lubrication and hydrodynamic regime. Hence, friction is a quantity that keeps changing at different tooth contact conditions in the process of lubricants that separate the contacting flanks under load.

In this paper we will see how as to how the friction coefficient changes at different regimes of lubrication; how the film thickness is addressed under partial EHL (Elastohydrodynamic Lubrication) and under transition. Besides, various methods adapted to evaluate the friction coefficient under shear of lube oil film by load and how various researches have considered when calculating load-dependent power loss.

1. The Friction Model

The Friction Model accounts for the non-Newtonian shear thinning behaviour of lubricant film. Further progression of dealing with this phenomenon leads to thermal behaviour or effect which enables prediction of lubricant temperature due to inlet oil shear heating. For a move out let us limit to the regime before the rise of temp/ pressure for the friction effect to remain in the scope.

The generated EHD pressure profile closely follows the Hertzian pressure profile under the entrainment except for inlet trail and secondary pressure peak in the contact outlet. This friction model has the basis deviating from the need for full solution of Reynolds fluid flow under the assumption of medium to high loads rendering piezo viscous Elastic EHD.



The central region carries the film shape as nearly flat at the height of the central film thickness. Depending on the form and slope errors and flank form conditions on the basis of load deflection, the contact zone can alter the film thickness. The contact area contour among meshing tooth flanks and deflection passed on by the load under transmission the film thickness alter. This gets subject to load-based shear caused on to the layer of oil film close to the driving flank pressing on the driven side flank by the layer of the oil film near that flank.

The friction under this scenario can be under for a given lub oil:

$$h_c = 4.31 R_e U_e^{0.68} G^{0.49} W_e^{-0.073} \left[1 - \exp\left(-1.23 \left(\frac{R_s}{R_e}\right)^{2/3}\right)\right] \quad (1)$$

Where

Ue - Dowson speed parameter - relative to entraining speed

Re - effective Radius of Curvature along the entraining direction (say X-axis)

G Dowson parameter

We Dowson Load Parameter

Rs Effective Radius of Curvature transverse to Re

Entraining speed Ue for oil flow inlet depends on dynamic viscosity at inlet, limit inlet temp and reduced elasticity modulus.

For simpler use and application where the pressure gradient of oil can be neglected as is assumed commonly in analytical EHD solution the shear rate is:-

$$\dot{\gamma} = \frac{\Delta U}{h_c}$$

t is the shear stress

$$\tau = \eta(p, \dot{\gamma})\dot{\gamma}$$

η is the effective dynamic viscosity.

$$\tau_L = \tau_{L,0} + \gamma_L p$$

Which is an important basic phenomenon

γL is the limiting shear stress pressure-based coefficient

P - Contact Pressure based on load

tL - Limiting Shear Stress

The friction coefficient:

μ = t/ p

where t is the average shear stress under EHD contact in pascals and p is the mean contact Hertzian pressure.

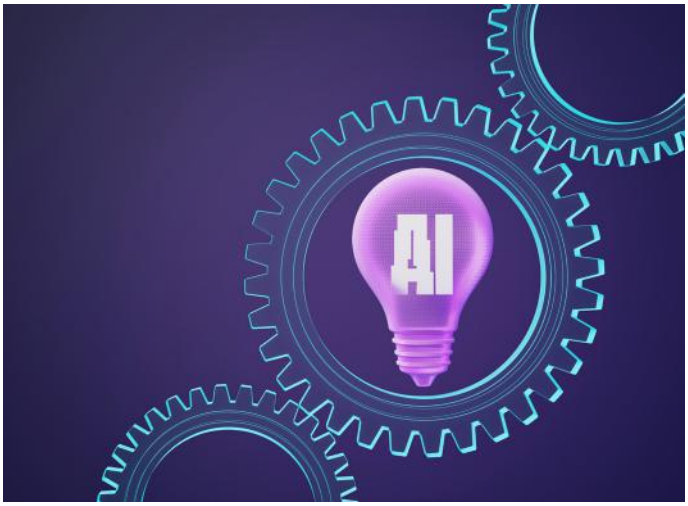
STAY TUNED TO READ THE NEXT PART IN THE UPCOMING EDITION!

The author is former Director and General Manager of Gleason Works India. He has four decades of experience in the gear industry, with special reference to machine tools and gear processes. He is also a Fellow of the Institution of Mechanical Engineers, UK, and a registered chartered engineer.

All You Need To Know About AI-Driven Gearbox Diagnostics in Gear Maintenance

- By Sushmita Das

The gear industry is the backbone of various sectors, including automotive, defence, heavy machinery, renewable energy and more. Gearboxes, as the heart of motion and power transmission systems, require rigorous maintenance protocols to ensure efficiency and reliability. In recent years, Artificial Intelligence (AI) has emerged as a transformative force in industrial maintenance, redefining how professionals diagnose and manage gearbox health.



The following article has examined the role of AI-powered diagnostics in the gearbox maintenance ecosystem, highlighting its effect on the efficiency, accuracy, and sustainability of industrial gear operations.

Discovering The Traditional Approach to Gearbox Maintenance

Conventional gearbox maintenance is contingent on regular inspections, manual measurements, and reactive responses to equipment failures. Key challenges include:

1. Manual Data Interpretation: Maintenance professionals manually analyse vibration, temperature, and wear patterns, which can lead to inconsistencies or oversight.

2. Unplanned Downtime: Unexpected gearbox failures usually disrupt production, resulting in expensive delays.

3. Inefficient Use of Resources: Maintenance schedules often follow fixed timelines rather than the actual condition of the equipment, leading to either under-maintenance or over-maintenance.

AI: The New Frontier in Gearbox Diagnostics

AI, fuelled by advanced algorithms and machine learning, introduces predictive and prescriptive capabilities into gearbox diagnostics. Thereby upon integrating AI, industry professionals can harness vast amounts of operational data to make informed decisions.

Key Features of AI-Driven Diagnostics:

1. Predictive Maintenance: AI analyzes historical data and real-time inputs to forecast potential failures, allowing for proactive interventions.

2. Real-Time Monitoring: Sensors collect continuous data on parameters such as vibrations, temperature, and oil conditions, feeding it into AI models for prompt analysis.

3. Fault Pattern Recognition: AI systems learn from data to identify patterns and anomalies, detecting issues such as misalignment, pitting, or gear wear long before they manifest as significant problems.

Benefits for Gear Industry Professionals

Automated AI-driven predictive maintenance delivers significant advantages to the manufacturing sector.

One of its primary advantages is the ability to identify potential issues before they lead to equipment failures. This proactive approach helps businesses prevent expensive downtime and repair costs while reducing the frequency of maintenance activities.

By minimising the risk of production disruptions caused by faulty equipment, companies can also save on expenses pertaining to hiring external contractors and service technicians for emergency repairs.

Moreover, AI systems streamline processes by eliminating the need for time-consuming manual inspections and diagnostic trips to the shop floor.

Another crucial advantage is enhanced workplace safety. AI gathers data autonomously from machines, even in challenging or hazardous environments, reducing the risks faced by engineers and technicians.

Ultimately, these benefits make AI-based predictive maintenance a more economical and efficient alternative to traditional maintenance practices and backup strategies.

AI Tools and Technologies Revolutionizing Gear Maintenance

1. Machine Learning Models:

These models analyse gearbox operation data to identify faulty patterns and predict future failures. They improve over time, becoming more accurate with additional data.

2. Digital Twins:

Digital twins create a virtual replica of the gearbox, enabling real-time simulation and analysis of performance under various conditions. This helps professionals test scenarios without disrupting actual operations.

3. IoT and Sensors:

Smart sensors embedded in gearboxes collect granular data, feeding it into AI systems. These sensors measure variables like vibration, acoustic signals, and lubricant condition, providing comprehensive health insights.

4. Augmented Reality (AR) for Diagnostics:

AR tools combined with AI provide technicians with real-time visualizations and instructions, enhancing troubleshooting and repair efficiency.

Use Cases in the Gear Industry

1. Automotive Sector

In electric vehicles (EVs), where gearboxes operate under unique load conditions, the role of AI is to ensure optimal performance by continuously analysing gear health and predicting potential failures.

2. Wind Energy

Wind turbine gearboxes face fluctuating loads and harsh environmental conditions. AI-driven diagnostics monitor such conditions, reducing downtime and ensuring uninterrupted power generation.

3. Heavy Machinery

AI tools are invaluable in mining and construction, where gearboxes endure extreme stress. They help detect wear and predict replacements, improving machine availability.

Overcoming Challenges in AI Adoption

While AI presents immense potential, its adoption in gearbox diagnostics comes with certain challenges mentioned below:

1. High Initial Investment: Deploying AI systems, sensors, and data infrastructure can be expensive. However, the long-term savings often outweigh the initial costs.

2. Data Management: Ensuring data quality, consistency, and security is critical for AI systems to perform optimally.

3. Skill Gap: Industry professionals need proper training to work alongside AI systems effectively and efficiently.

4. Integration with Legacy Systems: there are many existing gearboxes that lack the necessary infrastructure for AI integration, requiring retrofitting or upgrades.

Preparing for an AI-Driven Future

To fully leverage AI in gearbox diagnostics, gear industry professionals should:

1. Invest in Training: Equip teams with skills to interpret AI outputs and integrate them into maintenance workflows.

2. Collaborate with Tech Providers: Partner with AI solution providers to customise tools for specific operational needs.

3. Emphasize Data Quality: Develop robust data collection and management strategies to enhance AI model accuracy.

4. Adopt a Phased Implementation: Start with pilot projects to test AI systems' effectiveness before scaling across operations.

The Road Ahead

AI-driven diagnostics represent a paradigm shift in gearbox maintenance. As the gear industry embraces digitisation, AI offers a strategic advantage by improving reliability, reducing costs, and promoting sustainability. For professionals, staying ahead in this transformative era requires openness to innovation and a proactive approach to technology adoption.

The future of gearbox maintenance is not just about preventing failures—it's about empowering gear professionals to operate smarter, more efficiently, and more sustainably than ever before.

By adopting AI, the gear industry can align with modern manufacturing's demand for precision, agility, and environmental responsibility. As AI tools continue to evolve, their potential to redefine gearbox diagnostics and maintenance is limitless. For gear professionals, the time to embrace AI is now.

