# gear TECHNOLOGY INDIA

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**LUBRICATION**

*Friction in tooth flanks and its impact on various operating conditions in cylindrical gears - an Overview, Part -2*

**BUDGET**

*Budget 2025: A Manufacturing-Centric Vision for Industrial Growth: Implications for Gear and Allied*

In Association

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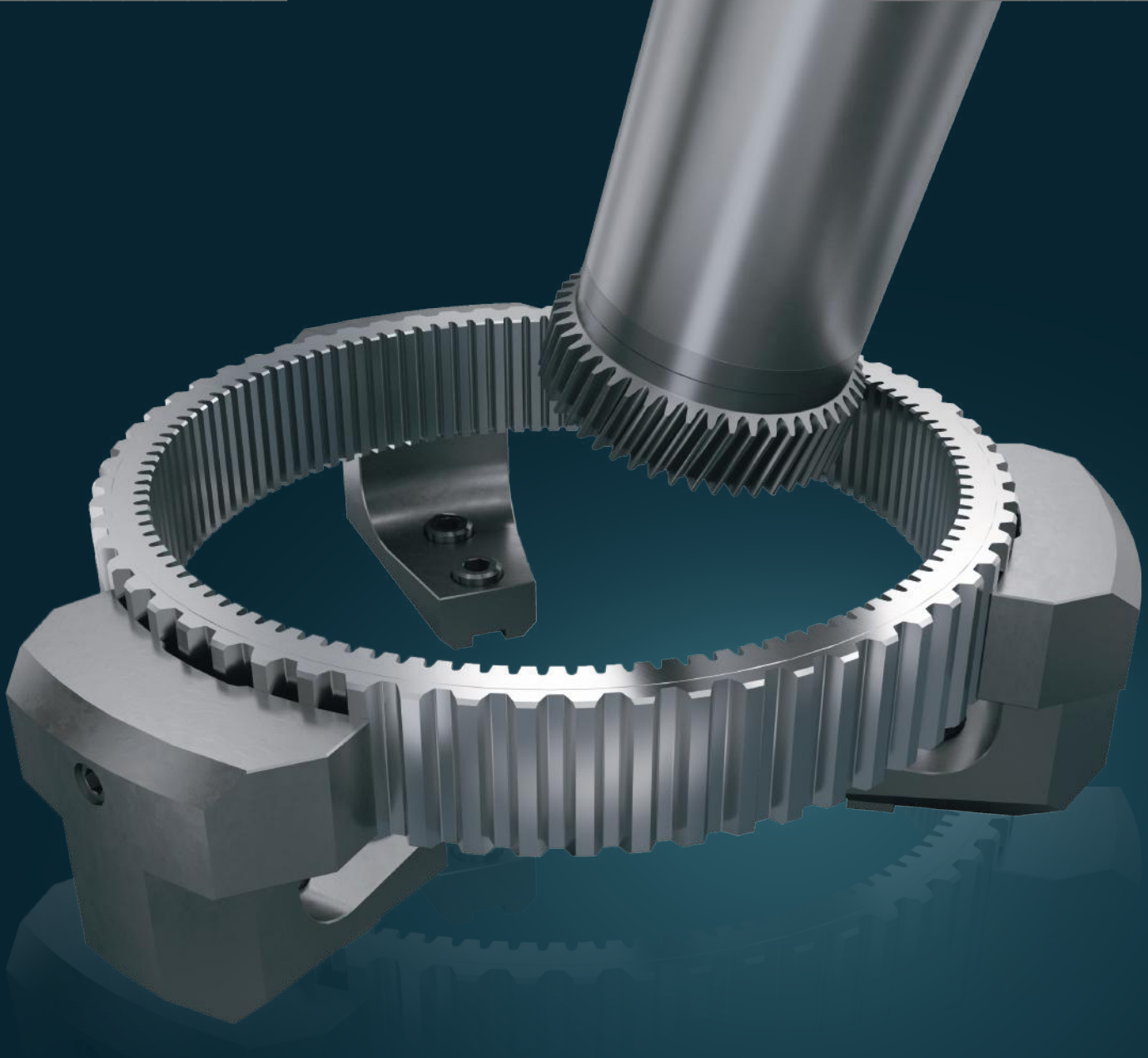
AMERICAN GEAR MANUFACTURERS ASSOCIATION



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Dear Readers,

Welcome to Volume 3, Issue 2 of Gear Technology India Magazine, where we place the spotlight on one of the most critical pillars of gear manufacturing—Machine Tools.

As the gear industry continues to evolve at a rapid pace, machine tools remain at the heart of innovation, precision, and efficiency. This edition brings you an insightful blend of technical depth, industry perspective, and future-ready narratives that reflect the dynamic changes shaping the gear Industry.

Our Cover Story, "Indian Machine Tool Industry: Challenges and Opportunities in Gear Manufacturing",—will take you to the current state of the domestic machine tools ecosystem, its growth potential, and the strategic direction it must take to support a globally competitive gear manufacturing landscape.

We continue our exploration of cutting-edge technology in gear making, with features on PVD coatings, machine retrofitting, and lattice gear design—each offering practical insights for manufacturers striving to enhance performance, reduce costs, and future-proof operations.

This issue also addresses the evolving workforce landscape with a thoughtful article on "Encouraging Young Women to Join the Gear Industry"—a timely reminder that diversity and inclusion are crucial for the future of manufacturing.

In interviews, we are privileged to bring you perspectives from industry leaders such as Mr. Punit Gupta of Blaser Swisslube India, discussing sustainability through advanced lubrication technologies, and Mr Deepayan Das-the Managing Director of Mahr Metrology India, sharing their commitment to precision and the future of measurement systems.

Further enriching this edition are stories on automation, power transmission trends, budget implications for the industry, defence collaborations, and corporate sustainability strategies from top industry players like NORD DRIVESYSTEMS and Rolls-Royce.

We also bring you a timely reminder from the AGMA Foundation—the scholarship application period is open, and we encourage aspiring engineers to seize this opportunity.

As we continue to build a platform that informs, inspires, and connects the gear manufacturing community, I invite you to explore this issue in depth and join the conversation about the future of our industry.

Thank you for your continued readership and support.

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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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**

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# Friction in tooth flanks and its impact on various operating conditions in cylindrical gears - an Overview, Part -2

- Soundararajan KP

In continuation to Part 1

**2. Friction Coefficient Under EHL:** When the operating parameters sustain the fluid flow under the action of load in the restricted area of contact between gear teeth, friction/ traction changes. The entraining velocity responsible for fluid flow into the contact zone and geometrical quantities like Slide Roll Ratio (SRR) are governing factors. This phenomenon on friction behaviour is better dealt by Swedish researchers, and a scenario is as follows:-

The ratio of difference in rolling velocities of meshing teeth and the mean of rolling velocities becomes the Slide Roll Ratio (SRR).

This parameter arising out of operating conditions, material of gear pair and position of line of action to the operating centre distance forms the component of relative Sliding to the rolling Component. This ratio is influenced by the design over the thermal effect generated by the loaded tooth.

In a way, friction loss as a part of power loss has its bearing on the friction coefficient estimation and applications. While the friction factor changes on account of contact surface roughness on tooth flanks, it is also a function of entraining speed to the SRR.

The friction charges linearly to SRR up to a certain level, assuming a steady entraining oil inflow and shear experienced over the film is not leading to changed shear rate.

The next phase is the non-linear friction coefficient over the same entrainment against an increasing SRR. This is attributed to the beginning of shear stress gaining a higher magnitude.

The third phase is similar to a plateau, with friction remaining uncharged during this phase where the non-Newtonian lubricant behaviour sets in.

The last phase of dropping friction is when the inlet temperature rises, and the flow becomes thermoviscous.

The EHD friction varying with SRR under the same loading and speed conditions may result in an error in the estimation of friction coefficients occurring in the Newtonian isothermal model.

When the shear thinning effect with the characteristics, shear stress reaching the limiting value the prediction of friction improve differently.

When the shear heating at the centre of conjunction gets added, the friction agrees with predicted & tested values at higher SRR values.

**3. Friction is considered** when estimating tooth friction losses as an important power loss; the same is calculated as:
Kelley's method
Ploos = Pin Hv f

Where;

Ploss is teeth friction loss
Pin is the Input Power ( w )

The factory Hv=

$$Hv = \frac{\pi}{\cos(\beta)} \cdot \left(\frac{1}{Z_1} + \frac{1}{Z_2}\right) \cdot \left(1 - \varepsilon_\alpha + \varepsilon_1^2 + \varepsilon_2^2\right) \qquad \text{eq 5}$$

β is the Hellix angle;
z1 z 2- pinion and wheel tooth number

$$\varepsilon_\alpha = \frac{g_f + g_a}{p_b} = \varepsilon_1 + \varepsilon_2 \qquad \text{Eq6}$$

gf - length of approach path
ga- length of recess path (m)
pb+ Base Pitch

Here, the coefficient of friction is evaluated according to Kelley:-

Eq 7 $$f = 0{,}0127 . \log_{10}\left[\frac{291205{,}8}{\frac{\rho . v . V_g . U^2}{F_{nu}}}\right]$$

p is the density ( kg/m3 )
v - oil viscosity ( Centistokes )

u- sum of rolling velocities (m/s)
Vg- Sliding velocity (m/s)

Fnu - Normal Tooth load per unit length of line of action.

Here, the friction changes per operating conditions on the path of contact.

An approximation is applied in finding the average of this friction coefficient along the path of contact.

**4. Traction analysis:**

To find which represents the actual situation of meshing gear tooth under speed and load, it is necessary to determine the lubrication regime for traction conditions. Usually, the Green Wood chart is used to determine this regime.

Often, the thin elastohydrodynamic films are formed as the gear teeth at higher loads and/or shear cause viscoelastic friction when the shear stress over the oil film exceeds the limiting Eyring shear of the lubricant. This value can subsequently reduce due to a rise in contact temperature.

One method of ascertaining non-Newtonian viscous shear of the lubricant oil film is the use of the Deborah number.

This critical parameter is measured as:-

Eq 8

$$D = \frac{\eta(p,T)U}{2bG}$$

G a is the lubricant's shear modulus, which can be related as:-

Eq 9

$$G = (G_0 + \alpha_0 p)e^{\beta_0(\frac{1}{T}-\frac{1}{T_0})}$$

G= (G0+ α0p)

Where;

Go is the Shear Modulus at ambient pressure, and Bo is the thermoviscosity index. T and To are bulk and reference atmospheric temperatures, respectively.

Non-Newtonian viscoelastic traction is expected. When D>L

Shear stress and friction are brought up when the Lubricants behave in a Non-Newtonian manner

When Stress becomes:-

Eq 10

$$\tau = \frac{\eta}{F(\lambda)}\dot{\gamma}.$$

γ is the non-linear Shear rate;
n dynamic viscosity

F(λ) is the Havriliak–Negami Function

The above relationship is used to determine the actual shear stress under the condition of non-Newtonian behaviour of lubricant when the Deborah number D>1.

When it is otherwise, the shear stress is:-

Eq11

$$\tau = \pm\frac{h}{2}\frac{\partial p}{\partial x} + \frac{\eta\Delta U}{h}.$$

a t Conventional Newtonian shear.

The condition of equation.10 occurs when the shear stress depends on pressure.

tl = Limiting shear stress = Eq 12

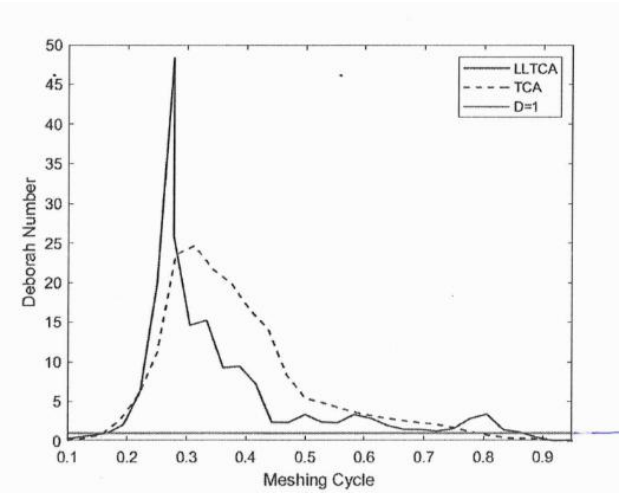
$$\tau_l = \tau_0 + \gamma\bar{p}$$

When p is the mean contact pressure

γ limiting shear strength proportionality Constant. -

This value is evaluated for the given lubricant and its properties for substituting the relevant data.

On account of Lubricated Loaded Tooth Content (LLTCA) mastering from the real tooth flock geometry. The Deborah number can charge during the mesh cycle on the basis of acted tooth profile deviation data. Where the load gets applied and influences the film thickness then and there, unlike the result, which can be different when lubricants free-contact are evaluated. Under LLTC, the Deborah number changes non-linearly over the generating length of the tooth mesh.



