gear TECHNOLOGY INDIA

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TECH EXPERT'S COLUMN

Corrected Lead Hobs: Understanding the need & machine settings

AGMA UPDATE

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In Association

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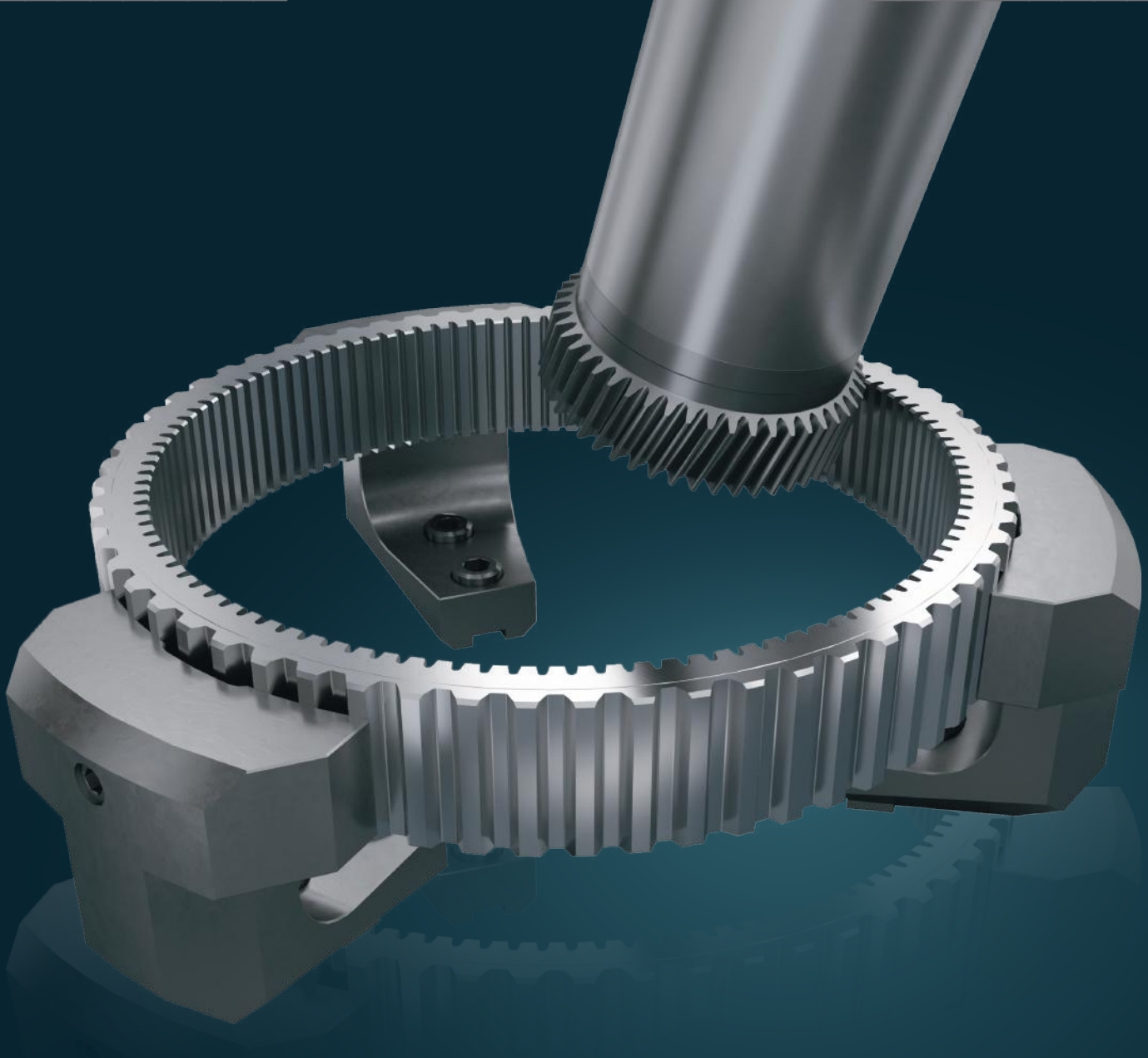

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Dear Readers,

As we turn the pages of **Volume 3, Issue 3 of Gear Technology India**, we do so with a sharp focus on one of the most foundational yet rapidly evolving technologies in gear manufacturing — Gear Hobbing Machines. This issue celebrates the intersection of time-tested processes and cutting-edge innovation, shining a light on how hobbing is being transformed by intelligence, precision, and automation.