Interview with Mr. Parminder Singh, Country Head Design and Manufacturing & Media Entertainment – India & SAARC at Autodesk, for Gear Technology India

- By Nishant Kashyap

1. The manufacturing and design industries are undergoing a rapid transformation. What do you see as the key drivers of this evolution in India and the SAARC region?

Some of the key trends in the design and manufacturing industries are:

1. AI and Digital Transformation: Autodesk is leveraging AI and machine learning in its software solutions to enhance design capabilities and automate repetitive tasks. This includes tools like Autodesk Fusion 360, which integrates CAD, CAM, and CAE into a single platform.

2. Cloud as technology - Cloud technology is a key trend revolutionizing the design and manufacturing industries, enabling greater collaboration, scalability, and efficiency. By leveraging cloud-based solutions, companies can access powerful tools and resources without the need for significant upfront investments in hardware and infrastructure.

Autodesk is at the forefront of this transformation, offering innovative cloud-based platforms like Autodesk Fusion. Fusion integrates CAD, CAM, and CAE in a single platform, allowing for seamless collaboration and real-time data sharing among team members, regardless of their location. This not only accelerates the design process but also enhances the quality of the final product. These cloud-powered tools exemplify how we are helping design and manufacturing professionals to innovate, increase efficiency, and create more sustainable products.

3. Smart Manufacturing: Autodesk supports the adoption of smart manufacturing practices by providing advanced manufacturing software solutions that integrate with IIoT and other Industry 4.0 technologies.

4. Additive Manufacturing: Autodesk offers solutions like Autodesk Netfabb, which supports additive manufacturing processes, enabling efficient and innovative product development.

5. Workforce Development: Autodesk is firmly committed to helping solve the skills gap problem and prepare the next generation for the jobs of today and tomorrow. We deliver on this commitment by providing free access to our full portfolio of professional-grade software to accredited institutions. Infact, in November this year, we entered into a MoU with IIT Bombay. The collaboration will combine Autodesk's industry expertise with IIT Bombay's leadership in education, research, and innovation. The objective is to train and provide skills to top talent, support India's growth, and shape the country's technical and scientific landscape.

6. Supply Chain and Product Lifecycle Management: Autodesk's software solutions, such as Autodesk Fusion Lifecycle, help streamline supply chain management and product lifecycle processes, enhancing overall efficiency.

7. Tool path generation on cloud - Autodesk is pioneering tool path generation on the cloud, revolutionizing the way manufacturers approach CNC machining and other automated processes. By utilizing cloud-based solutions like Autodesk Fusion, users can generate, simulate, and optimize tool paths in a highly efficient and collaborative environment.

This cloud-centric approach allows for real-time data processing and sharing, enabling teams to work together seamlessly from different locations. The advanced capabilities of Fusion as platform and Data models leverage Autodesk's powerful cloud computing infrastructure to perform complex calculations quickly, reducing the time required for tool path creation and iteration. This not only enhances productivity but also ensures higher precision and quality in the manufacturing process.

2. What are your thoughts on the evolving role of advanced technologies like AI and generative design in shaping the future of manufacturing and design industries?

When it comes to AI, we're seeing users leverage AI to iterate on concepts faster, and determine best exterior designs based on performance needs. AI can help come up with the best solutions for manufacturability, parts consolidation, and material usage in vehicles based on performance, cost and sustainability targets. We're already seeing AI-driven design tools gain mass acceptance as they can help conceptualize these possibilities and streamline the design process by automating repetitive tasks. Also, AI can enhance decision-making across the factory.

Speaking of AI from the lens of design, I feel, in the short term, AI will enable companies and governments to make better decisions earlier in the process. In the long-

term, we believe that AI can augment creative exploration and problem-solving, automate tedious and repetitive work and analyse project data to offer predictive insights --making it easier for users to innovate without needing extensive technical skills. For example, designers can now evaluate multiple options earlier on in the design process with Autodesk's design and make platform rather than prototyping all, manufacturers can now generate tool path from drawings, designers can automatically constraint sketches using AI.

3. Sustainability has become a critical focus across industries. How can technology play a more significant role in enabling sustainable practices in manufacturing and design?

We believe that technology will always be one of society's most powerful catalysts for progress. Autodesk's mission—to help everyone, everywhere, design and make anything—drives us to develop powerful solutions that help our customers tackle the world's biggest challenges. Today's advances in digital transformation, cloud-connected technology, and generative AI will yield monumental changes in how we design and make our world. As a trusted partner to our customers and ecosystem, we ensure that the innovators and creators building our future have the best tools to do so. Empowering people to design, collaborate, build, and fabricate in ways that improve productivity–while also reducing waste, saving money, and staying competitive–is the goal behind our sustainable design technology. Our software harnesses the power of automation to achieve business and sustainability goals.

Autodesk offers a range of tools and solutions that help extend product lifecycles and minimize waste through sustainable and circular design practices. Here are some ways in which Autodesk supports these goals:

- Generative Design: Autodesk's generative design tools use AI and machine learning to generate multiple design alternatives based on specified constraints and goals. This allows designers to optimize for material efficiency, reduce weight, and minimize waste, leading to more sustainable products.

- Lifecycle Assessment (LCA): Autodesk tools like Fusion and Revit include features for conducting lifecycle assessments. These assessments help designers understand the environmental impact of their materials and processes, enabling more informed decisions that reduce negative environmental impacts throughout the product lifecycle.

- Material Optimization: Autodesk's design software offers material optimization capabilities, allowing designers to select materials that are more sustainable and have lower environmental impacts. This includes the ability to simulate and analyse the performance of different materials, helping to reduce waste and improve recyclability.

- Digital Prototyping and Simulation: Autodesk's digital prototyping tools enable designers to create and test virtual models of their products. This reduces the need for physical prototypes, minimizing material waste and speeding up the design process.

- Additive Manufacturing: Autodesk supports additive manufacturing (3D printing) through tools like Netfabb. Additive manufacturing produces less waste compared to traditional subtractive manufacturing methods, as it builds products layer by layer, using only the necessary amount of material.

- Product Lifecycle Management (PLM): Autodesk's PLM solutions provide comprehensive tools for managing the entire product lifecycle. This includes capabilities for tracking product usage, maintenance, and end-of-life processes, ensuring that products are used efficiently and sustainably throughout their lifecycle.

- Design for Disassembly: Autodesk's tools support design for disassembly principles, allowing products to be easily taken apart at the end of their life. This facilitates recycling and reuse of components, reducing waste and extending the lifecycle of materials.

- Sustainability Analysis: Autodesk's tools offer sustainability analysis features, environmental impact analysis in Fusion. These features help designers assess and improve the sustainability of their designs, leading to more efficient and environmentally friendly products.

By leveraging these tools and solutions, Autodesk helps designers and manufacturers create products that are more sustainable, have longer lifecycles, and generate less waste. This supports the principles of circular design, where products are designed to be reused, refurbished, and recycled, contributing to a more sustainable future.

4. With AI becoming more prevalent in design and manufacturing, what challenges do you foresee in its adoption, and how can they be mitigated?

As AI becomes more prevalent in design and manufacturing, several challenges may arise:

- Workforce Resistance and Skill Gaps: The current workforce may lack necessary AI skills that will prevent them being relevant to current and future skills demands in the manufacturing sector.

- Data Quality and Integration: AI requires high-quality data; poor data can lead to errors. Also, integrating AI with existing systems may not be easy.

- Cost and Resource Constraints – Adoption of AI requires significant upfront costs and requires sufficient time and expertise for AI centric projects.

- Ethical and Regulatory Concerns: Its important to have the defined ethical and regulatory framework to protect data privacy, security and bias.

Some of the ways to address these challenges are:

Training and Change Management: upskilling and training the workforce is critical.

Data Quality and Integration: Establish practices to ensure data quality and consistency. Use experienced IT professionals for smooth AI integration.

Ethical and Regulatory Compliance: Develop transparent, fair, and accountable AI guidelines. Staying informed and conducting regular audits for compliance would prove helpful.

In summary, addressing these challenges through strategic planning and proactive measures will enable successful AI integration in design and manufacturing, driving innovation and growth.

5. Beyond AI and generative design, what other technologies or methodologies do you think are reshaping the future of design and manufacturing?

a. AI and machine learning – We'll continue to see AI transform industries, and ultimately help India address those capacity challenges and do more with less.

b. AR and VR – These tools are profoundly changing how design and make professionals interact with their data and collaborate in a remote environment. AR and VR provide a connected, immersive workspace where AEC professionals can work together in real-time on their 3D models, streamlining the design review process, improving communication and understanding, and reducing errors and rework costs. This leads to higher quality design decisions and better stakeholder alignment.

6. Precision and performance are at the heart of gear manufacturing. How can technologies like simulation, topology optimization, and advanced CAM tools help in achieving these goals?

6. Autodesk has a diverse portfolio spanning multiple industries. How do you see the integration of tools like BIM, simulation, and cloud-based platforms driving innovation across sectors?

At Autodesk, we offer a comprehensive suite of tools designed to support manufacturers in ensuring traceability within their operations. Here are some key features that help achieve this:

- Product Lifecycle Management (PLM): Autodesk's PLM solutions enable manufacturers to track and manage the entire lifecycle of a product, from inception through engineering design and manufacturing, to service and disposal. This ensures that every stage of the product development process is well-documented and traceable.

- Digital Prototyping: Tools such as Autodesk Inventor allow manufacturers to create and test digital prototypes of their products. This reduces the need for physical prototypes and ensures that all design changes and iterations are recorded and traceable.

- Data Management: Autodesk Vault provides powerful data management capabilities, enabling manufacturers to securely store and manage their engineering data. This includes version control, which ensures that all changes to design files are tracked and traceable.

- Manufacturing Execution Systems (MES): Autodesk's MES solutions help manufacturers track production processes in real-time. This includes monitoring the usage of materials, labour, and equipment, ensuring that all aspects of the manufacturing process are recorded and traceable.

- Quality Management: Autodesk's solutions support quality management processes by enabling manufacturers to document quality checks and inspections. This ensures that any defects or issues are recorded and can be traced back to their source.

- Supply Chain Management: Autodesk's tools help manufacturers manage their supply chains by providing visibility into the sourcing and movement of materials. This ensures that all materials used in production can be traced back to their origin.

Overall, Autodesk's suite of tools provides comprehensive support for traceability in manufacturing operations, allowing manufacturers to maintain detailed records of their processes and products, thereby enhancing accountability, compliance, and quality assurance.