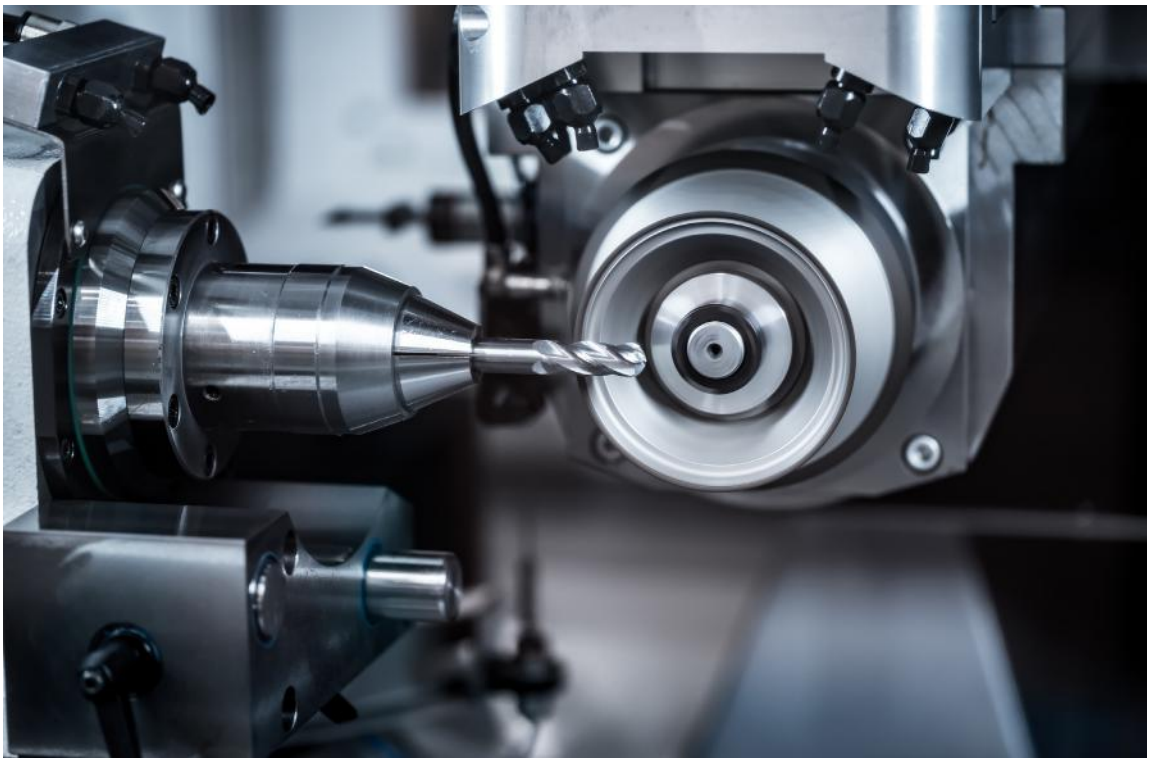

*The author is former Director and General Manager of Gleason Works India. He has four decades of experience in the gear industry, with special reference to machine tools and gear processes. He is also a Fellow of the Institution of Mechanical Engineers, UK, and a registered chartered engineer.*

# Indian Machine Tool Industry: Challenges and Opportunities in Gear Manufacturing

- By Sudhanshu Nayak

Machine tools form the foundation of gear manufacturing, playing a critical role in ensuring precision, efficiency, and reliability throughout the gear production process. Gears are integral to industries such as automotive, aerospace, railways, and industrial machinery, where accuracy and durability are non-negotiable. The evolution of machine tools has led to a paradigm shift in gear manufacturing, moving from traditional manual machining to CNC-driven, high-precision, and automated processes.

With the advent of multi-axis machining centers, gear manufacturers can now produce complex geometries with minimal material wastage. CNC hobbing, shaping, grinding, and power skiving have allowed for unprecedented levels of accuracy and efficiency. Additionally, automation in gear manufacturing, including robotic handling, predictive maintenance through IoT, and AI-powered quality control, has streamlined operations. These advancements have not only improved production speed but also ensured consistency, reduced human error, and enhanced overall cost-effectiveness.



As demand for high-precision gears rises globally, the role of machine tools in meeting these expectations becomes even more critical. With India aiming to be a manufacturing hub, its machine tool industry must continue evolving to meet domestic and international standards, pushing the boundaries of innovation in gear manufacturing.

## Growth of India's Machine Tool Industry and Its Impact on Gear Production

India's machine tool industry has witnessed significant growth, driven by factors such as rapid industrialization, increasing domestic demand, and government-led initiatives like the "Make in India" campaign. The sector has been strengthened by the push for self-reliance, reducing dependence on imported machine tools and developing indigenous capabilities. The machine tool market in India is expected to grow at a steady pace, with investments in automation, digitalization, and high-precision machining tools leading the way.

This growth has had a profound impact on the gear manufacturing industry. Indian gear manufacturers now have access to state-of-the-art machine tools that enable high-speed machining, improved surface finishing, and enhanced material efficiency. Companies are increasingly investing in CNC-based gear production technologies, reducing cycle times and increasing productivity. The automotive sector, a significant consumer of gears, has driven the need for advanced machining solutions capable of meeting stringent performance and durability requirements.

Additionally, the development of smart factories, where real-time data monitoring and predictive analytics optimize machining processes, has revolutionized gear production. The incorporation of Industry 4.0 principles is enhancing productivity, reducing waste, and ensuring quality control in gear manufacturing, making Indian firms more competitive in global markets.

## Evolving Gear Manufacturing Technologies in India

India's gear manufacturing industry is undergoing a transformation, with advanced machining technologies redefining production methodologies. Traditional gear manufacturing processes like hobbing and shaping are now being supplemented by modern techniques that enhance precision, efficiency, and sustainability.

**Power Skiving** has emerged as a game-changer in gear production, blending the advantages of shaping and hobbing. This method significantly reduces machining time, making it ideal for high-volume production. Power skiving also ensures better surface quality and dimensional accuracy, making it particularly useful for producing gears for electric vehicles (EVs) and aerospace applications.

Another notable innovation is **dry hobbing**, an eco-friendly alternative to conventional wet hobbing. By eliminating the need for cutting fluids, dry hobbing not only reduces environmental impact but also cuts operational costs. This method is gaining traction in industries seeking sustainable manufacturing solutions.

The introduction of **hard finishing techniques**, such as advanced grinding, honing, and skiving, has further refined gear manufacturing. These processes enhance gear surface quality, reduce noise levels, and extend gear lifespan, which is crucial for high-performance applications in the automotive and defense sectors.

**Additive manufacturing (AM) is revolutionizing gear prototyping and production**. With the ability to create complex geometries that were previously unachievable through traditional methods, 3D printing enables faster design iterations and reduces material waste. While still in the early stages for full-scale gear production, AM is becoming an essential tool for prototyping, repair, and small-batch manufacturing.

The integration of **AI and machine learning in gear production** is another breakthrough. AI-powered predictive maintenance minimizes machine downtime by identifying potential failures before they occur. Additionally, AI-driven tool path optimization enhances machining efficiency and extends tool life. Smart manufacturing powered by AI and IoT is helping Indian manufacturers reduce costs and improve consistency in gear production.

These advancements are positioning India as a leader in high-precision gear manufacturing. With increased R&D investment and the adoption of next-generation manufacturing processes, Indian companies are gaining global recognition for their ability to produce high-performance gears for critical applications.

## Key Investments, Policies, and Global Collaborations

The Indian government has introduced several initiatives and policies to promote the machine tool and gear manufacturing industries. Notable among them are:

- **Production Linked Incentive (PLI) Scheme:** This scheme encourages the domestic production of high-precision machine tools and components, reducing reliance on imports.
- **Establishment of Machine Tool Parks:** Industrial clusters dedicated to machine tool manufacturing, fostering innovation and efficiency.
- **Investment in Smart Factories and Automation:** Indian manufacturers are increasingly investing in AI-driven automation, improving consistency and efficiency in gear production.
- **Global Collaborations:** Indian companies are forming joint ventures and technology-sharing agreements with global leaders, gaining access to advanced gear manufacturing techniques.

These investments and policies are playing a crucial role in making India a competitive hub for high-precision manufacturing, attracting global players to set up production facilities in the country.

## Challenges in India's Gear Manufacturing Industry

Despite its rapid growth, India's gear manufacturing sector faces several challenges:

India's gear manufacturing sector faces multiple hurdles that need urgent attention. The **skill gap in advanced machining** remains a persistent issue, as there is a lack of trained professionals capable of handling sophisticated CNC machines and interpreting complex gear production processes. Bridging this gap requires enhanced vocational training and stronger industry-academia partnerships.

Another major obstacle is **infrastructure and supply chain inefficiencies**. The inconsistent availability of high-quality raw materials, coupled with inadequate logistics networks, hampers smooth production workflows. These bottlenecks lead to increased lead times and higher manufacturing costs.

The **slow adoption of Industry 4.0 technologies** is another challenge, particularly among small and medium enterprises (SMEs). While large-scale manufacturers are embracing automation, digitalization, and AI-driven quality control, many SMEs struggle.

**The Road Ahead: Opportunities and Future Outlook for Gear Manufacturing**

India's gear manufacturing industry has immense potential for growth, with numerous opportunities emerging due to advancements in digital manufacturing, automation, and sustainability. The adoption of Industry 4.0 technologies, including smart factories, real-time monitoring, and AI-driven quality control, will be instrumental in driving efficiency and precision.

The rising demand for electric vehicles (EVs) is another key factor shaping the future of gear manufacturing. EVs require lightweight, high-efficiency gear solutions, presenting an opportunity for Indian manufacturers to develop innovative products. Additionally, the push for sustainability is encouraging the adoption of energy-efficient machining processes and recyclable materials, further aligning with global industry trends.

With strategic investments in automation, talent development, and R&D, India can establish itself as a leading hub for high-precision gear manufacturing. By embracing advanced machining technologies and sustainable practices, Indian manufacturers can compete with their global counterparts and expand their market reach.

## Conclusion: Strengthening India's Position in Gear Manufacturing

To strengthen its position as a global leader in gear manufacturing, India must prioritize several key areas. First, bridging the skill gap is essential, which can be achieved through specialized training programs and stronger industry-academia collaborations. Equally important is the need to enhance infrastructure and build a resilient supply chain to ensure the consistent availability of high-quality raw materials and precision components. Accelerating the adoption of Industry 4.0 technologies—particularly among small and medium enterprises (SMEs)—will play a crucial role in boosting operational efficiency and global competitiveness. In addition, strengthening international collaborations will help facilitate technology transfer and elevate domestic manufacturing capabilities. Lastly, investing in sustainable manufacturing practices is vital not only to meet global environmental standards but also to reduce long-term operational costs and enhance industry resilience.

***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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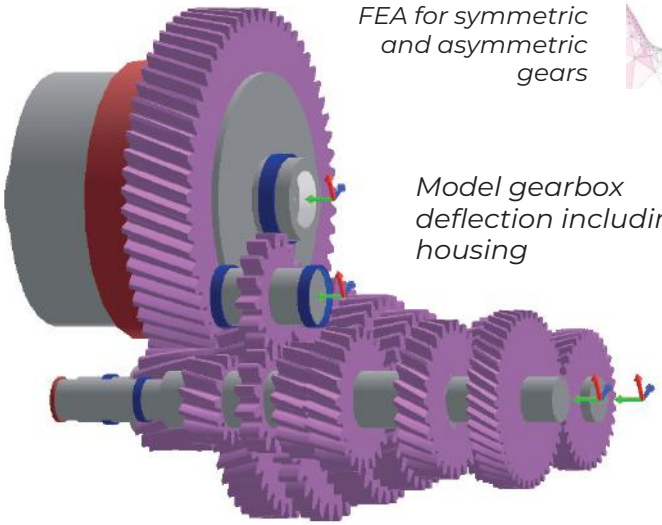
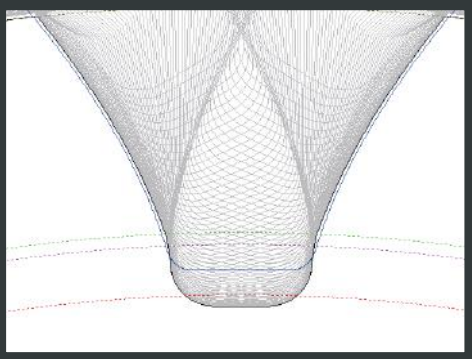
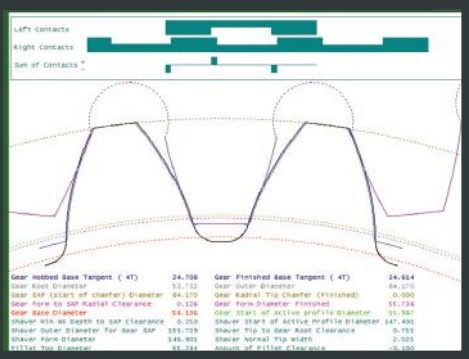


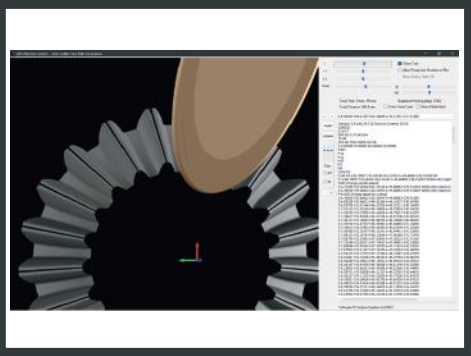
*Model gearbox deflection including housing*



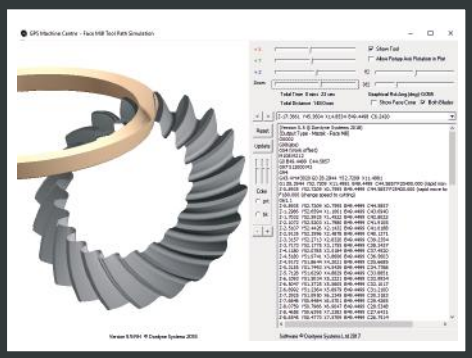
Hob / Grind Roll Out



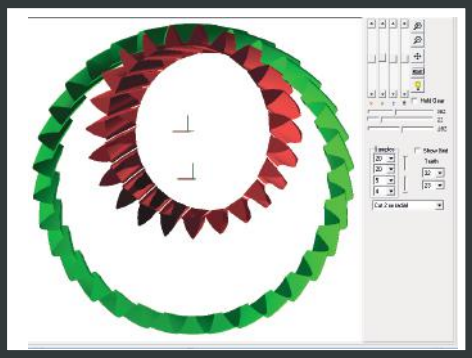
Shaving' and Shaping



Coniflex CNC



End Mill / Face Mill CNC



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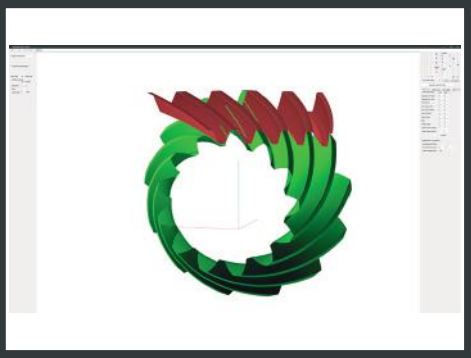

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# Improving Gear Manufacturing with PVD Coatings

- By Olivia Fey & Mike Greenwald

Gear manufacturers face ever-increasing demands for tighter tolerances, faster throughput, and extended tool lifetimes. As a result, protective coatings are essential for the cutting and shaping tools used in gear production. Physical Vapor Deposition (PVD) coatings, in particular, play a central role in modern gear tooling, having progressively evolved to address challenges associated with high cutting speeds, extreme thermal loads, friction, and wear.

In this article, we review various PVD coatings widely adopted in gear manufacturing, providing both a technical overview of how these coatings benefit cutting and shaping operations, and a brief history of their introduction and refinement over the decades.

## Brief History of PVD Coatings in Gear Manufacturing

PVD coatings have come a long way since their introduction. Understanding how they evolved provides insight into why the gear industry depends so heavily on them today.

**1. Early Developments (1970s–1980s):**

**Initial Interest in Titanium Nitride:** Titanium nitride (TiN) emerged as one of the earliest PVD coatings for high-speed steel (HSS) tools in the late 1970s and early 1980s. The success of TiN in metal cutting prompted gear makers to test it on hobs and shaping tools. TiN's characteristic gold color and moderate cost, combined with the mechanical benefits of reduced wear, made it an ideal "first-generation" PVD coating in gear manufacturing.

Vacuum Vapor Deposition and Sputtering Advances: Innovations in vacuum technology, cathodic arc, and sputtering allowed better coating uniformity on tools with complex geometries such as gear hobs.

**2. Growth of the Industry (1990s):**

**New Coating Chemistries:** As tool steels and carbide substrates improved, gear manufacturers sought coatings with higher oxidation resistance and hardness. This led to the introduction of variants such as TiCN (titanium carbonitride) and CrN (chromium nitride).

**Industrial Adoption:** PVD coatings gained traction in major automotive and aerospace gear-making lines, transitioning from experimental or niche solutions to mainstream, production-ready technologies.

**3. Modern Era (2000s–Present):**

**Al-Containing Coatings:** The industry shift toward higher-speed, dry-machining conditions spurred the popularity of AlTiN (aluminum titanium nitride) and AlCrN (aluminum chromium nitride), both of which offer outstanding hot hardness and oxidation resistance.

**Hybrid Multilayers and Tailored Processes:** Continued research into plasma physics and deposition processes has yielded advanced multilayer and nanolayer coatings (e.g., AlTiCrN, multi-phase nitrides). Today, gear manufacturers have a wide menu of coatings and can select one or more that precisely match the cutting conditions and desired tool life.

From these historical roots, PVD coatings have developed into a sophisticated suite of solutions for gear tool protection. The following sections examine the most common coating chemistries in detail, providing a practical understanding of how each can improve gear machining.

## Range of PVD Coatings Used in Gear Manufacturing

Modern gear production demands coatings that can handle intense thermal loads, severe mechanical stress, and high-speed cutting. While titanium nitride has been a workhorse, it is only one piece of a larger family of specialized PVD coatings.

**1. TiN (Titanium Nitride)**

TiN remains one of the most prevalent coatings for gear cutting tools:

**Deposition Process:** Often deposited via cathodic arc or reactive sputtering, typically at 2–5 µm thickness.

**Properties:** Offers hardness of ~20-25 GPa, superior toughness, and oxidation resistance up to around 500 °C.

**Advantages:** Known for good performance at moderate cutting speeds and cost-effectiveness. Provides lower friction compared to uncoated tools, reducing the chance of built-up edge (BUE).

**Limitations:** Its thermal stability and hardness may not be sufficient for extremely high-sped or dry cutting operations common in newer gear-manufacturing lines.

While TiN remains a mainstay, the evolution of gear steels and the demand for increased productivity call for more advanced coatings. One of the first variants to appear was titanium carbonitride, offering improved hardness and wear resistance.

**2. TiCN (Titanium Carbonitride)**

TiCN introduces carbon into the TiN matrix:Properties: Higher hardness (~25-30 GPa) and lower friction compared to TiN, and improved resistance to abrasive wear.

**Thermal Resistance:** Similar to TiN, but not as high as aluminum-containing coatings.

**Typical Use:** Beneficial in gear cutting and forming operations that require extra abrasive-wear resistance, and where temperatures do not exceed TiCN's range (~400-500 °C).

Gear cutting requirements escalated, particularly for dry machining, the market demanded coatings that could endure well above 500°C. Aluminum-containing coatings now fill that niche, offering the thermal stability TiCN sometimes lacks.

**3. AlTiN (Aluminum Titanium Nitride)**

AlTiN has become one of the foremost coatings in high-performance gear cutting:

**Deposition Process:** Cathodic arc or high-power pulsed magnetron sputtering, typically 2-4 µm thick.

**Properties:** Hardness often in the 25–35 GPa range. Thanks to its Al content, AlTiN forms an aluminum oxide film on the surface at high temperature (~800 °C or more), significantly slowing oxidation and substrate softening.

**Advantages:** Lets the tool tolerate higher cutting speeds, higher temperatures, and -in some cases -dry or near-dry machining. This is valuable for the advanced steels used in modern gear manufacturing.

**Limitations:** Slightly more expensive than TiN, and the deposition process typically demands more refined equipment.

Although aluminum titanium nitride dominates many high-temperature applications, other formulations exist that cater to specific operational demands. Chromium-based coatings, such as CrN and AlCrN, have also found dedicated use cases.

**4. CrN (Chromium Nitride)**

CrN is known for its excellent corrosion resistance and lower friction:

**Properties:** Hardness of ~15-20 GPa, lower friction coefficient than TiN, and decent oxidation resistance up to ~700 °C.

Typical Use: Particularly effective in preventing built-up edge in certain steels and in humid or corrosive shop environments. While it's not as hard as AlTiN, its excellent toughness can mitigate chipping in certain gear cutting setups.

**Advantages:** Excellent adhesion, minimal reactivity with many alloys, moderate cost.

**Limitations:** Not as wear-resistant at extreme temperatures or speeds compared to Al-containing coatings.

Beyond titanium- and chromium-based options, aluminum-chromium nitride and more complex multilayer structures continue to push the boundaries of performance. Next, we consider the benefits of these advanced composites.

**5. AlCrN (Aluminum Chromium Nitride)**

AlCrN emerged as a competitor to AlTiN for high-speed machining:

**Deposition and Composition:** Combines aluminum, chromium, and nitrogen; typically, 2-3 µm thick.

**Properties:** High hardness (25-30+ GPa), robust oxidation resistance (up to ~1000 °C), and lower friction in steel cutting compared to pure TiN.

**Advantages:** Particularly known for its resilience in interrupted cutting operations (like gear shaping), where the cutting edge frequently enters and leaves the work. The chromium fraction helps control residual stresses, improving toughness.

**Applications:** Commonly used for gear hobbing and shaping in advanced steels and certain cast irons.
In addition to these popular single-phase coatings, toolmakers are now exploring sophisticated multilayer or nanolayer systems that combine multiple nitrides. These advanced composites can meet the toughest gear manufacturing requirements.

**6. Advanced Multilayers (AlTiCrN, Nanolayer Nitrides, etc.)**

By alternating layers of various nitrides and carbides, coating suppliers create coatings that merge enhanced toughness with ultra-high hardness:

**Multilayered or Nanolayered:** Stacks or superlattices of alternating layers (titanium nitride, chromium nitride, aluminum nitride, etc.) in single-digit nanometer thickness can combine high toughness, super-hardness (~30-40+ GPa), and extended hot hardness.

**Benefits in Gear Cutting:** Enhanced resistance to crack propagation, superior thermal stability, and better friction behavior. Particularly suitable for demanding applications such as high-speed gear milling or shaping with minimal coolant.

**Cost and Complexity:** Deposition systems and process control become more involved, potentially increasing the coating cost. However, the significant gains in tool life can justify the investment in mass-production lines.

## Mechanisms of Tool Improvement

PVD coatings deliver multiple performance enhancements that translate directly into higher productivity and lower tool costs:

**1. Wear Resistance via Increased Hardness**

Nitrides and carbonitrides present a hard barrier, protecting the substrate from abrasive wear by gear steel chips. This results in a stable and sharper cutting edge over extended cycles.

**2. Thermal Oxidation Resistance**

Aluminized coatings -like AlTiN orAlCrN -form stable oxides above 700-800 °C, drastically slowing oxidation and preserving the substrate's heat-treated properties. This is especially critical in dry or near-dry cutting conditions.

**3. Friction and Built-Up Edge (BUE) Reduction**

Lower friction coefficients help chips evacuate quickly, lowering the likelihood of chip welding to the tool ("built-up edge"). Smooth PVD surfaces (especially from modern arc-smoothing or magnetron processes) further reduce friction.

**4. Load Distribution**

Dense, uniform coatings distribute high contact pressures more evenly. This lessens micro-chipping at the cutting edge, maintaining consistent gear geometry through the production run.

Despite these clear advantages, the success of a PVD coating also hinges on proper substrate preparation, deposition parameters, and subsequent checks. The next section offers practical advice on ensuring coated gear tools perform at their best.

## Practical Guidance for Gear Manufacturers

**1.Match the Coating to the Cutting Application:**

- TiN, CrN for moderate speeds and general steels.
- TiCN for higher wear resistance in moderately high speeds.
- AlTiN, AlCrN for high-speed, dry, or near-dry gear cutting with top-tier oxidation resistance.
- Multilayer Nitrides for the most demanding environments, high loads, and extreme thermal cycling.

**2. Substrate Selection and Conditioning**

**Material:** Common tool materials include HSS and cemented carbides. Each must be hardened and stress-relieved to the correct specification prior to coating.

**Surface Finish:** Pre-coating polishing, mi-

cro-blasting, or other surface finishing steps help ensure uniform coating adhesion.

**3. Deposition Control**

**Temperature Management:** Keep deposition temperature within the tolerance of the substrate's heat treatment. For HSS, typical PVD cycles stay below 550°C.

**Bias Voltage and Pressure:** Fine-tuning bias voltage ensures a dense, adherent coating. Operating in excessive bias or pressure can raise residual stress, risking delamination.