Parminder Singh
Country Head, Autodesk Design & Manufacturing, Media & entertainment

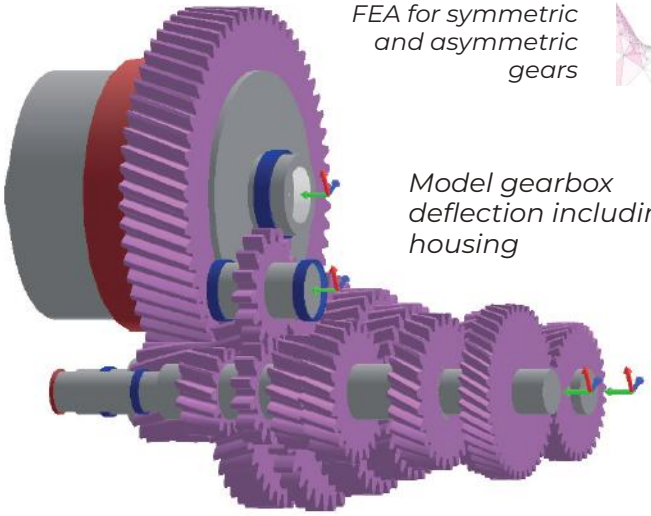
Parminder Singh is the Country Head for Autodesk's Design & Manufacturing and Media and Entertainment verticals in India & SAARC. With over two decades of experience spanning across the manufacturing, consumer packaged goods (CPG), automotive, aerospace, and telecommunications sectors, Parminder has been instrumental in driving digital transformation for enterprise organizations. His expertise lies in creating value propositions, leading teams, devising strategies for customer win-backs, stakeholder management, and building partnerships with CXOs across India.

Dontyne

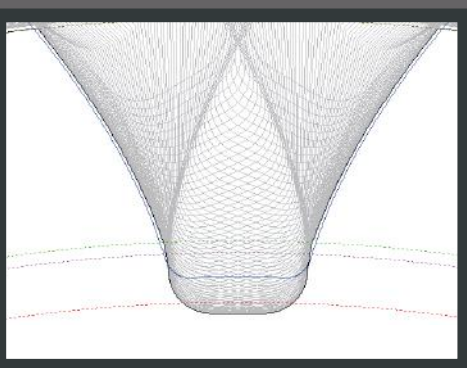
Systems

Automatic tool designs and simulations for Hobbing, Continuous Grinding (with dressing),Shaping, Shaving, Profile Grinding, Skiving, Honing, End Mill or Face Mill, Forging, Injection Moulding.

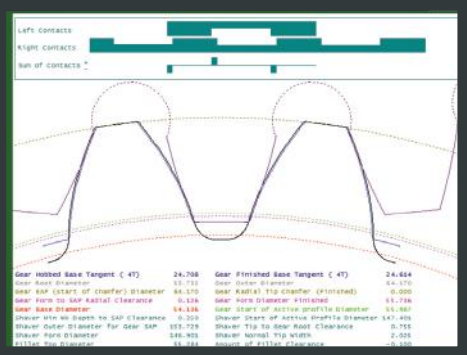
FEA for symmetric and asymmetric gears



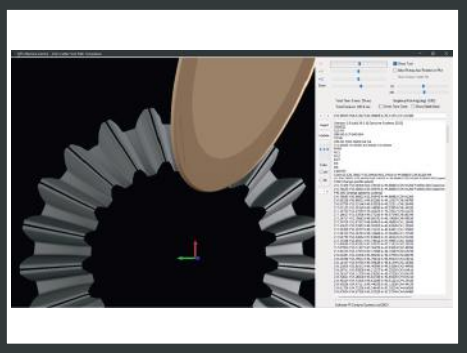
Model gearbox deflection including housing



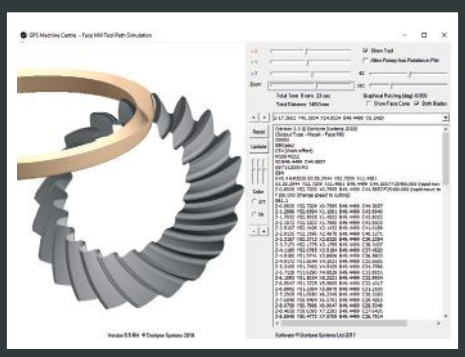
Hob / Grind Roll Out



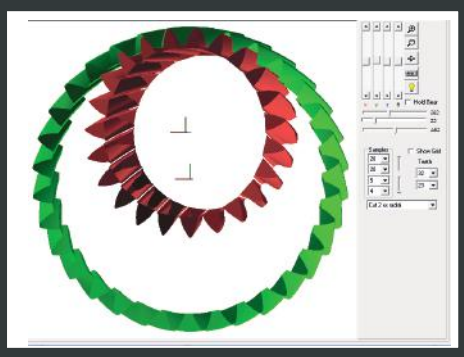
Shaving' and Shaping



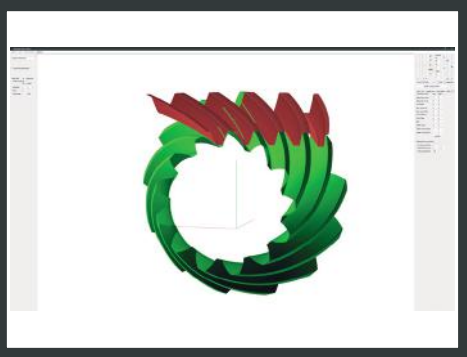
Coniflex CNC



End Mill / Face Mill CNC



Skiving



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Impacts on Gear Machining in the Era of Regenerative Braking

- By Vivek Singh

"As the automotive market calls for more hybrid vehicles, gear manufacturers must design for cyclic loads on gears."

Regenerative braking technology allows electric and hybrid vehicles to recover kinetic energy while braking and convert it to electrical energy stored in the battery. This technique uses electric motors as generators, with innovative gear systems facilitating efficient energy transmission. Precision gear systems are crucial because they optimise torque delivery, reduce losses, and enable smooth interaction with motor systems. As a result, the shift toward regenerative braking has increased the demand for improved gear machining and tool-making technologies. Precision gear manufacturing and cutting tool companies play a critical role in advancing technology through tighter tolerances, novel materials, and enhanced manufacturing processes. This demand underscores their role in advancing braking system performance and enabling energy-efficient automotive solutions.

The Role of Gears in Regenerative Braking

Regenerative braking absorbs kinetic energy during deceleration and converts it into electrical power rather than releasing it as heat. This technique enables electric and hybrid vehicles to recharge their batteries, hence increasing energy efficiency and driving range.

Gears play an important part in regenerative braking systems, as their functions allow for effective energy conversion and provide stable vehicle performance. It connects the vehicle's wheels and motor when braking, converting rotational motion into electrical energy with little loss. Systems such as planetary gears or multi-speed gearboxes are designed to control energy transfer at changing speeds. In addition, gears limit torque fluctuations while braking, enabling for smooth transitions and reliable deceleration by adjusting in real-time to ensure constant performance without abrupt shifts.

Another important factor to consider is durability, as repeated braking cycles put a lot of stress on gears. Gears must be made with high-performance materials, innovative surface treatments, and precise manufacturing techniques to ensure long-term reliability and minimal wear. Meeting these technical needs is critical for gear manufacturers and toolmakers, as innovation and engineering perfection, directly impact regenerative braking system performance and efficiency.

Changes in Machining Technologies

Regenerative braking systems place new demands on gear makers, necessitating advances in machining technology. One significant difference is the requirement for higher precision and tighter tolerances. Gears must work under variable torque conditions with minimum energy waste, necessitating exceptionally tight tolerances for consistent performance during multiple deceleration cycles.

Owing to the cyclical pressures inherent in regenerative braking, these systems prioritise higher-strength, high-performance materials. Gears must survive numerous load cycles, resist wear, and retain structural integrity in dynamic environments. This has required toolmakers to modify machining procedures to handle these new materials while maintaining their qualities during production.

New gear designs are also being developed to prioritise optimising energy conversion, minimising friction losses, and fulfilling dynamic torque requirements. Machining these complicated shapes required advanced and novel manufacturing techniques. While CNC machining is critical to these improvements, 3D manufacturing is also being implemented to provide more design flexibility and precision while costing repeatability. Modern CNC technology enables the efficient manufacturing of complex gear designs while maintaining consistent quality and meeting high-volume production requirements.

Specialised Tooling for High-Performance Gear Production

Achieving gears with lightweight designs, higher durability, and micro-geometries necessitates modern and specialised machining techniques to handle the unique problems of producing regenerative braking gears.

Making use of carbide-based cutting tools with sophisticated coatings such as titanium nitride (TiN) and diamond-like carbon (DLC) is crucial for extending tool life, reducing wear, and ensuring high machining precision.

These cutting tools are engineered for greater strength, allowing continuous performance across multiple cycles without degradation. Similarly, specialised tool geometries and custom profiles are designed to handle the complex gear features required by regenerative braking systems. Advanced precision grinding methods are fundamental since they ensure the final tooth profiles.

Advanced precision grinding methods are also required to ensure that the final tooth profiles are produced with ultra-tight tolerances and flawless surface finishes. This reduces operational vibrations and energy losses while increasing fatigue resistance during repeated braking scenarios. Furthermore, after machining, specialised surface treatments such as carburisation and nitriding are used to optimise material characteristics, improve wear resistance, and lengthen gear life.

These developments in cutting tool design, precise grinding, and surface treatments are critical for developing regenerative brake gears that can efficiently transfer torque, cycle repeatedly, and provide optimal energy performance.

Material compatibility has become a primary priority as gears are increasingly manufactured from high-strength steels, lightweight composites, and wear-resistant alloys. Machining methods must adapt to accommodate the specific features of these new materials while maintaining precision and efficiency.

Micro-machining for smaller gear designs has emerged as a significant technological development. EV braking systems require ultra-miniaturized, high-precision gears, thus toolmakers are incorporating modern techniques such as laser cutting and micro-grinding to achieve these requirements. These approaches provide unprecedented accuracy while creating complicated micro-geometries required for energy-efficient braking cycles.

Toolmakers are implementing advanced automation, adaptive tooling, and AI-driven process monitoring to meet production efficiency needs. These solutions aim to lower cycle times while maintaining quality, ensuring manufacturing scales up to meet the increased demand for EV vehicles and their regenerative braking systems. Tools and technologies like smart tooling systems are central to addressing these trends while maintaining quality and consistency at scale.