**Avoid Over-thickness:** 2-4 µm is typical for gear-cutting edges. Excessively thick coatings can crack or spall under repeated mechanical shock.

**4. Post-Deposition Inspection**

**Thickness Verification:** Calotte grinding or X-ray fluorescence confirms that the coating thickness matches the target range (usually 2–4 µm for gear applications).

**Adhesion Tests:** Scratch or Rockwell indentation tests reveal interface strength. Any early-stage delamination issues can be spotted and corrected before full production.

**5. Ongoing Tool Maintenance**

**Wear Monitoring:** Checking flank or crater wear helps identify whether the chosen coating matches the cutting speed, coolant usage, and steel hardness.

**Reconditioning:** Many PVD coatings can be stripped chemically. Re-sharpening or re-honing the substrate, followed by fresh PVD, often yields multiple lifetimes from a single tool.

By embracing these practices, gear-manufacturing teams can extract maximum value from PVD-coated tools, achieving excellent throughput, precision, and cost-effectiveness. In the final section, we summarize the key takeaways.

## Conclusion

PVD coatings have fundamentally transformed gear manufacturing, allowing consistent production of high-precision gears under demanding speeds and loads. From the early days of TiN in the 1970s–80s to the modern developments in AlTiN, AlCrN, and nanolayer coatings, these thin, tough films protect the cutting edges from wear, oxidation, and friction. By judiciously selecting the coating composition and deposition parameters, gear makers can achieve extended tool life, reduced downtime, and improved surface finishes.

As the gear industry continues pushing for shorter cycle times, heavier loads, and dry machining to minimize environmental impact, advanced PVD coatings will remain a cornerstone of tooling technology.

United Protective Technologies, LLC (UPT) is an industry leader in high-performance coatings. Founded in 2002, UPT has spent decades bringing solutions to the surface..

UPT's PVD coatings are used by industry leaders, including the US Military, to protect tools and components used in demanding environments.

**For more information, please visit UPT's website: www.upt-usa.com**

## Key References


- Mattox, D. M. Handbook of Physical Vapor Deposition (PVD) Processing. Noyes Publications.
- Veprek, S., et al. "Superhard Nanocomposite Coatings: The TiN/Si3N4 System." Surface and Coatings Technology, 133–134 (2000): 152–159.
- Vetter, J. "Dry Cutting with Coated Tools: Potentials and Limitations." Surface and Coatings Technology 163–164 (2003): 659–664.
- Rebelo de Figueiredo, M., et al. "Friction Coefficients of PVD Coatings in Cutting Operations." Wear 267.5–8 (2009): 997–1002.


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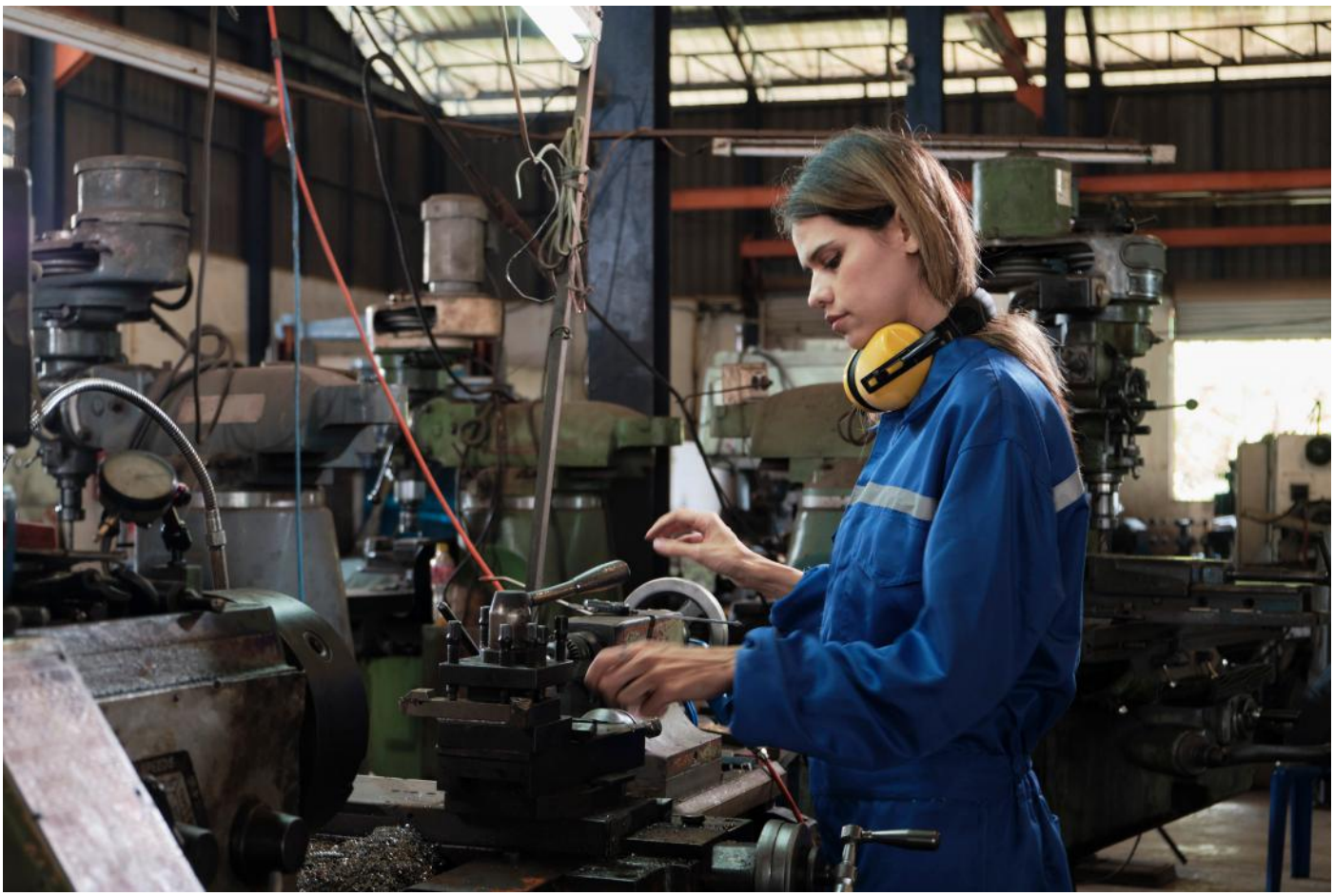
# Encouraging Young Women to Join the Gear Industry: A Roadmap for the Future

- By Sushmita Das

The gear industry has long been the spine of modern engineering, powering everything from manufacturing to aerospace technology. Yet, despite its critical role, the sector remains largely male-dominated. Women account for only a small fraction of the workforce in gear manufacturing and engineering. However, times are changing, and with the rise of automation, digitalisation, and sustainability-driven innovations, there has never been a better time and scope for young women to step into this exciting field.



Let's discover how we can encourage women to join the gear industry now and in the future.

## Why the Gear Industry Needs More Women?

1. Diversity Drives Innovation: Studies have repeatedly shown that diverse teams bring fresh perspectives, leading to better problem-solving and innovation. The gear industry, which is rapidly evolving with new technologies such as electric drives and Industry 4.0, can greatly benefit from more women engineers contributing to its progress.

2. Demand for Skilled Professionals: With advancements in precision engineering, CNC machining, and gear grinding, the industry is experiencing a skills gap. Encouraging young women to pursue careers in this field can help bridge that gap while creating new opportunities for personal and professional growth.

3. A Future-Oriented Industry: The push toward sustainability and energy efficiency is transforming gear manufacturing. From electric vehicle transmissions to high-efficiency industrial gearboxes, the field offers meaningful work that contributes to global progress.

## Challenges Women Face in the Gear Industry

Despite the growing acceptance of women in STEM fields, several challenges persist in the gear industry:

- **Lack of Awareness:** Many young women are simply

unaware of the opportunities available in gear engineering and manufacturing.

- **Gender Bias:** While improving, biases still exist in many workplaces, making it harder for women to enter leadership positions.
- **Limited Role Models:** The industry has few well-known female figures, making it difficult for aspiring engineers to find mentors and inspiration.

## Steps to Encourage Young Women to Join the Industry

1. Early Exposure to Engineering and Manufacturing

Girls need to be introduced to engineering concepts early on. Schools and technical institutes should emphasize hands-on learning, allowing young women to explore gear design, robotics, and manufacturing technology.

- Schools can organize field trips to gear manufacturing plants.
- Universities should host workshops featuring female engineers sharing their experiences.
- Companies can collaborate with educational institutions to introduce gear technology in STEM curricula.

## 2. Scholarships and Internship Programs

Financial and practical support is crucial in encouraging more women to enter this field. Many companies and organizations are already offering scholarships specifically for women pursuing mechanical engineering and manufacturing-related courses.

- Internships provide hands-on experience and help students build confidence in their technical skills.
- Sponsorships for technical training programs can encourage young women to specialize in gear-related disciplines such as precision machining, CAD/CAM design, and automation.

## 3. Mentorship and Role Models

One of the most effective ways to inspire young women is by showcasing successful female professionals in the industry.

- Industry leaders should actively mentor aspiring engineers.
- Social media and professional networks like LinkedIn should highlight stories of women excelling in gear manufacturing.
- Companies can launch mentorship programs pairing young women with experienced professionals.

## 4. Workplace Inclusivity and Career Growth Opportunities

Attracting women to the industry is only part of the equation; retaining them is equally important.

- Companies should implement policies that promote inclusivity, such as flexible work hours and parental leave benefits.
- Organizations should encourage leadership training programs to help women advance in their careers.
- Creating women's networking groups within companies can provide support and community.

The gear industry is evolving, and women have a crucial role to play in its transformation. Whether through engineering, research, or leadership, young women entering this field can look forward to rewarding careers with significant impact. Schools, businesses, and industry leaders must work together to create an inclusive environment that welcomes more women into the world of gear manufacturing.

If you are a young woman who is passionate about engineering, now is the time to explore the gear industry. The opportunities are vast, the demand is growing, and the future awaits you. Step forward, take on the challenge, and be a part of the next wave of innovation in mechanical engineering.

Explore scholarship opportunities at https://agmafoundation.org/

***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.***

# AGMA Foundation Scholarship Application Submission Period is Open

- By Gear Technology India

## About the AGMA Foundation Scholarship Program

Open to students interested in a career in the gear industry and/or power transmission as it relates to the gear industry.

Applicants must be enrolled or recently accepted as full- or part-time students in a nationally accredited program.

Annual scholarships are available for those enrolled at technical/associate, undergraduate, and graduate schools.

Preference is given to applicants with current or recent experience working in the gear and/or power transmission industry.

## AGMA Scholarships

*Making an Impact on Students by Advancing Education*

The AGMA Foundation awards scholarships to outstanding engineering students at the Associate/Technical, Undergraduate, and Graduate levels. The scholarship program was created to help fill the need for skilled employees in the gear industry.

Help keep the gear and power transmission industry moving. Consider making a contribution to the AGMA Foundation Scholarship Program and help kickstart a career in gear

Applications must be submitted in full by Tuesday, July 1, 2025.

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# The Future of Lightweight Power Transmission: Designing Lattice Gears

- By Vivek Singh

It is transparent to note that nature has inspired much of modern engineering, from submarines to aeroplanes. Engineers have always drawn inspiration from nature in some form, where efficiency and strength are perfectly balanced.

With their complicated internal structures, Lattice Gears are the closest and most recent outcome of this inspiration, reflecting on natural formations such as bone architecture and honeycomb patterns, both noted for their lightweight yet strong qualities. This biomimicry permits gears that are not only physically optimised but also far lighter than typical solid counterparts without sacrificing durability. Beyond nature, the aerospace and automobile sectors have fuelled the demand for high strength-to-weight ratio components. Aircraft and high-performance vehicles demand components that are lightweight while remaining extremely reliable under dynamic stresses. Traditional gears typically struggle to achieve this balance, while lattice-based designs provide a breakthrough by lowering material utilisation while maintaining mechanical integrity.

Computational structure optimization is a crucial enabler of this innovation, as it uses AI-driven simulations to optimize internal structures. Unlike traditional subtractive procedures, which are limited by machining constraints, this methodology allows for intricate, algorithm-generated structures that would be very difficult to construct using traditional techniques. The rise of additive manufacturing (3D printing) opened up wider possibilities and applications of lattice gears. Engineers can now design customised, high-performance gears for specific purposes using accurate layer-by-layer manufacturing.

## What It Takes To Design Such Complex Gears

The design of lattice gears is centred around achieving an optimal balance between strength, weight, and durability. Unlike standard solid gears, lattice gears use smart material distribution, complicated internal geometries, and stress management techniques to improve performance under extreme situations.

### • Material Distribution and Load Bearing

One significant advantage of lattice gears is their ability to reduce material usage while maintaining strength. These gears can withstand high torque and dynamic loads while being substantially lighter than their solid counterparts. Finite Element Analysis (FEA) plays a crucial role in optimising material placement and guaranteeing structural integrity where forces are concentrated, such as at gear teeth and hub interfaces.

### • Internal Geometry & Complexity

Lattice gears use multi-scale lattice infill to increase mechanical efficiency by distributing loads more uniformly across the structure. Advanced triply periodic minimal surfaces (TPMS) and cellular lattice structures are used to design extremely efficient stress-dissipating networks. These complicated shapes are quite effective in handling shock absorption, vibration dampening, and energy dissipation, making them excellent for high-speed, high-load applications in aerospace and robotics.

## Stress Management and Fatigue Resistance

Traditional gears frequently experience fatigue because of localised stress concentrations. Stresses are distributed more uniformly in lattice structures, which reduces the risk of fatigue failure. Graded lattice density, with finer structures in high-stress parts and coarser structures in low-stress sections, can greatly improve the lattice gear's lifespan and reliability. In addition, additive manufacturing techniques enable smooth transitions between different lattice zones, which improves durability under cyclic loading conditions.

After all these designs and stress analyses, everything depends upon the ability of manufacturing and material possibilities. With carefully tailored material distribution, computationally optimised shapes, and superior stress management, lattice gears are transforming gear design, providing lighter, stronger, and longer-lasting solutions for next-generation mechanical systems.

Let's Differentiate Lattice and Conventional Gears

Lattice gears represent a big leap in modern engineering, with major advantages over standard solid gears. Weight, load distribution, manufacturing complexity, and extreme-condition performance are the most significant variations.

| Aspect | Lattice Gears | Conventional Gears |
|---|---|---|
| Weight Reduction | 30-50% lighter due to optimized material placement and lattice structures. | Fully dense structure, heavier, leading to increased inertia. |
| Load Distribution | Multi-scale lattice infill distributes stress evenly, reducing fatigue and enhancing lifespan. | Stress concentrated at specific points, leading to localized wear. |
| Manufacturing Complexity | Requires additive manufacturing (AM) like SLM or EBM, with advanced computational modeling. | Typically produced using subtractive methods like hobbing and grinding. |
| Performance Under Extreme Conditions | Better thermal stability and impact resistance, due to lattice's heat dissipation and shock absorption. | Prone to thermal stress buildup and impact-related damage. |

## Material Considerations and Applications of Lattice Gears

Lattice gears rely highly on materials to offer improved strength, weight reduction, and optimal performance. Metallic lattice gears, particularly those constructed of titanium and high-performance alloys, are popular in aerospace and defence due to their high strength-to-weight ratio and durability to harsh working conditions. Carbon fibre-infused composites offer an excellent blend of lightweight strength and wear resistance, making them perfect for automotive and robotics applications. High-performance polymers are now finding use in medical devices, where biocompatibility and precision are essential for prosthesis and surgical instruments.

Lattice gears' application potential grows with advances in additive manufacturing and material science. In aircraft and defence, these gears dramatically reduce payload weight, improve fuel efficiency, and increase durability. The automobile benefits from their lightweight nature, which improves fuel efficiency and reduces drivetrain mass while retaining structural integrity. Robotics and automation benefit from lattice gears' optimised strength and weight balance, which improves motion control and overall system performance.

As engineering technology advances, lattice gears are poised to transform high-performance mechanical systems. Their capacity to provide higher efficiency, versatility, and durability makes them indispensable in essential applications, influencing the future of gear design and manufacturing.

The Path Forward for Lattice Gear Design

The future of lattice gear design seems promising thanks to AI-powered optimisation, smart manufacturing, and scalable manufacturing processes. AI-driven generative design is transforming the way lattice structures are imagined, allowing for real-time simulations that optimize material distribution, load-bearing efficiency, and stress management for maximum performance. Real-time monitoring and predictive maintenance will become the norm as smart manufacturing and digital twin technologies integrate, ensuring greater gear dependability and operational efficiency.

A big hurdle remains in scaling lattice gear production for wider industry adoption. Advances in additive manufacturing, particularly high-speed 3D printing and hybrid manufacturing processes, enable large-scale production while keeping the precision required for high-performance applications. As these technologies evolve, lattice gears will move from specialist, high-performance industries to mainstream industrial applications, redefining efficiency, durability, and mechanical performance in aerospace, automotive, robotics, and beyond.

# Retrofitting Old Machines: A Budget-Friendly Approach to Modern Gear Manufacturing

- By Nishant Kashyap

The evolution of gear manufacturing has seen rapid technological advancements, with modern CNC machines, automated inspection systems, and digital connectivity becoming the industry standard. However, many manufacturers still rely on older, well-built machines that lack these modern features. Replacing such machines with new, state-of-the-art alternatives often requires significant capital investment, which is not always feasible, especially for small and medium enterprises (SMEs). Retrofitting emerges as a strategic and budget-friendly solution to modernize existing machinery, bridging the gap between outdated technology and the growing demands of precision gear manufacturing.

Retrofitting involves upgrading old machines with

modern components such as CNC controls, servo motors, and digital monitoring systems while retaining their fundamental mechanical structure. This approach extends the lifespan of existing machines, enhances precision, improves efficiency, and integrates modern capabilities without the heavy financial burden of acquiring entirely new equipment. As the gear industry moves towards higher precision and efficiency, retrofitting is proving to be an essential strategy for manufacturers looking to stay competitive in a cost-effective manner.

## The Need for Retrofitting in Gear Manufacturing

Aging machines pose several challenges in gear manufacturing. Mechanical wear and tear result in increased backlash, inconsistent gear profiles, and reduced cutting accuracy. Outdated controls, often reliant on manual operations, limit efficiency and repeatability, making it difficult to meet today's stringent tolerances. Additionally, older machines are less energy-efficient, leading to higher operational costs. These factors make it challenging for manufacturers to keep up with the demands of modern applications, including aerospace, automotive, and industrial gear production.

Retrofitting makes sense when the mechanical structure of a machine remains sound, but its electronic and control systems are outdated. Rather than replacing an entire machine, manufacturers can upgrade key components, transforming a conventional gear-cutting or grinding machine into a high-precision system capable of delivering superior results. This approach not only reduces capital expenditure but also minimizes production downtime compared to installing a new machine.

## Key Retrofitting Strategies for Gear Manufacturing Machines

One of the most impactful retrofitting methods involves converting manual machines into CNC-controlled systems. By integrating CNC technology, manufacturers can achieve improved precision, repeatability, and automation in gear production. Retrofitting a conventional gear hobbing or shaping machine with a CNC control system eliminates manual dependencies and significantly enhances efficiency. This transformation involves replacing analog controls with digital CNC systems, integrating servo motors, and installing linear encoders to achieve precise motion control.

Additionally, upgrading the gear-cutting and finishing capabilities of older machines can yield substantial improvements in performance. High-speed spindles can replace outdated ones, allowing for better cutting speeds and improved surface finishes. Tool holders and fixtures can be modernized to accommodate advanced cutting tools such as carbide and ceramic inserts, which provide longer tool life and greater cutting efficiency. Implementing advanced lubrication and cooling systems further enhances performance by ensuring proper heat dissipation and chip evacuation, ultimately improving gear accuracy and tool longevity.

Automation plays a crucial role in modernizing gear manufacturing, and retrofitting old machines with robotic systems can greatly enhance efficiency. Automated loading and unloading systems, coupled with robotic material handling, reduce cycle times and labor dependency. IoT integration allows for real-time monitoring of machine parameters, tracking vibration, temperature, and tool wear to predict maintenance needs before failures occur. This predictive maintenance approach reduces unexpected breakdowns, ensuring consistent production output and

extending machine life.

Mechanical enhancements form another key aspect of retrofitting. Replacing worn-out lead screws with high-precision ball screws eliminates backlash, significantly improving machining accuracy. Traditional stepper motors can be replaced with servo-driven systems to achieve smoother motion control and higher torque capabilities. Bearings and gearboxes within the machine can also be upgraded to reduce noise, enhance efficiency, and provide better load-carrying capacity. These mechanical refinements collectively contribute to a more stable and precise manufacturing process.

Another critical area of retrofitting focuses on energy efficiency. Older machines are often highly power-intensive, leading to increased operational costs. Retrofitting with energy-efficient servo drives can reduce power consumption while maintaining or even improving performance. The introduction of regenerative braking systems in high-load applications allows energy to be recovered and reused within the system, further reducing overall energy expenditure. Simple yet effective upgrades, such as LED machine lighting and smart cooling fans, contribute to cost savings without compromising productivity.

## Challenges and Considerations in Retrofitting

While retrofitting offers substantial benefits, it comes with its own set of challenges. The initial investment, although lower than purchasing a new machine, can still be significant, especially when integrating CNC systems, servo motors, and IoT connectivity. Ensuring compatibility between new and old components can be complex, as some older machines may not be structurally capable of handling high-speed CNC operations. Additionally, training operators and maintenance personnel to work with upgraded systems is essential for maximizing the benefits of retrofitting. Without proper training, the transition from conventional to CNC-controlled operations may lead to inefficiencies.

Another critical consideration is the availability of spare parts for older machines. Some machines may have custom-built components that are difficult to source, requiring either reverse engineering or modifications to accommodate new replacements. Proper planning and consultation with retrofitting specialists can help mitigate these challenges, ensuring a seamless upgrade process.

Future Trends in Machine Retrofitting for Gear Manufacturing

The future of retrofitting in gear manufacturing is poised for exciting developments, with emerging technologies shaping the next generation of upgrades. AI-driven predictive maintenance is gaining traction, utilizing machine learning algorithms to analyze wear patterns and anticipate failures before they occur. By leveraging AI, manufacturers can optimize machine uptime, reduce unplanned maintenance, and enhance overall productivity.

Another groundbreaking advancement is the adoption of digital twin technology, which creates a virtual model of a retrofitted machine. This digital twin allows manufacturers to simulate different operating conditions, optimize performance, and predict potential issues in real time. By integrating digital twins with retrofitted machines, manufacturers can achieve unparalleled precision and process efficiency.

Hybrid manufacturing, combining additive manufacturing with retrofitted machines, is another area of growth. 3D printing technology enables the creation of custom tool holders, fixtures, and replacement parts, reducing lead times and costs associated with traditional manufacturing methods. This approach allows older machines to be adapted for specialized applications, extending their usefulness in modern production environments.

Sustainability is also becoming a key focus in retrofitting, with manufacturers exploring eco-friendly upgrades. The use of biodegradable cutting fluids, regenerative braking, and solar-powered machine components contributes to a greener manufacturing process. As the industry shifts towards sustainable practices, retrofitting offers a viable path for reducing the environmental impact of gear production while maintaining cost-effectiveness.

## Conclusion

Retrofitting presents a compelling solution for manufacturers seeking to modernize gear production without the prohibitive costs associated with new machinery. By upgrading older machines with CNC technology, automation, and energy-efficient systems, manufacturers can achieve high precision, improved efficiency, and enhanced productivity. While challenges such as initial investment and compatibility issues exist, strategic planning and expert consultation can help overcome these obstacles.

As gear manufacturing continues to evolve, retrofitting will play an increasingly vital role in ensuring that manufacturers remain competitive in a rapidly changing landscape. With advancements in AI-driven maintenance, digital twins, and hybrid manufacturing, the future of retrofitting is set to become even more sophisticated. For gear manufacturers looking to extend the life of their equipment while embracing modern production capabilities, retrofitting is the key to sustainable and cost-effective progress.

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

# Budget 2025: A Manufacturing-Centric Vision for Industrial Growth: Implications for Gear and Allied Industries

- By Sushmita Das

India's Union Budget 2025-26 reaffirms the government's strategic commitment to industrial development, with a strong emphasis on manufacturing. From enhanced Production Linked Incentive (PLI) allocations to the announcement of a National Manufacturing Mission, the budget offers a robust roadmap for strengthening the domestic manufacturing ecosystem—particularly relevant to the gear and allied industries, which lay the foundation of several critical sectors such as automotive, renewable energy, aerospace, and heavy machinery.


## National Manufacturing Mission – A Holistic Industrial Framework

A key highlight of Budget 2025 is the launch of the National Manufacturing Mission, which aims to bolster the "Make in India" initiative by offering comprehensive policy support, implementation roadmaps, and structured monitoring mechanisms. The mission covers small, medium, and large-scale industries, offering a unified approach toward industrial excellence.

For gear manufacturers and allied sectors, this mission presents an opportunity to align with a national framework that prioritises the following:

1. **Ease and cost of doing business** – enabling smoother operations, lower compliance burdens, and improved logistics infrastructure.
2. **Technology availability** – supporting the adoption of advanced machining, automation, and Industry 4.0 technologies.
3. **Quality product manufacturing** – encouraging process standardization and certification that enhance global competitiveness.
4. **MSME vibrancy** – Empowering small and medium gear component makers with financial support and skill-building initiatives.
5. **Future-ready workforce** – Bridging the skill gap in high-precision machining, robotics, and digital manufacturing technologies.