Challenges and Opportunities for Gear Manufacturers in the Regenerative Braking Landscape

The switch to regenerative braking systems is altering the needs of gear machining and tool-making industries, posing both barriers and opportunities. One of the most important difficulties is to meet the growing demand for precision and performance in high-performance regenerative braking systems. These systems rely on ultra-tight tolerances and complex gear shapes, mandating that toolmakers adapt traditional machining processes to modern ones, and sophisticated material standards. Also, the production expenses connected with specialised gears and novel tooling methods increase the stress.

However, these obstacles present incredible opportunities. Tool manufacturers can maintain competitive advantages while meeting these technical demands by adopting to new technologies such as additive manufacturing, micro-machining, AI-driven processes, and automation. Emerging trends, such as enhanced coatings and smart tooling procedures, enable production efficiency, waste reduction, and quality improvement.

Furthermore, solid supply chain alliances with carmakers migrating to regenerative braking constitute a strategic growth opportunity. These collaborations can shorten production timeframes and encourage innovation, benefiting all parties involved. Strategic R&D investments, focusing on next-generation tooling and adaptable manufacturing solutions, enable tool manufacturers to lead in this dynamic market. Gear makers can maintain relevance and competitiveness in the regenerative braking gear industry by tackling technological difficulties through innovation and strategic adaptation.

Thoughts for Readers

Regenerative braking has a huge impact on gear manufacturing processes. It has created a demand for specialised tools, improved machining processes, and technologies that can provide longevity, reliability, and performance throughout several braking cycles. Changes such as the use of AI-driven technologies, sophisticated micro-machining, and adaptive tooling are influencing how gear manufacturers and toolmakers respond to these trends.

To support the expansion of the electric vehicle sector, toolmakers must prioritise innovation, adaptation, and strategic investments in sophisticated technology. Gear tool producers now play a critical role in material compatibility strategies, innovative surface treatments, and smart manufacturing solutions. Innovation will be key to success as the industry shifts to regenerative braking systems. Toolmakers can ensure their relevance and competitiveness in the evolving automotive landscape by addressing technological challenges and opportunities with precision and strategic focus.

Precision in Motion: Exploring Gear Generation and Profile Teeth Grinding

- By Himanshu Jain

In recent years, achieving high gear accuracy has become a paramount priority in ensuring optimal performance across various applications. For instance, the automotive industry is undergoing a significant transformation with the rapid adoption of electric vehicles (EVs). Projections indicate that EVs could account for approximately 42% to 58% of global car sales by 2030.

In EVs, noise reduction is a significant concern. The absence of an internal combustion engine makes other noises, such as gear noise, more noticeable. The precision of gears is crucial in minimizing this noise, and grinding processes play a major role in achieving the necessary accuracy.

This article explores two key grinding methods—Gear Generation Teeth Grinding and Profile Teeth Grinding delving into their principles, applications, and guidance on selecting the appropriate method for specific scenarios.

Generation Gear Grinding

Generation Gear Grinding

SLN	Factor	Generation Gear Grinding	Profile Teeth Grinding
1	Workpiece Size	Ø10 to Ø 500 mm Module 0.5 to 8	Ø150 to Ø 5000 mm Module 0.5 to 50
2	Grinding Wheel	Grinding worm Multistart (1 to 7 start)	Single Rib profile wheel Gap by Gap tooth Grinding
3	Lead Crowing Achieve	5–20 µm	10–80 µm or more.
4	Root Grinding Capability	No, root grinding is not feasible	Yes, allows precise root modifications
5	Surface Finish Classification	DIN 5-7, AGMA 11-13	DIN 4-6, AGMA 12-14
6	Production Volumes	High Volume, Mass production	Low to Medium volumes, Specialized Gears
7	Precision	Good, but slightly less precise than profile grinding	High, suitable for high-accuracy gears
8	Cycle Time	Shorter, due to continuous rolling action	Longer, as it grinds individual teeth
9	Cost	Lower per unit for large production runs	Higher per unit due to slower process and precision
10	Application	Automotive, Industrial etc.	Wind Power, Ship Builder, Aerospace etc.

Based on the comparison above, we can determine the most suitable grinding method for our part by considering factors such as production volume, gear design complexity, precision requirements, and cost efficiency.

Generation Gear Grinding

When designing and manufacturing gears with generation teeth grinding, key factors such as gear geometry, material selection, and critical decisions about machine choice, fixture design, and heat treatment methods are crucial to optimize the process for quality, performance, and cost-effectiveness.

1. Machine Selection-

- Based on Gear Data (Max Diameter, Module, Max Length etc.)
- Max Allowable Grinding Wheel Diameter, Speed
- Max Rotary table load
- Automation: No of spindles (2), If high volume production to save loading- unloading time.

2. Fixture Selection-

- Hydraulic (Cost high, Shorter time)
- Mandrel (Low Cost, Longer time compare to Hydraulic)

Fixture directly impact on process parameters, so choose fixture according to volume.

3. Stock Allowance Per Flank-

- Depends on deformation after Heat Treatment.
- Finalize stock allowance based on module and tip diameter of part.

The theoretical stock allowance per flank typically ranges from 0.10 mm to 0.50 mm. If heat treatment (HT) causes significant deformation, a deformation factor should be applied based on the extent and shape of the part. For example:

- Solid gears tend to have less deformation during HT.
- Thin-walled parts experience higher deformation during HT.

Adjust the deformation factor accordingly to ensure that an adequate stock allowance is maintained for grinding.

4. Number of Strokes-

- Larger stock allowance requires more passes.
- In some cases, multiple passes help manage the wear of the grinding wheel, ensuring consistent cutting performance.

Stock Allowance	0.12 mm	0.18 mm	0.24 mm	0.30 mm	0.36 mm	0.42 mm	0.50 mm
No of Strokes	2	3	4	5	6	7	8

Typically, the last 1–2 passes are reserved for finish grinding, where a reduced feed rate is used. This approach ensures a finer surface finish and achieves the desired precision without excessive material removal.

5. No of Start- In generation grinding

The number of starts on the grinding wheel refers to how many cutting edges are actively engaged during the process. Here's how to decide:

- Single-start: Used for fine grinding or high-precision applications where surface finish and profile accuracy are critical. This setup provides better control but slower material removal.

- Multistart - Choose a number of starts that does not evenly divide the number of teeth on the gear.

Example- No of Teeths= 27, No of Start= 2 or 5

6. Process Parameters

After determining the above variables in the grinding process, the next step is to set the process parameters accordingly. (Grinding worm RPM & Feed)

- Larger Tip Diameter: Requires lower RPM to avoid excessive heat and wear.

- Smaller Tip Diameter: Requires higher RPM to achieve the desired cutting speed and material removal.

- Larger Module (larger teeth): Needs lower RPM to maintain proper cutting conditions.

- Smaller Module (finer teeth): Needs higher RPM for efficient material removal.

7. Dressing & Dresser type

In gear generation grinding, selecting the right dressing tool is essential for achieving high-quality results.

1. Double Radius Form Roll

2. Single Taper Disc

3. Double Taper Disc

4. Composite Diamond Roll

5. Profile Diamond Roll

The Double Taper Disc is widely used due to its high precision, longer life, and stability, making it ideal for consistent dressing and superior surface finishes. The dressing cycle and grinding wheel RPM should be selected based on the dresser type and desired part quality. Proper selection ensures optimal performance, tool longevity, and a high-quality finish.

Note: Ensure the use of appropriate process parameters to prevent common issues such as grinding burns and chatter marks on gear teeth.

Profile Gear Grinding

To produce parts using profile grinding, it's essential to focus on factors such as the part type and its geometry. Based on these, select the appropriate machine and grinding wheel type. Next, consider parameters like stock allowance, grinding approach, specific material removal rate (Qw), axial feed, and chip volume (Vw) to determine the optimal dressing cycle.

We will explore what needs to be adapted at each stage of the part during profile grinding.

1. **Machine Selection**- The selection of the machine should be based on the part geometry, grinding wheel size, and required accuracy to ensure precise grinding and optimal results.

2. **Selection of Grinding Wheel**- The selection of a grinding wheel depends on factors such as the material type (harder materials need CBN or diamond), abrasive type (e.g., aluminium oxide for general use), grain size (finer for finishing, coarser for roughing), bond type (vitrified for precision, resinoid for flexibility), and wheel hardness (softer for hard materials). Additionally, consider the wheel shape, grinding process, and required surface finish. Proper wheel selection ensures efficient grinding and achieves the desired part quality.

3. **Stock Allowance**- In profile grinding, it's essential to define the theoretical stock allowance and deformation factor based on the heat treatment process (e.g carburizing or nitriding). Stock allowance typically ranges from 0.1 mm to 0.7 mm, depending on factors such as the heat treatment process, tip diameter, module, and part geometry.

4. **Material Removal Rate (Qw)** - Depend on Module & Heat treatment method.

- **Carburizing Parts:** Material removal rate (Qw) ranges from 5-16 mm³/mm/sec.
- **Nitriding Parts:** Material removal rate (Qw) ranges from 5-9 mm³/mm/sec.
- **Module Consideration:** The appropriate and adaptable Qw can be defined based on the module for efficient material removal.

5. Axial Feed

Based on factors like material type (softer materials allow higher feed), grinding wheel type (harder wheels need slower feeds), surface finish requirements (slower feed for finer finish), part geometry (complex shapes need slower feed), material removal rate (Qw), and machine stability. Balancing these factors ensures effective grinding while maintaining precision and part quality.

Feed ranging from- 4000- 5500 mm/min

6. Chip Volume

For the roughing cycle, higher chip volume (Vw) is used, influenced by factors like larger module, heat treatment, diameter, and face width to remove more material quickly. In the finishing cycle, lower chip volume is preferred to achieve a smooth surface finish, with smaller chip volumes influenced by smaller module, heat treatment, diameter, and narrower face width. Roughing focuses on efficient material removal, while finishing prioritizes precision and surface quality.

Roughing Vw – 2500-6000 mm3/mm
Finishing Vw= 200-350 mm3/mm

So based on decided chip volume we can calculate after how many no of teeth we can dress the wheel in each cycle by using below formula-

Number of teeth's ground until dressing cycle= Vw/(ae X Z)
Vw= Chip volume (mm3/mm)
ae= Total radial infeed (mm)
Z= Face width of gear (mm)

7. No of Passes

Generally we followed the profile grinding by 2 passes (Roughing & Finishing)

Roughing Pass- We need to define no of strokes based on Rouging stock (from total stock we need to keep 0.04 to 0.05 mm for finish) rest we need to remove in roughing cycle.