## Clean Tech Manufacturing – A New Avenue for Growth

The mission also embraces Clean Tech Manufacturing, focusing on building domestic capacity in next-generation technologies like:

- Electric vehicle motors and controllers
- High-efficiency transmission components
- Wind turbines and solar PV equipment
- Electrolyzers and grid-scale battery systems

These developments are poised to significantly impact gear manufacturing, as precision gear components are integral to many of these emerging technologies. The transition toward energy-efficient solutions will drive demand for lighter, high-strength, and high-performance gear systems and allied parts.

## PLI Scheme Expansion – Stronger Incentives, Stronger Industry

Another cornerstone of Budget 2025 is the enhanced Production Linked Incentive (PLI) scheme, which received substantial budget increases across critical sectors:

- Electronics & IT Hardware:  9,000 crore
- Automobiles & Auto Components:  2,818.85 crore
- Specialty Steel:  305 crore
- Advanced Chemistry Cell (ACC) Battery Storage:  155.76 crore

For the gear industry, particularly those catering to automotive and capital goods sectors, this is a significant enabler. The increased outlays signal rising demand for locally manufactured gearboxes, gear-cutting tools, and high-precision components. The automotive sector alone—bolstered by incentives—will require advanced transmission systems and lightweight, high-durability gear assemblies to meet global standards.

Furthermore, the focus on specialty steel supports material availability for precision gear production, enabling better performance and longevity for components used in high-stress environments.

## FDI Reforms – Fueling Industrial Investments

With the continued liberalization of Foreign Direct Investment (FDI) norms, manufacturing sectors now offer 100% FDI under the automatic route. Between 2014 and 2024, FDI equity inflow in manufacturing rose by 69%, highlighting growing investor confidence.

For gear and allied manufacturers, this translates to improved access to global technologies, capital, and joint venture opportunities—essential for scaling up operations and upgrading manufacturing capabilities.
Sectoral Impact and Emerging Opportunities

## Budget 2025's manufacturing focus aligns with evolving market dynamics:

- **Automotive Electrification:** Increased investment in EVs and components will spur demand for high-efficiency gear solutions for drivetrains, motors, and controllers.
- **Renewable Energy:** Gearboxes for wind turbines and support for solar infrastructure will expand application areas.
- **Telecom and Electronics:** Precision components used in telecom infrastructure and control systems open newer verticals for gear applications.
- **Aerospace and Defence:** Quality-focused initiatives enhance readiness for export-oriented precision gear production.

## Conclusion: A Turning Point for Industrial Manufacturing

Budget 2025 offers a structured, incentive-driven approach to empower Indian manufacturing on a global scale. For the gear industry and its allied sectors, this is a pivotal moment to invest in technology upgrades, expand product portfolios, and align with the broader industrial vision.

With the confluence of the National Manufacturing Mission, expanded PLI schemes, clean tech initiatives, and investor-friendly reforms, the gear manufacturing ecosystem is well-positioned to play a transformative role in India's next phase of industrial growth.

**Reference**

Ministry of Commerce & Industry
https://pib.gov.in/PressReleaseIframePage.aspx-?PRID=2107825

**BUDGET 2025-2026**
https://www.indiabudget.gov.in/doc/budget_speech.pdf

***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.***

# Sustainability Through Advanced Lubrication Technology

## An Exclusive Interview with Mr. Punit Gupta, Managing Director, Blaser Swisslube India

- By Sushmita Das

In the world of metalworking, coolants and lubricants are often seen as mere consumables — low on the priority list, yet essential. But Blaser Swisslube has turned this perception on its head. With an unwavering focus on innovation, sustainability, and customer-centricity, the company has emerged as a global leader in metalworking fluids. In this insightful and technical conversation during our visit to IMTEX 2025, Mr. Punit Gupta, Managing Director of Blaser Swisslube India, shares insights into the company's legacy, its bold vision, and how it is helping gear manufacturers boost productivity and sustainability.

**Q: Mr. Gupta, please tell us about yourself and your company, Blaser Swisslube.**

A: Blaser Swisslube is a very special company, and I feel proud to be part of it. It's a family-owned business that has been around for nearly 90 years — to be precise, 88 years. The company was founded in 1936 by Willy Blaser, a visionary entrepreneur with a deep passion for creating value through innovative products.

**Q: That's fascinating. Could you share the story behind how the company started?**

A: The story is quite unique and inspiring. When Willy Blaser started the company in 1936, he noticed that farmers' leather boots were not protecting their feet effectively. He developed a water-resistant shoe cream and introduced it directly to farmers — polishing their boots himself and leaving behind a small sample. He would return in two weeks to see if it worked for them. If it did, they could purchase it. If not, he was happy just to have served them. This philosophy of 'serving before deserving,' adding value, and caring for people and the environment remains the foundation of our company even today.

**Q: How has the company evolved since those early days?**

A: While we no longer manufacture shoe cream, that same spirit of innovation and service continues to drive us. Over time, we transitioned into the field of metalworking fluids, which is far more complex and impactful for industrial productivity. Today, we offer high-performance cutting fluids and lubricants that enhance machining output, improve tool life, and contribute to safer and cleaner work environments.

**Q: How does Blaser stand out in a segment where coolants are often overlooked?**

A: Our CEO, Marc Blaser, always says that we must be superspecialists in our area with a laser-focused approach. Coolants are often seen as a Z-category item on the shop floor, but our goal is to elevate them into strategic tools that enhance productivity. This bold approach is why our tagline is: "We Help You Win – Now & in the Future."

**Q: Can you share some examples, particularly in gear manufacturing, where your products have made a difference?**

A: Certainly. In gear manufacturing processes such as hobbing, shaping, and grinding, we conduct extensive tests with our customers. We've documented significant improvements in productivity, tool life, and workplace cleanliness. Gear cutting often generates smoke and mist — but our advanced cutting oils significantly reduce this, creating a cleaner, safer, and more efficient machining environment.

**Q: What are some challenges you face in introducing these solutions to the market?**

A: The biggest challenge is changing customer perception. Many still view coolants as a 'necessary evil.' We want to transform that thinking by educating the market on how these fluids can drive productivity, sustainability, and operator well-being. Our goal is to empower customers and operators with better working conditions and better results.

**Q: You mentioned sustainability. How does Blaser support this goal technically?**

A: The answer lies in the chemistry and formulation of our products. Our R&D teams invest heavily in developing lubricants that meet both performance and environmental standards. We design products that last longer, perform better, and reduce waste — all while ensuring safety and sustainability.

**Q: Is R&D done locally in India?**

A: No, our research and development is headquartered in Switzerland, where we have the largest R&D capabilities in our field. The innovations developed there are then implemented worldwide, including in India.

**Q: What is the vision of Blaser Swisslube for the future?**

A: Our vision is simple: as machining becomes more complex, our customers need trusted partners who can grow with them. We aim to be that partner — always reliable, always innovative. We remain committed to our core philosophy: "We Help You Win – Now & in the Future."

## Closing Note

Blaser Swisslube's journey — from a humble shoe cream to cutting-edge metalworking fluids — is a story of continuous innovation, unwavering values, and a deep commitment to customers. As the manufacturing world moves toward greater complexity and sustainability, Blaser continues to lead the way by turning the overlooked into the essential.


*Punit Gupta*
*Managing Director, Blaser Swisslube India*

# Precision in Every Measurement: Mahr Metrology India's Vision for the Future of Manufacturing

- By Sushmita Das

As the Indian manufacturing landscape evolves toward high-precision, high-performance production, the role of dimensional metrology becomes increasingly critical. Mahr Metrology India Pvt. Ltd., a subsidiary of the globally renowned Mahr GmbH Group, stands at the forefront of this transformation, empowering industries with cutting-edge metrology solutions. In an exclusive conversation with Sushmita Das the Associate Editor of Gear Technology India Magazine, Mr. Deepayan Das, Managing Director of Mahr Metrology India, shares valuable insights into the company's legacy, its product innovations, and its strategic vision for shaping the future of precision engineering in India.

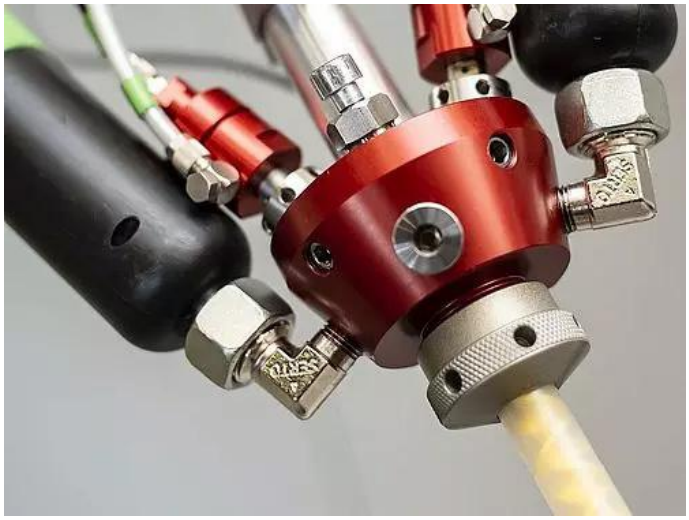
**Q1. Mr. Das, could you start by giving us a brief overview of Mahr Metrology India and its global legacy?**

Certainly. I'm Deepayan Das, Managing Director of Mahr Metrology India Pvt. Ltd., which is a 100% subsidiary of the Mahr GmbH Group. Mahr is a 160-year-old, family-owned company headquartered in Germany, specializing in dimensional metrology. Globally, we serve a diverse customer base across industries such as automotive, aerospace, machine building, renewable energy, new-age energy, semiconductors, electronics, medical devices, and more.

**Q2. What are the key product offerings from Mahr that are helping manufacturers enhance quality and productivity?**

Our core domain is dimensional metrology, and we consider ourselves partners in our customers' quality control and assurance processes. We broadly categorize our offerings into two segments:

**1. Shop Floor Metrology Solutions** – These include handheld instruments such as calipers, micrometers, dial gauges, and various gauge combinations.



**2. System Solutions** – These consist of advanced metrology systems such as contour measuring machines, form measuring machines, and shaft measuring machines used in quality labs and metrology centers.

Additionally, Mahr provides customized measuring stations developed in collaboration with our engineering teams in Germany. We also offer after-sales services, applications engineering, and training support through our India-based service team.

**Q3. Since your products are so application-specific, do you encounter any challenges in adapting them to customer needs?**

While we don't develop products locally—these are manufactured by our parent company in Germany—we do face application-related challenges. Since dimensional metrology solutions are highly application-oriented, customers need to program and adapt machines to their specific requirements.

We work closely with them to make this process seamless. Mahr machines are designed to be user-friendly and easy to program. However, when customers deal with complex geometries or unique parts, our expert application engineering team steps in to support them throughout the integration process.

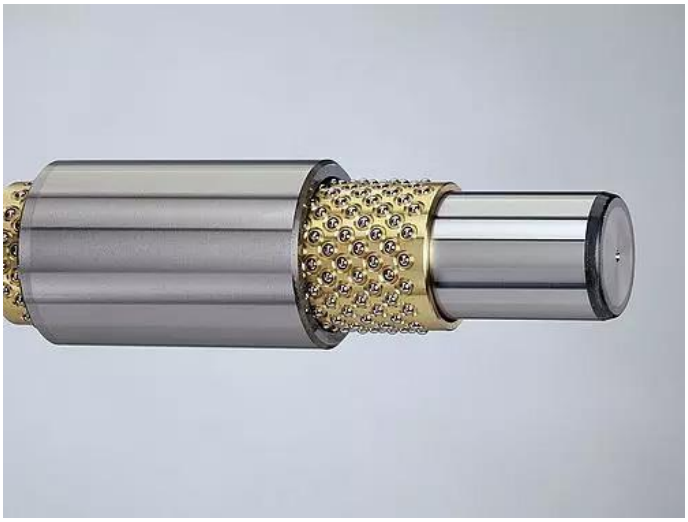
**Q4. How does Mahr India overcome these technical and application challenges?**

We strongly believe in building technical expertise within our team. A significant part of our investment goes into the training and development of our engineers. All our engineers undergo structured training in Germany and are classified into Level 1, Level 2, and Level 3 based on their skill development.

Our goal is to ensure that every new engineer completes Level 1 training within six months of joining. Based on their performance and interest, they are further trained to attain Level 2 and Level 3 certifications. In fact, our Indian team has one of the highest numbers of Level 3 certified engineers globally, and we even support Mahr's international customers from India.

**Q5. How do Mahr's products contribute to energy efficiency and sustainability goals?**

Dimensional metrology equipment by design consumes very little energy, so energy efficiency is inherently part of our product philosophy. However, our larger contribution to sustainability is by enabling our customers to manufacture more efficient and sustainable products.

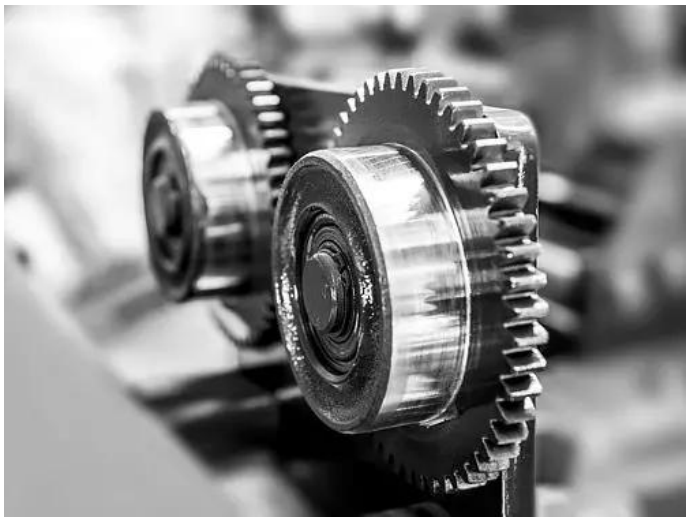


For instance, in the case of internal combustion engines, manufacturers are under pressure to meet increasingly stringent environmental regulations. Tighter tolerances are essential for higher efficiency—and that's where Mahr plays a critical role by enabling precise measurements.

Similarly, we support customers in sectors like renewable energy, electronics, and semiconductors by delivering standard and customized solutions that enhance product quality and production sustainability.

**Q6. What is your vision for Mahr India in the coming years?**

The future looks very promising for India's manufacturing sector. The growth in electronics, semiconductors, aerospace, and other new-age industries presents a tremendous opportunity. As the country continues to push toward becoming a global manufacturing hub, the need for precision and quality will only increase.



Mahr India aims to align with this growth by continuing to deliver world-class metrology solutions, expanding our local capabilities, and reinforcing our commitment to customer support and innovation. We see a bright future ahead, both for Mahr and the Indian manufacturing ecosystem.

## Conclusion

As India accelerates its journey toward becoming a global manufacturing powerhouse, the importance of quality, precision, and technological advancement cannot be overstated. Mahr Metrology India, with its robust engineering expertise, customer-centric solutions, and commitment to excellence, continues to play a pivotal role in this transition. Through continuous innovation and a strong focus on application-driven solutions, Mahr is not just measuring components—it is enabling the future of manufacturing, one micron at a time.

***Deepayan Das***
***Managing Director, Mahr Metrology India Pvt Ltd***

Image Courtesy: Mahr Metrology
www.mahr.com/en-int/

# Hollow vs. Solid Gears: Performance Trade-offs in Automotive & Aerospace Applications

- By Sudhanshu Nayak

Gears play a crucial role in automotive and aerospace applications, where efficiency, weight, durability, and performance are key considerations. While traditional solid gears have been the standard for decades, advancements in material science and manufacturing techniques have enabled the adoption of hollow gears in specific applications. The debate over hollow versus solid gears revolves around their respective advantages, limitations, and suitability for different operational demands. This article explores the performance trade-offs between these two types of gears and their implications in automotive and aerospace engineering.

## Understanding Hollow and Solid Gears

Solid gears are constructed from a single, continuous piece of metal, providing inherent strength, rigidity, and resistance to high torque loads. They are commonly used in high-load applications where durability is a primary concern.

Hollow gears, on the other hand, feature a central void that reduces their overall mass while maintaining structural integrity. They can be manufactured using various techniques, including forging, additive manufacturing, and precision machining. Hollow gears offer significant weight reduction and improved rotational inertia, making them desirable in applications where minimising weight is crucial.

## Performance Factors in Automotive Applications

In the automotive industry, gears are essential for power transmission in engines, gearboxes, and differentials. The choice between hollow and solid gears depends on factors such as load-bearing capacity, efficiency, and material composition.

### Weight Reduction and Fuel Efficiency

One of the most compelling advantages of hollow gears in automotive applications is weight savings. By reducing gear mass, vehicle weight is lowered, which enhances fuel efficiency and reduces emissions. In electric vehicles (EVs), where battery range is a critical factor, lighter components contribute to improved energy efficiency.

### Torque and Durability Considerations

Solid gears have a clear advantage in high-torque applications, such as heavy-duty trucks and performance cars. They offer superior strength and fatigue resistance, making them ideal for handling extreme forces in high-performance transmissions and differentials.
Vibration and Noise Characteristics

Hollow gears tend to exhibit different vibrational behaviours compared to solid gears. The presence of a hollow core alters the gear's modal frequencies, potentially reducing noise and improving acoustic performance in some applications. However, improper design can also lead to unwanted resonance and fatigue failure, necessitating careful structural analysis.

### Manufacturing Complexity and Cost

Hollow gears require advanced manufacturing techniques and precise material distribution to maintain strength while reducing mass. This often leads to higher production costs compared to solid gears, which are simpler to manufacture and machine. Techniques such as multi-axis CNC machining and additive manufacturing play a critical role in making hollow gears viable.

## Hollow vs. Solid Gears in Aerospace Applications

Aerospace engineering places an even greater emphasis on weight reduction, given the direct impact of mass on fuel consumption and aircraft performance.
Lightweight Design for Enhanced Efficiency

Hollow gears are widely used in aerospace applications to minimize weight without sacrificing performance. Every kilogram saved in an aircraft results in significant fuel savings and improved payload capacity. Hollow gears contribute to the overall efficiency of aircraft engines, landing gear mechanisms, and flight control systems.

## Load-Bearing Capabilities and Fatigue Life

Despite their weight advantages, hollow gears must meet stringent strength and fatigue resistance requirements. Aerospace-grade materials, such as titanium and high-strength alloys, help compensate for potential weaknesses, ensuring that hollow gears can withstand high rotational speeds and dynamic loads.

## Thermal Expansion and Stress Distribution

Aerospace components are subjected to extreme temperature variations and stress conditions. Solid gears have better resistance to thermal expansion and deformation, making them more suitable for applications with high thermal and mechanical stresses. Finite Element Analysis (FEA) simulations are often used to predict how hollow and solid gears respond under thermal and mechanical loads.

## Material Selection and Manufacturing Techniques

Both hollow and solid gears benefit from advancements in material science and precision manufacturing.
Advanced Materials for Enhanced Performance
High-strength alloys, composite materials, and additive manufacturing techniques enable the production of lightweight yet durable gears. Hollow gears often require specialized materials to compensate for reduced mass while maintaining mechanical strength.

## Materials commonly used include:

- **Titanium alloys:** These alloys offer a high strength-to-weight ratio, corrosion resistance, and excellent fatigue life.
- **High-performance steels:** Used in solid gears where extreme load conditions are expected.
- **Carbon-fiber composites:** Used experimentally in some aerospace and motorsport applications for additional weight savings.

## Additive Manufacturing and Precision Machining

The rise of 3D printing and hybrid manufacturing has made it easier to produce complex hollow gear designs with optimized weight distribution and internal reinforcement structures. Solid gears, while more straightforward to manufacture, also benefit from advanced machining techniques that improve their surface finish and durability.
Methods such as:

- **Selective Laser Melting (SLM)** enables the creation of intricate hollow gear structures while maintaining high strength.
- **Electron Beam Melting (EBM)** offers a similar advantage with improved material density control.
- **Powder Metallurgy (PM)** and Hot Isostatic Pressing (HIP) provide alternative routes for fabricating high-performance hollow gears.

## Application-Specific Trade-offs

The choice between hollow and solid gears ultimately depends on the specific application requirements.

- **Automotive Industry:** Hollow gears are advantageous for lightweight electric and hybrid vehicles, while solid gears remain dominant in high-torque applications such as performance cars and heavy-duty trucks.
- **Aerospace Industry:** Hollow gears are preferred in applications where weight reduction is critical, such as aircraft engine components and landing gear systems, whereas solid gears are used in extreme load-bearing applications requiring maximum durability.

## Future Trends and Research Directions

The ongoing development of new materials and manufacturing processes continues to push the boundaries of what is possible in gear technology. Some emerging trends include:

- Smart Gears: Incorporating sensors within hollow structures to monitor real-time stress, temperature, and wear conditions.
- Topology Optimization: Advanced computational techniques to create gear designs with minimal weight while maximizing strength.
- Self-Healing Materials: Research into metals and composites that can repair microscopic cracks and extend gear lifespan.

## Conclusion

Hollow and solid gears each have their unique advantages and trade-offs. In automotive applications, hollow gears contribute to weight reduction and fuel efficiency, whereas solid gears offer superior durability for high-torque scenarios. In aerospace, the emphasis on weight savings makes hollow gears highly desirable, provided they meet stringent performance and fatigue resistance standards. As manufacturing technologies continue to evolve, the adoption of hollow gears is expected to grow, offering new opportunities for efficiency improvements in both industries. Engineers and manufacturers must carefully evaluate application-specific demands to select the most appropriate gear type for optimal performance and longevity.

# Rolls-Royce and Triveni Engineering Ink MoU for 4MW Marine Gas Turbine Generators

- By Sushmita Das

Rolls-Royce Marine North America Inc. and Triveni Engineering and Industries Limited (NSE: TRIVENI) have signed a Memorandum of Understanding (MoU) to explore collaboration opportunities for 4MW marine gas turbine generators (GTGs) for Indian customers. This partnership will focus on designing, developing, and manufacturing marine GTGs, alongside comprehensive sales and support services.


## Strategic Partnership for India's Naval Growth

John Shade, Executive Vice President for U.S. Business Development and Future Programs at Rolls-Royce Defence, emphasized the significance of this collaboration. He stated, "Rolls-Royce has a proven track record of powering some of the world's most advanced naval platforms, including the U.S. Navy's DDG-51 destroyer. India is a key strategic growth market for Rolls-Royce, and we are confident that our industry-leading marine gas turbine generators are an ideal choice to power the Indian Navy's future fleet."

Abhishek Singh, Senior Vice President of Business Development and Future Programs for India and Southeast Asia at Rolls-Royce, highlighted the benefits of localization. He remarked, "This MoU with Triveni is part of our efforts to bring the combined strengths of our naval marine products and services to the Indian market. This is significant, given the potential to establish end-to-end support for our marine gas turbine generators in India, from installation and testing to aftermarket support."

## Triveni Engineering's Role in Indigenous Manufacturing

Tarun Sawhney, Vice Chairman & Managing Director of Triveni Engineering & Industries Ltd., expressed enthusiasm for the partnership, stating, "We are excited about this technology collaboration with Rolls-Royce for indigenously manufacturing their cutting-edge marine gas turbine generators in India. This partnership will not only enhance India's naval defence capabilities but also strengthen the indigenous naval defence ecosystem."

Triveni Engineering has over five decades of expertise in rotary engineering and engineered solutions. The company has become a preferred supplier to the Indian Navy and Indian Coast Guard, offering advanced technologies and capabilities. To support its defence initiatives, Triveni is setting up a new multi-modal defence facility with large-scale infrastructure for manufacturing, integration, and testing of various naval marine equipment.

## Rolls-Royce: A Leader in Marine Gas Turbines

With over 80 years of experience in naval markets, Rolls-Royce remains a leading provider of power and propulsion solutions for major global defence programs. Since introducing the Allison 501-K17 in 1972, Rolls-Royce has led the marine gas turbine generator market. Currently, over 350 Rolls-Royce gas turbine generators are in ac-

tive operation worldwide, including with the British Royal Navy, the Republic of Korea Navy, the Japanese Maritime Self-Defence Force, and the U.S. Navy.

In the U.S., Rolls-Royce's AG9140 generator sets have powered the DDG-51-class warships, with over 200 units installed. The next-generation AG9160 generator set, capable of delivering 4MW of power, represents a 33% increase in capacity over its predecessor.

## Strengthening India's Defence Ecosystem

In India, Rolls-Royce has a robust ecosystem for aerospace and defence, with MTU engines powering several vessels of the Indian Navy and Coast Guard. Triveni Engineering, a leader in India's high-speed gears market, has extensive experience in manufacturing energy-efficient, high-power, high-speed products and solutions for defence applications.

The collaboration between Rolls-Royce and Triveni Engineering is a significant step in strengthening India's defence manufacturing capabilities. By leveraging advanced technologies and local expertise, this partnership is poised to enhance India's naval power and contribute to the country's self-reliance in defence production.

## About Rolls-Royce Holdings PLC

Rolls-Royce develops and delivers complex power and propulsion solutions for critical applications in air, sea, and land environments. With a presence in 48 countries and customers in over 150 nations, Rolls-Royce serves 250 commercial large aero engine customers, 160 armed forces, and navies globally. The company is committed to becoming a net-zero enterprise by 2050.