Example= Total stock allowance= 0.34 mm

Roughing Stock= 0.295 mm Calculate Infeed normal per flank for roughing

$$\frac{(Qw \times \sin(\text{Pressure angel}) \times 60)}{(\text{Axial Feed})}$$

Total Stock/Infeed stock = No of strokes in roughing.

For Example, Qw= 6
Pressure Angle= 25° (Radian= 0.436)
Axial Feed= 4500

Infeed Normal per flank= 6 x 0.436 x 60/ 4500= 0.034 mm

Roughing Strokes= 0.295/0.034= 9 strokes
Finish Stock= 0.045 mm (here use 2 strokes max)

8. Grinding Approaches

We need to determine the appropriate grinding approach based on the desired final quality of the part.

Grinding Approach	Generation Gear Grinding	Profile Teeth Grinding
Double Flank Completely	Yes	<0.035
Double Flank Roughing+Single-Flank Finishing	Yes	0.035 to 0.055
Single Flank Completely	Yes	0.055 to 0.080
Double Flank Roughing+Single Flank Roughing+Single Flank Finishing	Yes	>0.025 +Root Grinding
Double Flank Completely	No	<0.015
Double Flank Roughing+Single Flank Finishing	No	0.015 to 0.035
Single Flank Completely	No	0.035 to 0.060

Once all the process parameters and approaches are set, we are ready to begin profile grinding. Before starting, ensure proper **stone positioning** to achieve optimal grinding contact and accuracy. It's also essential to closely monitor the process to avoid issues such as **grinding burn**, which can affect part quality. Keeping track of factors like grinding wheel sharpness, coolant flow, and feed rates throughout the process will help prevent overheating and maintain surface integrity. By following these precautions and maintaining close control over the grinding process, you can achieve the desired profile with high precision and minimal defects.

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The Performance Standard: GearSkiving from LMT Fette with Process-reliable Simulation

- Product Report

LMT Tools provides high-performance and process-reliable Gear Skiving tools that guarantee top performance in the production of internal and external gears thanks to their special combination of excellent cutting edge preparation and individual process simulation.

In gear skiving, the tool is at an angle to the axis of the workpiece to be machined. This so-called cross-axis angle in conjunction with a synchronous movement between the tool and workpiece axes as well as an axial feed form the gear teeth. It is a very precise and fast process, but places high demands on the tools used. If these are not optimally designed, wear occurs very quickly as a result of the process. As a leading specialist in gear cutting tools, LMT Fette is now driving forward the development of high-performance solutions. Specially developed simulation software supports the path from the customer drawing to safe and successful tool use.

Simulation creates reliability

The complex multi-cutting strategies typical of the process often lead to a time-consuming path to the final good part. The software allows a detailed assessment of the relevant process parameters already in the design phase, taking into account the respective customer requirements. In this way, all difficulties can be eliminated in advance and the ideal tool can be developed and created as early as the simulation process. This creates reliability, both for the tool manufacturer and the customer, and leads to more efficient tool and process layouts.

Optimal adaptation of macro and micro geometry

Gear skiving requires particularly durable high-performance cutting edges because the continuously changing machining conditions lead to very high stress on the tool cutting edge. LMT Fette therefore relies on an innovative process for gear skiving cutting edge preparation. Targeted rounding ensures greater ease of cutting and also has a positive effect on wear behavior and thus tool life. In combination with a specially designed cutting geometry, a protective hard coating and a substrate made of powder metallurgical steel, the customized tool solutions set standards in terms of efficiency and machining reliability.

New performance standards in gear skiving

With its high performance and wide range of applications, gear skiving offers great potential for the production of internal and external gears and is clearly superior to conventional manufacturing processes in many cases. For example, it enables faster machining times than hobbing, offers a wider range of applications than gear hobbing and, thanks to lower tool costs and the elimination of special machines, also has an advantage over broaching.

LMT Fette manufactures all gear skiving tools using the closed-loop method (grinding process, measurement, calculation of correction values). The result is a high-precision cutting wheel that is precisely matched to the customer-specific process and meets the highest requirements for quality, economy and process reliability.

Future of Gear Performance: Emerging Trends in Surface Engineering

- By Vivek Singh

Each gear's surface reflects a story and accounts for its performance. It's where friction reduces efficiency, contact stress tests durability, and even little defects might lead to failure. In industries like automotive and aerospace, where gears have to endure high loads and function in severe conditions, the surface is more than just a coating; it is a foundation of reliability.

Surface engineering has the ability to change the way gears work by solving these pressing performance factors. Advanced procedures such as plasma nitriding, laser surface texturing, and cryogenic treatment improve wear resistance, minimise friction, and extend fatigue life. These approaches allow gears to withstand extreme working conditions while remaining precise and efficient. Surface treatments were given top priority by gear makers. It is the key to manufacturing resilient, high-performance components that satisfy the ever-increasing demands of current applications.

Why Gear Surface Matters

The surface of a gear plays a pivotal role in determining its performance and longevity. Surface engineering techniques address critical issues like wear, friction, and fatigue, directly impacting how efficiently a gear operates and how long it lasts.

The gear surface directly affects is performance and durability since it directly affects wear resistance, friction, and fatigue. Advanced surface engineering approaches address these issues, ensuring it perform efficiently and survives longer. One of the key advantages of surface engineering is increased wear resistance. Plasma nitriding is a treatment that hardens the surface of the gear, minimising material loss and increasing its lifespan. This leads to minimal maintenance requirements and stable performance throughout time. In addition, processes like laser surface texturing and specialised coatings greatly minimise friction, resulting in smooth and efficient power transmission. This is especially important for high-speed applications, as slight inefficiencies can have a big impact. Even the economic and operational benefits of surface engineering are compelling. The surface treatments techniques extend the service life of a gear, lowering downtime and replacement costs while ensuring operation at all times. Also, treated surfaces are better able to withstand harsh circumstances such as high loads, variable temperatures, and abrasive environments, making them essential for industries such as aerospace, automotive, and heavy machinery.

Surface engineering solutions are critical for manufacturers in developing gears that fulfil strict performance standards while also providing long-term economic benefits. These developments not only improve gear reliability but also highlight their importance in modern industrial applications.

Key Surface Engineering Techniques

Modern gear manufacturing uses advanced surface engineering techniques to improve performance and life expectancy. The following are some of the most effective approaches for meeting the specific requirements of industrial applications.

Laser Surface Texturing(LST)

Laser Surface Texturing uses precision lasers to create micro-textures on the gear surface. These micro-textures function as lubricant reservoirs, minimising friction and wear during operation. The procedure is carefully regulated, resulting in homogeneous surface alterations without compromising the gear's structural integrity. LST is especially successful in high-speed or high-temperature applications, such as car transmissions and aircraft mechanisms, where lubrication efficiency is crucial.

Plasma Nitriding

Plasma nitriding is a thermochemical treatment that introduces nitrogen ions onto the gear surface. This method increases surface hardness, wear resistance, and fatigue strength while creating minimal dimensional deformation. The technology is extensively employed in industries where gears must tolerate significant contact stress, such as heavy machinery and robotics. Plasma nitriding is preferred because it may create a harder surface layer while maintaining the gear's core ductility.

Cryogenic Treatment

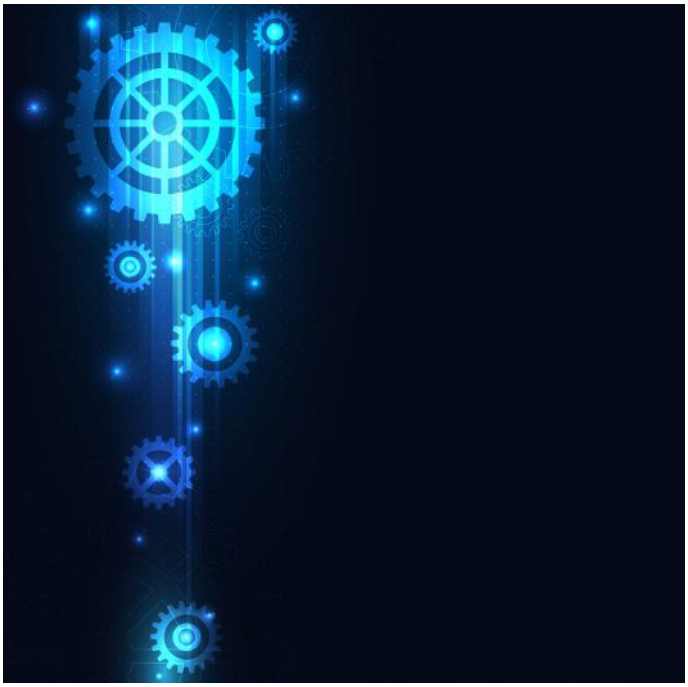
Cryogenic treatment involves chilling gears to extremely low temperatures, usually below -196°C, in order to stabilise their microstructure. This procedure decreases residual stresses while increasing the material's toughness and fatigue resistance. It also enhances wear qualities by finely distributing carbide, making it especially effective for gears subjected to cyclic loads or abrasive conditions. Cryogenic treatment is frequently used in combination with other surface treatments to improve overall performance.

Gear Surface Engineering for India's Unique Manufacturing Needs

India's different industrial and environmental conditions bring particular challenges and opportunities for gear surface engineering. Now the India Gear makers are also progressively using advanced techniques to address these specific needs.

Collaborations in Research and Development

Indian gear manufacturers are working with prestigious universities to create customised surface treatments and coatings. These collaborations are aimed at developing solutions that are suited to the country's tropical climate and high dust levels. For example, research into improved coatings, such as hydrophobic and wear-resistant layers, guarantees that gears stay efficient in damp and abrasive environments. This R&D-driven approach also encourages innovation in low-cost, scalable technology suitable for small and medium-sized industries.



Challenges and Solutions of Manufacturing Gears Locally

Indian industries experience different wear mechanisms caused by factors such as high ambient temperatures and particle exposure. These circumstances accelerate surface degradation, necessitating sophisticated coatings such as DLC (Diamond-Like Carbon) and specialised nitriding treatments. Manufacturers are also adopting hybrid technologies, which combine plasma treatments with cryogenic techniques, to improve wear resistance and longevity.

By focussing on localised solutions and collaborating on R&D, Indian gear manufacturers are overcoming operational issues while remaining competitive in global markets.

Performance Metrics in Gear Surface Engineering

- Wear Rates: Lower wear rates demonstrate the efficiency of coatings and surface treatments in extending gear life.
- Coefficient of Friction: A lower coefficient of friction indicates better lubrication efficiency, which reduces energy losses while enhancing overall gear performance.
- Gear Life and reliability: Improved surface treatments lead to longer gear life, lower failure rates, and greater dependability in high-stress applications.

Testing and Validation Methods

To confirm the efficacy of surface engineering, gear are put through thorough testing Tribological testing is one the common testing techniques which evaluates friction, wear, and lubrication efficiency under controlled settings, providing useful information on the long-term performance of treated gears. Additionally, fatigue resistance testing produces operational pressures to measure how well gears survive repeated loading and probable fracture or failure. These tests are critical for determining the durability and dependability of surface treatments, ensuring that gears fulfil the high-performance criteria required in demanding industrial applications.

Future Trends in Surface Engineering

As the demand for high-performance gears grows, surface engineering will increasingly rely on innovative techniques and technology. Here are some emerging techniques that can meet future needs for gear surfaces.

- Nano-Coatings: These ultra-thin coatings are extremely durable while still keeping the exact precision required for high-performance gears. Their capacity to reduce wear and friction will be critical for extending gear life.
- Multi-Functional Coatings: By combining wear resistance and self-lubricating qualities, these coatings improve gear efficiency, minimising the requirement for external lubrication and boosting performance in harsh situations.

Conclusion

Advanced surface engineering techniques, including nanocoatings, multifunctional coatings, and digital tools, are transforming gear manufacturing. These tech-

nologies improve wear resistance, reduce friction, and increase gear life, particularly in demanding applications such as aerospace, automotive, and robotics. To remain competitive, gear makers should adapt and incorporate developing surface engineering techniques into their manufacturing processes.

Continuous innovation, as well as the application of improved coatings and digital monitoring systems, will ensure the success and efficiency of gear performance over time. Surface engineering's precision will be critical to the future of gear manufacture. Manufacturers must spend in R&D to generate personalised solutions that meet the changing needs of industries. The dedication to improving surface engineering approaches will propel the next wave of innovation in gear technology.

Insights from Gear Technology India's 2024 Polls

- By Sushmita Das

Moving into an era of innovation and transformation, the gear industry finds itself at the crossroads of extraordinary advancements and evolving challenges with time.

Gear Technology India conducted several insightful polls throughout 2024 on LinkedIn to gauge the happenings of the industry, unearthing valuable perspectives from gear industry professionals and enthusiasts alike. Let's explore the results and check out the trends shaping the future of gears.

The Biggest Trend in the Gear Industry

In one of the polls, we asked, "What do you think is the biggest trend in the gear industry right now?" and the response was clear: **Electric Vehicle Integration** emerged as the frontrunner with 40% of the votes. This reflects the ongoing shift towards sustainable transportation and the critical role gears play in EV drivetrains. **Advanced Gear Materials** followed closely at 35%, highlighting the industry's focus on durability and performance. Interestingly, **AI and Automation** garnered 20%, showcasing the rising impact of smart manufacturing technologies. Only 5% chose **Sustainability Practices**, suggesting room for further growth in eco-friendly initiatives.

Key Factors in EV Gear Selection

The transition to electric vehicles brings unique challenges to gear manufacturing. When asked, "What's the most important factor when choosing gears for EVs?", the respondents prioritised **Noise Reduction** (60%), emphasising the demand for quieter operation in EVs. **Efficiency** came in second with 37%, reinforcing the need to optimise energy use. Surprisingly, **Durability and Cost** received minimal attention, suggesting they're either assumed or secondary concerns in EV-specific contexts.

Critical Aspects of Gear Manufacturing

In another poll, we asked, "What do you think is the most critical factor in gear manufacturing today?" An overwhelming 56% identified **Precision and tolerance Control** as paramount, a testament to the industry's drive for accuracy in high-performance applications. **Cost Efficiency** secured 22%, while **Material Selection and Innovations** received 11% each, underlining the balanced focus on quality and affordability.

The Heat Treatment Debate

Heat treatment remains a cornerstone of gear manufacturing, and we asked, "What is the most critical aspect of gear heat treatment?" The majority (54%) voted for **Reducing Distortion & Warping** as the top priority, reflecting the challenges of maintaining gear integrity during processing. **Achieving Uniform Hardness** (33%) and **Optimizing Cycle Time** (13%) followed, highlighting the dual goals of performance and efficiency. In a separate heat treatment poll, **Distortion Control** again led the results (42%), reinforcing its significance across applications.

Challenges with Bevel Gears

Bevel gears are indispensable but come with their own set of challenges. Respondents were clear: **Manufacturing Complexity** was the biggest hurdle, cited by 56%. Other concerns included **Design Limitations** (19%), **High Cost** (13%), and **Maintenance and Durability** (13%), painting a comprehensive picture of the obstacles faced by professionals.

AI's Role in the Gear Industry

Artificial Intelligence is redefining how we approach gear manufacturing. When asked, "What is the most impactful application of AI in the gear industry today?" a majority (50%) chose **Predictive Maintenance**, underscoring the importance of minimizing downtime and maximizing equipment lifespan. **Process Optimization** (21%), **Quality Control** (14%), and **Supply Chain** (14%) also demonstrated the diverse applications of AI in improving efficiency and reliability.
Opportunities for Collaboration

Finally, we were delighted to see unanimous enthusiasm in our poll asking, "Would you be interested in getting featured in Gear Technology India's e-magazine?" A resounding 100% said yes, affirming the industry's eagerness to share insights and achievements with the wider community.

Your Opinion Matters

The 2024 Tech Polls conducted by Gear Technology India offered a compelling glimpse into the shifting priorities, challenges, and opportunities within the gear industry. From the rise of electric vehicle integration to the critical focus on precision, noise reduction, and AI-driven advancements, these insights mark the industry's dynamic evolution and relentless pursuit of excellence.

As we step into 2025, the data serves as a roadmap for the future, highlighting where innovation, collaboration, and sustainability efforts are most needed. Gear professionals and enthusiasts alike have played a pivotal role in shaping these conversations, and their participation reflects a shared commitment to advancing the industry.

A Heartfelt Thank You

We extend our deepest gratitude to all who participated in these polls. Your votes and insights are invaluable, helping us understand the evolving landscape of the gear industry. Together, we're not only identifying challenges but also paving the way for innovation and excellence. Stay tuned for more engaging discussions and trends as we continue this journey of exploration and growth.

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.

Grind Master Showcasing Its Innovative Products At IMTEX 2025

- By PRODUCT REPORT

Microfinishing of Next Generation Automotive Shafts –
For - Motor Shafts for EV, Hybrid Vehicle Transmission Shafts, DCT Shafts

Grind Master NANOFINISH range of machines for microfinishing and superfinishing of Automotive Powertrain, Suspension and Steering parts is trusted by leading OEMs globally.

NANOFINISH Model CMX500 is a revolution in processing of high speed rotating shafts in next generation automotive powertrains which operate at much higher rpms than conventional powertrains.

Microfinishing not only improves the surface finish to stringent specifications, but also improves the geometry of the journals and reduces the noise levels in the powertrain. Applied to Motor Shafts – Rotor and Stator Shafts, Transmission shafts – Input and Output Shafts this process has been introduced by global leading OEMs after research in which Grind Master was a partner.

NANOFINISH machine range is built with ABSOLUTE ENGINEERING, resulting in high quality that reflects in form of process reliability and machine reliability. Equipped with NANOSMART control systems which have been appreciated by global customers, the modular product range is a trustworthy finishing solution platform for Automotive industry.

Product Writeup
ROLL Finishing Machines For Hydraulic Cylinders, Textile Rolls, Printing Rollers

Grind Master NANOFINISH SMP3000/SMP5000 Series is versatile solution for Finishing of heavy Rolls – upto 5000mm long, using a variety of modular configurable finishing process including –
Belt Grinding
Specialized Finishing Wheels
Superfinishing films

The machine is applied for hydraulic cylinder piston rod finishing for earth movers worldwide, producing the highest finishing standards. Fine finishing is a critical requirement before / after surface treatment for corrosion prevention, and increases the corrosion resistance tremendously. Performance of high pressure Hydraulic cylinder in terms of corrosion resistance, sealing, friction and life of cylinder depends so much on surface finish of piston rod

and telescopic cylinder tubes. Surface definition varies depending on the hydraulic pressure and the working condition in which cylinder is expected to perform. We have mastered the finishing processes to optimally achieve this result.

NANOFINISH machine range is built with ABSOLUTE ENGINEERING, resulting in high quality that reflects in form of process reliability and machine reliability. Equipped with NANOSMART control systems which have been appreciated by global customers, the modular product range is a trustworthy finishing solution platform for Hydraulics and other Roller manufacturing industry.

Product Writeup
Bearing Raceway Finishing Machine – for Cylindrical, Taper, and Spherical Ball Bearings

Grind Master NANOFINISH BRV Series is an excellent example of collaborative breakthrough Indian Technology Development, built for superfinishing of high precision bearing raceways for cylindrical roller, Taper roller and ball bearing raceways. Raceway superfinishing is a critical operation in the bearing industry, and hitherto most machines for this process have been imported from Europe or Japan. Finishing is required for both Inner Race (outer ring) and outer race (Inner Ring)

NANOFINISH BRV range provides a high quality Indian alternate that matches imported machines in build quality and process accuracy, while providing superior features especially from its intelligent control system. First machines of this series have already been installed and produced excellent results.

Raceway superfinishing for ball bearing raceways is mission critical with stringent surface finish and geometry requirements. By developing machines for this precision application Grind Master has become one of a handful of companies globally. The development of Ball bearing raceway finishing has been done in collaboration with AMTDC-IIT Madras under support from MHI, Govt. of India.

NANOFINISH machine range is built with ABSOLUTE ENGINEERING, resulting in high quality that reflects in form of process reliability and machine reliability. Equipped with NANOSMART control systems which have been appreciated by global customers, the modular product range is a trustworthy finishing solution platform for Hydraulics and other Roller manufacturing industry.