## About Triveni Engineering and Industries Ltd.

Triveni Engineering & Industries Limited (TEIL) is a diversified industrial conglomerate with expertise in sugar and engineering. In the engineering sector, its Power Transmission business focuses on high-speed gears and gearboxes, serving industries such as oil and gas, defence, and marine applications. Triveni is a leading supplier to OEMs and industrial segments, delivering robust and reliable solutions with 360-degree service support. The company's defence business continues to expand, contributing to propulsion gearboxes, propulsion shafting, and gas turbine generators for the Indian Navy and Coast Guard.

***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.***

# NORD DRIVESYSTEMS SUSTAINABILITY STRATEGY FOR 2025

- PRESS RELEASE

*NORD DRIVESYSTEMS sustainability strategy for 2025 Image: NORD DRIVESYSTEMS*

AtNORD DRIVESYSTEMS, our sustainability strategy for 2025 focuses on acting in an environmentally conscious, responsible and integer manner. A cross-divisional team
as well as the management and owners are part of the implementation. Besides NORD's products, it includes four further fields of action.

"Our sustainability strategy for 2025 is a promise to our customers, to the public and to ourselves to consequently act in an ecological, economic and socially responsible manner", emphasizes Carolin von Rönne from the area of Process and Organisational Development & Corporate Sustainability Management at NORD DRIVESYSTEMS. The strategy comprises five key aspects:

## Products

When it comes to sustainability, our products at NORD are also our top priority. This is because the design, life cycle and application areas have an impact on the environment. The concept of sustainability is therefore already rooted in the product development process. "Drives can be found in many areas of industry, where they consume a large proportion of the energy used," explains Carolin von Rönne. "With efficient drive solutions such as the IE5+ synchronous motor, we want to make a significant contribution to reducing CO emissions." The NORD ECO service furthermore supports companies in finding the most efficient drive solutions for them.

Governance & processes
The sustainability management was introduced at NORD in 2022. Since then, the company has achieved important milestones such as an annual sustainability report according to GRI, environmental certifications and the integration of international structures. The central objective in this field of action is the establishment of an international governance structure and CSRD-compliant reporting for the entire NORD DRIVESYSTEMS Group with 48 subsidiaries in 36 countries because the success of other factors – in particular environment, energy and climate – depends on it.

## Environment

In order to coordinate structured measures and document them in a legally secure manner, international environmental management is essential for NORD. This is implemented in accordance with ISO14001 for the largest subsidiaries. In addition, the climate balance for Scope 1–3 is determined group-wide. NORD DRIVESYSTEMS Group further aims to reduce its energy consumption and amount of waste as well as increase the share of self-produced electric power and the use of renewable energies. Existing biodiversity areas are to be further expanded.

*NORD-IE5The IE5+ synchronous motor from NORD is characterised by its high efficiency and compact design Image: NORD DRIVESYSTEMS*

## People

In times of skills shortage, NORD continues to increase its attractiveness as an employer. The company is currently rolling out a global digital learning management system to offer all employees the opportunity for further individual development. Further targeted campaigns and measures are intended to promote diversity among the workforce. "Inclusion, respect for human rights, strengthening our work culture, safety and continuous transfer of knowledge are only some of the topics we would like to promote", says Carolin von Rönne.

## Supply chain

NORD wants to reassure its customers and employees that sustainable production is given high priority both at manufacturing facilities and in the upstream supply chain. Risk analyses and other processes are carried out within the framework of the Germany Act on Corporate Due Diligence Obligations in Supply Chains (LKSG)

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# Sunnen Highlights HTE-1600W Tube Hone Designed for Small Diameter, Long Bore Application

- EVENT REPORT

*All-Electric, High-Efficiency Machine Delivers Superior Bore Geometry and Surface Finish for Firearms, Medical, Mining, and Energy Applications*

ST. LOUIS, MO - Sunnen Products Company, a global leader in high-precision honing, bore sizing and engine rebuilding equipment, highlights its HTE-1600W Tube Hone, an all-electric precision honing machine designed for optimal bore geometry and surface finish in small diameter, long bore applications.

The HTE-1600W sets a new standard in bore finishing for the Firearms and Defense, Medical, Mining, and Energy industries. This innovative machine features an all-electric design, ensuring ease of maintenance and up to 90% efficiency. The HTE-1600W excels in processing parts with IDs from 4-20 mm and lengths up to 1,500 mm, delivering ideal bore geometry and surface finish.

At the heart of the HTE-1600W is advanced technology that drives superior performance. Its active 3-axis function control manages stroke positions, motion control, stone feed, spindle speed, and cutting pressure, resulting in high accuracy and superior bore geometry. The machine offers 100% process control with tool overload protection, preventing tool breakage and ensuring consistent results.

Compared to traditional bore lapping methods, the HTE-1600W offers significant advantages. It substantially reduces cycle time, decreasing processing time compared to manual bore lapping. The machine's stroke repeatability within 0.006 in (0.15 mm) ensures consistent and precise honing results. A size lock system with stone wear compensation maintains accuracy over time and reduces the need for frequent adjustments.

The HTE-1600W's design incorporates a one-piece base for improved performance and cost-effectiveness. Additionally, the machine's traveling steady rest provides additional support for the tooling used with long workpieces, enhancing versatility.

The machine is compatible with Sunnen MMT and LBT tools, offering flexibility for various small, long diameter bore applications.

Sunnen's commitment to quality is evident in the HTE-1600W's 3-year warranty. The machine interface is available in 13 languages, enhancing its usability for operators worldwide. Additional features include a dual filtration system for clean honing fluid and improved part quality, and the ability to hone for time, number of strokes, or to a programmed diameter, offering flexibility to meet various part requirements.

For additional information on Sunnen and the HTE-1600W Tube Hone visit www.sunnen.com.

## About Sunnen Products Company

Sunnen Products Company, a global leader in precision manufacturing for over a century, has established itself as a premier provider in the creation, sizing, and finishing of machined surfaces. Headquartered in St. Louis, Missouri, Sunnen is a "total solutions provider," manufacturing everything from machinery and abrasives to precision bore gages and customized coolants. This comprehensive approach enables Sunnen to deliver turnkey honing solutions that encompass cutting-edge equipment, tooling, consumables, and coolants. The company's expertise spans a diverse range of industries, including aerospace, automotive, energy, hydraulics, medical, firearms & defense, and tool & die, showcasing its versatility and commitment to innovation. Sunnen's dedication to quality is evident in its products, which exemplify the company's focus on high efficiency, precision, and advanced technology. With a worldwide presence and a track record of building thousands of honing machines, Sunnen continues to drive innovation in bore sizing and finishing, providing tailored solutions to meet the exacting demands of modern manufacturing across diverse sectors.

# Canadian company wins ROBOTICS AWARD 2025

- EVENT REPORT

The ROBOTICS AWARD 2025, one of the most coveted awards in the international robotics community, was presented to Canadian company Maple Advanced Robotics on 19 February 2025 at the HANNOVER MESSE Press Preview. The award-winning MARI AARS project is an AI-driven robotics platform for fast and code-free programming.
19 Feb 2025

**Hannover.** On occasion of HANNOVER MESSE, Deutsche Messe presents the annual ROBOTICS AWARD that honors robot-based automation and logistics solutions. This year's winning project, MARI AARS, is an AI-driven robotics platform for fast and code-free programming. This is made possible by advanced 3D scanning, automatic robot path generation, and an intuitive graphical flowchart interface that eliminates the need for coding and CAD files. In addition, the MARI AARS platform includes features that compensate for deviations, ensuring a consistent level of quality.


In her laudation, jury member Dr. Annika Raatz from Leibniz University praised the outstanding innovation of this robotic platform: "With its autonomous path planning, MARI solves one of the biggest challenges of high-mix production, namely constant reprogramming and setup. This opens up new opportunities – especially for small and medium-sized companies – that will also help to counteract the shortage of skilled workers."

Dr. Jochen Köckler, Chairman of the Managing Board, Deutsche Messe AG, added, "Maple Advanced Robotics is a company from Canada that represents the tremendous innovative strength of our partner country. Canada has long established itself as a leader in robotics with a strong research community and a culture of creativity and collaboration. The exhibiting companies from Canada will demonstrate this at HANNOVER MESSE 2025."
The prize includes a promotion package consisting of exhibition space at the Application Park at HANNOVER MESSE, a presentation slot at the Robotics Forum and an interview in the Robotics Podcast.

## ROBOTICS AWARD

The ROBOTICS AWARD honors robotic automation and logistics solutions. Companies and institutions from Germany and abroad are eligible to enter, regardless of whether they are exhibitors at HANNOVER MESSE 2025. The solutions are judged on their level of technical innovation, marketability and economic viability.

## HANNOVER MESSE

HANNOVER MESSE is the world's leading trade fair for industry. Under the lead theme of "Industrial Transformation", more than 4,000 exhibiting companies from the mechanical engineering, electrical and digital industry as well as the energy sector come together to present solutions for the production and energy supply of today and tomorrow. The main exhibition areas in 2025 are Smart Manufacturing, Digital Ecosystems, Energy for Industry, Compressed Air & Vacuum Technology, Engineered Parts & Solutions, Future Hub, and International Trade & Investment. A conference program with roughly 1,600 speakers complements the program. The next edition runs in Hannover from 31 March to 4 April 2025. Canada is Partner Country.

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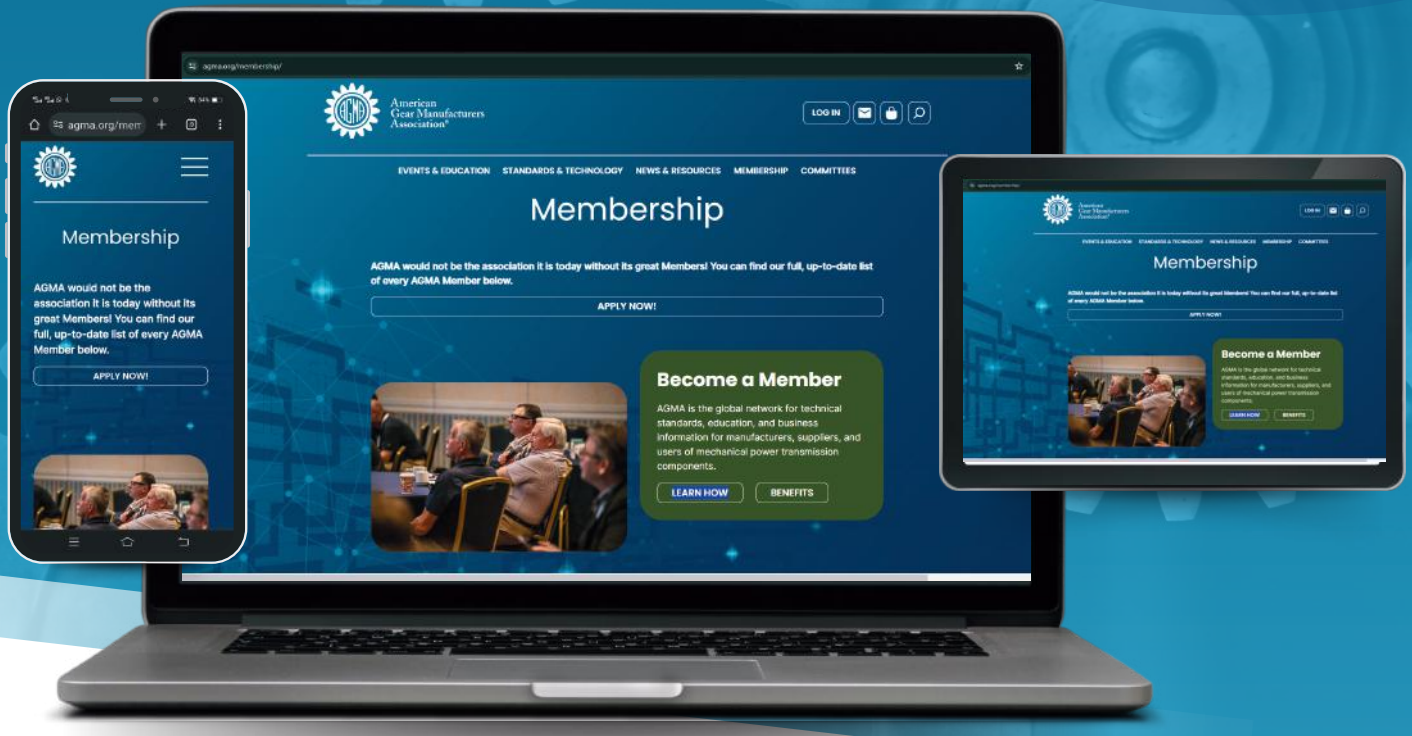


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