CalibroMeasure: Solving Manufacturing's Toughest Quality Inspection Challenges at IMTEX 2025

- Pre-event Report

What happens when inspection becomes a bottleneck? Delayed production, high rejection rates, and frustrated teams. At CalibroMeasure, we understand these pain points all too well. That's why, for over a decade, we've dedicated ourselves to building inspection solutions that don't just measure quality—they transform it.

With unmatched expertise and a sharp focus on Gear Metrology, CalibroMeasure has redefined what's possible in quality inspection. From automating the span measurement process—a feat rarely attempted in the industry—to introducing a highly economical Gear Roll Tester, we have consistently pushed the boundaries of innovation.

We don't stop at conventional solutions. When a client needed to measure PCD runout with respect to the non-holding datum of splines, we delivered a tailored solution that exceeded their expectations helping bring Standard room inspections to shopfloor. It's this commitment to solving unique challenges that makes CalibroMeasure a reliable partner for major exporters and precision component manufacturers worldwide.

At IMTEX 2025, we'll showcase how our advanced systems are making inspections faster, smarter, and more reliable for businesses that demand excellence. Whether it's simplifying multi-parameter inspections or delivering real-time feedback, we're here to transform how manufacturers approach quality.

Our Solutions:

- Gear Measurement Systems
- Multi-Gauging Solutions
- Customized Inspection Solution
- Automated Span/DOB Measurement
- Gear Roll Testers
- CNCtize Range - Digitizing existing fixtures.
- FlexGauge - Flexible in-line 3D gauging solutions

Let's meet at IMTEX 2025 and explore how we can help you achieve better quality, and faster delivery. Because at CalibroMeasure, quality isn't just a checkpoint—it's the promise of a job well done.

CNCTIZE DOB

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Self-Healing Gears: Materials of the Future

- By Sudhanshu Nayak

Mechanical systems have always faced a critical challenge—wear and tear. Gears, as the backbone of numerous industries, are no exception. Enter self-healing gears, a revolutionary approach combining advanced material science with engineering ingenuity. These gears promise to repair themselves, reducing downtime, extending operational lifespans, and paving the way for more efficient and sustainable mechanical systems.

The Science Behind Self-Healing Materials

At the heart of self-healing gears lies advanced material technology. Self-healing materials are engineered to autonomously repair damage caused by stress, friction, or impact. These materials are broadly classified into two categories:

- **Intrinsic Self-Healing Materials:** These possess inherent repair capabilities through reversible molecular bonds or dynamic chemical reactions. Heat or light often triggers these responses, leading to the reformation of broken bonds.

- **Extrinsic Self-Healing Materials:** These materials contain embedded capsules or networks filled with healing agents, such as adhesives or resins. When cracks appear, the agents are released, filling the voids and restoring structural integrity.

Bio-Inspired Self-Healing: Nature as a Mentor

Nature has always inspired innovation, and self-healing gears are no exception. Engineers have replicated these mechanisms in synthetic materials from tree bark that regrows after damage to human skin that regenerates. For example:

- **Vascular Networks:** Mimicking the circulatory system in organisms, researchers have developed gears with microchannels filled with liquid healing agents that flow to damaged areas upon fracture.

- **Self-Healing Polymers:** Similar to how skin forms a scab, polymers reform molecular bonds, sealing cracks when exposed to specific stimuli.

Applications in Modern Industries

The potential of self-healing gears extends across multiple industries:

1. Aerospace: In aerospace, where failure is not an option, self-healing gears can prevent catastrophic outcomes. For instance, in aircraft engines, where gear systems endure extreme stresses, self-healing materials ensure reliability, even in harsh conditions.

2. Automotive: The automotive sector can benefit significantly from reduced maintenance needs. Self-healing gears are especially useful in electric vehicles (EVs), where energy efficiency and durability are paramount.

3. Energy: Offshore wind turbines and oil rigs operate in remote locations, making frequent maintenance impractical. Self-healing gears reduce the need for interventions, ensuring continuous energy generation.

4. Defense and Space Exploration: In defence and space missions, where conditions are extreme, self-healing gears provide unparalleled reliability, reducing the need for human intervention or replacements during operations.

Recent Breakthroughs in Self-Healing Gear Technology

- Microcapsule Technology: Researchers are embedding microscopic capsules filled with repair agents into gear materials. These capsules rupture upon damage, releasing the agent to fill cracks and restore functionality.

- 3D-Printed Self-Healing Gears: Advances in additive manufacturing have enabled the creation of gears with embedded self-healing mechanisms, tailored for specific applications.

- Metallic Self-Healing Systems: Traditionally associated with polymers, self-healing capabilities are now being extended to metals, a critical material for high-stress gear applications.

Challenges and Limitations

The development and implementation of self-healing gears, while revolutionary, come with a set of technical, financial, and operational challenges that need to be addressed for broader adoption:

1. Cost of Materials

Self-healing materials, especially those incorporating advanced technologies like embedded microcapsules or self-healing polymers, are significantly more expensive than traditional materials. The production processes involved in integrating healing agents or creating dynamic bonds often require specialised equipment and expertise, driving up costs. This makes self-healing gears less accessible, particularly for smaller industries or cost-sensitive applications. Over time, economies of scale and advancements in manufacturing techniques could reduce these costs.

2. Efficiency of Healing

The effectiveness of self-healing materials depends on factors like the type and extent of damage, the speed of the healing process, and the working conditions of the gear. For instance:

- Time to Heal: In high-stress environments like aerospace or automotive engines, delays in the healing process can compromise the gear's functionality, potentially leading to catastrophic failure.
- Completeness of Repair: Some self-healing mechanisms may only partially restore the material's strength and integrity, leading to cumulative wear over time.

Researchers are actively working on improving healing efficiency through better material formulations and responsive triggers such as light, heat, or chemical activation.

3. Material Compatibility

Integrating self-healing materials into existing systems requires careful consideration to ensure compatibility with other components. For example:

- The material should withstand operational conditions like high temperatures, pressure, or exposure to corrosive environments.
- It must also maintain performance characteristics such as load-bearing capacity and wear resistance.

Achieving this balance between healing properties and mechanical robustness is a significant challenge for engineers and material scientists.

4. Environmental Adaptability

The functionality of self-healing mechanisms must extend across a wide range of environments. For instance:

- Extreme Temperatures: In aerospace or defence applications, gears might experience both sub-zero and high-temperature conditions. Healing agents or polymers need to remain effective across this range.
- Exposure to Moisture or Chemicals: Offshore wind turbines or underwater equipment require self-healing materials to resist water ingress and chemical corrosion while maintaining repair capabilities.

Adapting these materials to such diverse scenarios demands extensive testing and iteration.

The Sustainability Perspective

Self-healing gears have the potential to revolutionise mechanical systems by significantly contributing to environmental sustainability. One of the primary benefits of these gears is their ability to extend the lifespan of machinery. By repairing themselves, they reduce the frequency of replacements, thereby cutting down on the demand for manufacturing new parts. This not only conserves raw materials but also minimises the energy consumption associated with production processes. Moreover, fewer gear replacements lead to a substantial reduction in industrial waste, aligning with global goals for a circular economy. Industries such as automotive and aerospace, which generate significant amounts of metal waste, are poised to gain immensely from this innovation.

Additionally, researchers are delving into biodegradable self-healing materials that can decompose naturally at the end of their lifecycle. This advancement further reduces the environmental footprint of mechanical systems and aligns with broader sustainability objectives. Beyond waste reduction, self-healing gears also promote energy efficiency. By maintaining operational performance over extended periods, they help systems consume less energy, indirectly lowering the carbon footprint of machines. Together, these factors make self-healing gears a promising solution for creating more sustainable and eco-friendly industrial systems.

Future Possibilities: Combining AI and IoT

The integration of self-healing gears with advanced technologies such as artificial intelligence (AI) and the Internet of Things (IoT) opens up transformative possibilities:

1. Real-Time Monitoring

Embedded sensors can monitor the health of gears continuously, detecting micro-damages or stress

points before they evolve into significant problems. This proactive approach ensures uninterrupted operation and enhances the reliability of systems.

2. Autonomous Healing Activation

Through IoT integration, sensors can trigger the self-healing process autonomously when damage is detected. For example:

- A signal can activate heating elements to facilitate polymer bond reformation.
- Healing agents can be released into cracks automatically, reducing downtime and human intervention.

3. Data-Driven Insights

AI algorithms can analyse sensor data to predict wear patterns, enabling systems to optimize operational conditions and minimize stress on gears. This predictive maintenance approach extends the lifespan of gears and reduces costs associated with unexpected failures.

4. Smart Maintenance Scheduling

With AI and IoT, maintenance schedules can be tailored to the actual condition of the gears rather than fixed intervals. This condition-based approach reduces unnecessary downtime and ensures gears are serviced only when needed.

The Role of AI in Predictive Maintenance

AI plays a pivotal role in enhancing the functionality of self-healing gears, particularly through its capabilities in predictive maintenance. Machine learning models excel at identifying subtle patterns of wear and tear that might go unnoticed by human operators. For example, AI can detect slight variations in gear vibration or temperature, which may indicate the onset of damage. Once identified, AI systems can precisely pinpoint the location of the damage within the gear system, enabling targeted self-healing or repair. This targeted approach not only optimizes the use of healing agents but also enhances the overall efficiency of the system.

Furthermore, AI contributes to performance optimization by analyzing operational data and recommending adjustments to machine settings, such as load distribution or rotational speeds. These adjustments help reduce stress on the gears, preventing future damage and extending their lifespan. Additionally, predictive maintenance powered by AI eliminates much of the guesswork associated with traditional maintenance methods, significantly reducing the likelihood of human error. By ensuring repairs are both timely and effective, AI-driven systems improve the reliability and sustainability of self-healing gears.

From Concept to Reality: Industrial Adoption

Self-healing gears are steadily transitioning from research labs to real-world applications, with industries making significant strides to bridge the gap. Collaborative research is playing a crucial role in this evolution, as partnerships between universities, material scientists, and industrial players accelerate the development of self-healing technologies. Notably, major aerospace and automotive companies are funding research into self-healing materials to enhance the reliability of critical components in their systems.

Prototypes of self-healing gears are undergoing rigorous field testing in high-stakes environments such as wind turbines, automotive engines, and robotic systems. These trials provide invaluable data on performance, durability, and the challenges of real-world applications. Simultaneously, efforts are being made to scale the production of self-healing materials to make them more affordable and widely accessible. Innovations in 3D printing and additive manufacturing are significantly contributing to these advancements, streamlining the production process and reducing costs.

Another essential aspect of industrial adoption is the development of regulatory standards. Self-healing gears must meet stringent safety and performance criteria to be deployed in critical applications. Organizations are working to establish clear guidelines for testing and certification to ensure the reliability of these gears. Moreover, as production techniques mature, the economic viability of self-healing gears is becoming increasingly apparent. While the initial costs of self-healing materials remain high, the long-term savings from reduced maintenance and extended gear lifespans are making this technology a promising investment for various industries.

Conclusion

Self-healing gears represent the future of mechanical engineering, blending resilience, sustainability, and innovation. While challenges remain, ongoing research and development promise a future where gears can autonomously repair themselves, ensuring uninterrupted performance across industries. As technology progresses, self-healing materials are not just a concept—they are poised to transform the very foundation of gear technology, making systems smarter, more efficient, and environmentally friendly.

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.

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Precision and Innovation: Schuessler's Solutions Shaping the Future of Gear Manufacturing in India

- By Sudhanshu Nayak

The gear manufacturing industry in India is at an important juncture, balancing unique challenges with promising opportunities. In this exclusive interview, we will get into the insights of industry experts to understand how Indian manufacturers are addressing cost pressures, skill shortages, and infrastructure gaps while leveraging advancements in automation and precision technologies. From inno
vative tool-holding solutions to emerging industrial trends, the discussion explores actionable strategies and groundbreaking innovations that aim to elevate the Indian gear industry to global standards. Additionally, we get an exciting glimpse into what Schuessler is bringing to IMTEX 2025, promising to redefine productivity and precision in gear manufacturing.

How do you think the gear manufacturing industry in India differs from the rest of the world in terms of challenges, opportunities, and approaches to adopting advanced technologies?

India's gear manufacturing industry faces challenges like cost pressures, skill shortages, and infrastructure limitations, which slow down the adoption of advanced technologies. However, the growing demand in the automotive and industrial sectors presents opportunities for expansion. While automation and precision manufacturing are gradually being adopted, the focus in India is still on cost-effective solutions rather than the latest innovations seen globally.

What do you think are the biggest challenges faced by gear manufacturers in India, and how are they overcoming them?

The biggest challenges faced by gear manufacturers in India include cost pressures, a shortage of skilled labor, and outdated infrastructure. To overcome these, manufacturers are focusing on optimizing existing processes to reduce costs, investing in training programs to improve skills, and gradually upgrading infrastructure with government support. Additionally, they are adopting automation and technology where feasible to increase efficiency and maintain quality.

What makes your tool holding solutions stand out for gear manufacturing processes, especially when working with complex or high-speed applications?

Schuessler's tool holding solutions, including our Hawkeye® and shrink fit holders, stand out in gear manufacturing due to their precision, durability, and ability to handle complex and high-speed applications. Hawkeye® technology ensures high accuracy and minimal runout, while shrink fit holders provide superior clamping force, reducing vibrations and enhancing tool life. These solutions improve machining accuracy, reduce downtime, and boost productivity, making them ideal for both standard and advanced gear manufacturing processes.

How do your shrinking and balancing tool holding systems help improve machining accuracy for gear manufacturers?

Schuessler's shrinking and balancing tool holding systems enhance machining accuracy for gear manufacturers by ensuring optimal stability and reducing vibrations. The shrink fit technology provides a strong, secure clamping force, while the balancing technology ensures that the holders are perfectly balanced, minimizing any operational vibrations. This results in smoother machining, improved tool life, and more precise gear manufacturing, even in high-speed and complex applications.

Can you share any examples or insights into how your tool holding systems have or could help Indian gear makers—especially smaller players—overcome machining challenges or enhance their processes?

One example of how Schuessler's tool holding systems have helped an Indian gear manufacturer, especially a smaller player, is through our work with a customer facing tool stability and vibration challenges during high-speed operations. After implementing our shrink fit and balancing tool holders, they experienced a 25% increase in tool life, along with improved clamping force and reduced vibrations. This led to more precise machining, enhanced production efficiency, and the ability to produce high-quality gears, ultimately helping them stay competitive in the market.

What are some upcoming industrial trends or technologies that you believe the Indian tooling industry should prepare for in the next decade?

The Indian tooling industry should prepare for several key trends and technologies in the next decade:

Automation and AI: Increased adoption of robotics and AI will streamline processes, improving precision and efficiency while reducing costs.

Additive Manufacturing: 3D printing will continue to advance, offering faster prototyping and more cost-effective solutions for complex tooling needs.

Industry 4.0: Smart factories and IoT will help monitor production in real time, enabling predictive maintenance and minimizing downtime.

Sustainability: The shift towards eco-friendly materials and energy-efficient manufacturing will become more important.

Advanced Materials: The use of advanced alloys and composites will enhance the performance and durability of tools for high-demand applications.

As the Indian gear industry continues to grow, what steps do you think are most crucial for ensuring its long-term success and global competitiveness?

For the Indian gear industry to succeed in the long term and stay competitive globally, the following steps are essential:

Adopt New Technologies: Investing in automation and smart manufacturing will improve efficiency and quality.

Develop Skilled Workers: Training workers in advanced manufacturing techniques will ensure high standards.

Focus on Quality: Ensuring consistent quality and meeting international standards will help compete in global markets.

Go Green: Adopting sustainable practices will improve competitiveness and meet global environmental expectations.

Invest in Innovation: More focus on research and development will help manufacturers stay ahead of trends and meet market needs.

These steps will help the industry grow and compete successfully in both local and global markets.

What are you planning to showcase at the upcoming IMTEX 2025?

At IMTEX 2025, we will showcase our innovative Hawkeye® technology, shrink fit holders, and the latest shrink-fit machine with a barcode chip reader at Hall No. 2B, Stall B111.

Our innovative CEO, Mr. Klaus Schüssler, and dynamic Global Sales Head, Mr. Andy Broghammer, will be present to discuss these cutting-edge solutions designed to enhance precision, efficiency, and productivity in the tooling industry. We look forward to welcoming you!

Simon Grundmann
Director, Schuessler India Pvt Ltd

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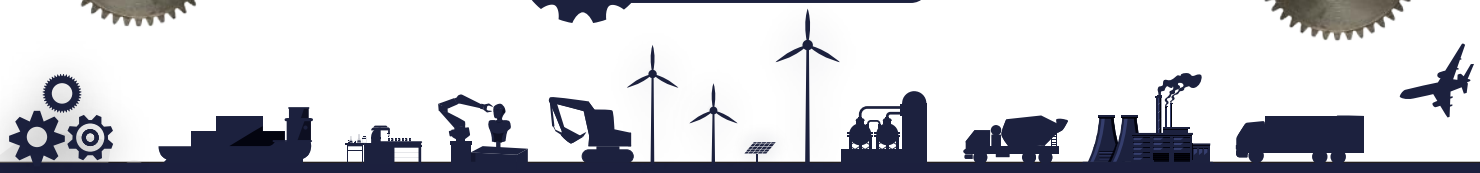

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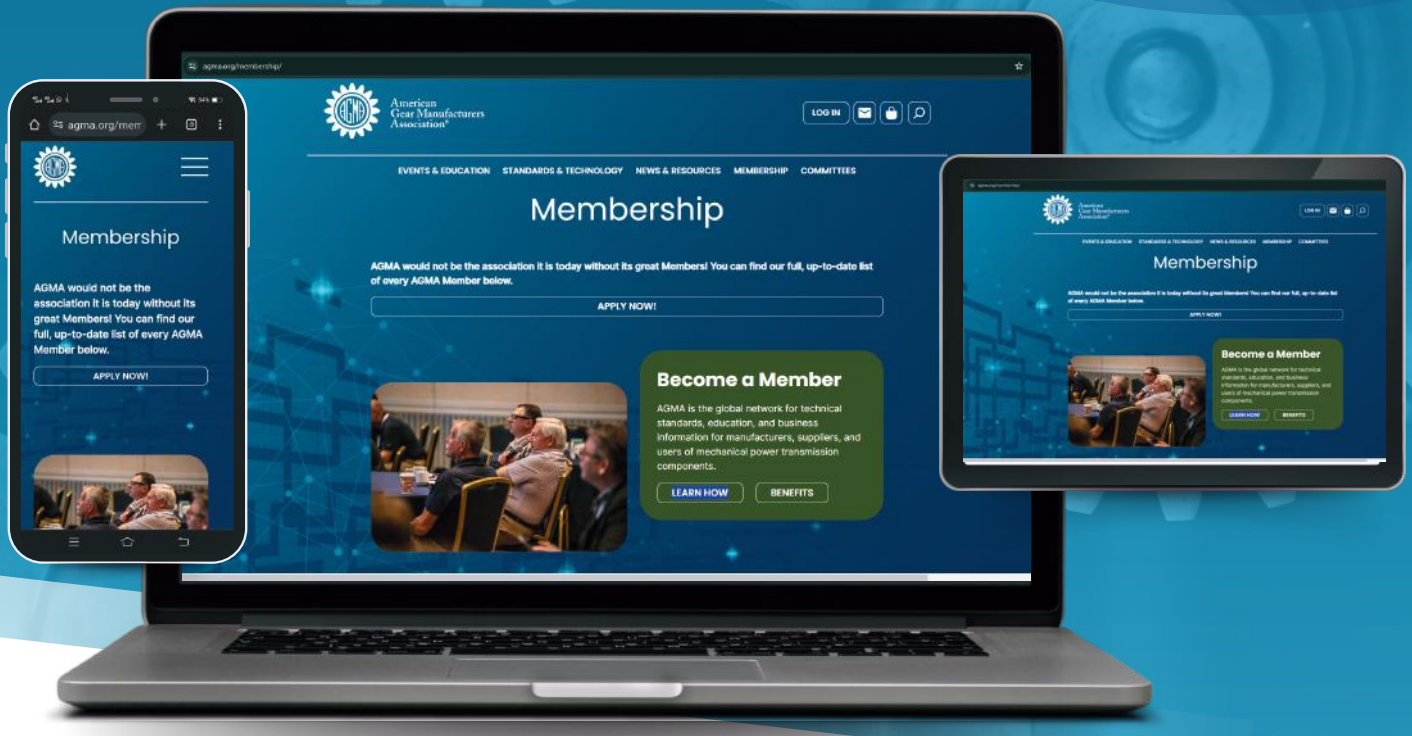

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