Our **cover story**, "AI Meets Steel: How Smart Hobbing Machines Are Redefining Precision and Productivity," captures the essence of this transformation. As artificial intelligence integrates with metal-cutting equipment, we are witnessing the birth of machines that are not only faster and more accurate but also adaptive and self-optimising. This shift is more than technological — it is strategic, shaping the future of global competitiveness.

From the **Tech Expert's Column** on Corrected Lead Hobs and machine settings to insightful articles on **closed-loop manufacturing**, **FSP for gear strengthening**, and **zero-backlash performance through precision machining**, we explore how traditional gear-making techniques are being refined for modern demands.

In this issue, we are also proud to highlight voices shaping India's gear and manufacturing landscape. Our interview with **CMTI** reveals a national mission toward **indigenous innovation**, while our conversation with experts in **next-gen lubricants** speaks to the evolving needs of high-stress gear environments.

Beyond technology, we bring you updates from **AGMA**, including its historic alliance with ABMA to form the **Motion and Power Manufacturers Alliance (MPMA)** — a move that signifies greater unity and global vision. In our **tech innovation** section, an engaging piece draws parallels between **mechanical design and the human brain**, inviting us to imagine a world where engineering and intelligence co-create the future.

As the industry gears up for **EMO Hannover 2025**, this issue positions you at the heart of what's next — from **digital engineering showcases** to the **robotics-driven expansions of global players** like Mayr and Flender.

In every column and report, you'll find one message echoed loud and clear: **Gear hobbing machines are no longer just tools — they are becoming intelligent systems driving tomorrow's factories.**

We hope this issue inspires you, informs you, and equips you for the exciting road ahead in gear manufacturing.

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.

PUBLISHER
Anitha Raghunath
anitha@virgo-comm.com

CONTENT CONTRIBUTOR
editorial@geartechnologyindia.com

ASSOCIATE EDITOR
Sushmita Das

TECHNICAL WRITERS
C Selvaraj
Nishant Kashyap
KP Soundarajan
Cdr MS Srikant (Retd)
Vishwajit Kothari
Sudhanshu Nayak
Vivek Singh

TECHNICAL EXPERTS
Chinnappan Selvaraj
Vishwajit Kothari

DESIGNER
Aneena AS

ADVERTISING, MARKETING & SALES
Vashdev S Gwalani
dev@virgo-comm.com | M: 9740611121

CIRCULATION / SUBSCRIPTION
Selva Kumar
selvakumar@virgo-comm.com

ACCOUNTS
Vidhya Praveen
accounts@virgo-comm.com

MANAGEMENT
Raghunath G
Matthew Croson

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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.

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Table Of CONTENTS

Corrected Lead Hobs: Understanding the need & machine settings

- By Sanjay Gupta

During our interactions with customers, we find that the common challenge faced by customers about getting incorrect component parameters using Corrected Lead Hobs.

The topic will address the following questions.

- What are corrected lead hobs?
- Why is it necessary to design such hobs?
- What are the correct machine settings depending upon the type of machine, CNC or Semi-CNC or manual?

What is Corrected Lead Hob?

In Corrected Lead hobs, Module & Pressure Angle of Hob is different from that of the component. If the Pressure angle of hob is less, then it is a Short Lead Hob and when Pressure Angle is more, then it is Long Lead Hob.

Why is it necessary to design Corrected Lead Hob?

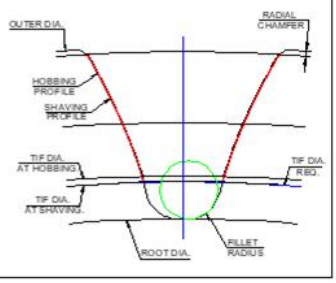
When the True Involute Form (TIF) diameter and Fillet Radius of the component are not achieved with the original Pressure Angle, then the Pressure Angle is reduced or increased to obtain the correct TIF & Fillet Radius. This can be explained with the following example.

Standard Hob Design: Our requirement is that TIF Shaving should be below required TIF Diameter. However, when hob is designed in a normal way, the TIF required & TIF shaving are almost at the same values as is visible from Picture 1.

NORMAL MODULE

COMP DATA		
COMP DWG No.		P05167(0.022.2088.0) 40T
NO OF TEETH		40
NORMAL MODULE		3
NORMAL P.A.		20°
HELIX ANGLE/HAND		23° LH
OUTSIDE DIA		136.540/136.700
ROOT DIA		122.307/122.428
DOP	HOBBING	140.72/140.75
	SHAVING	140.57/140.60
	PIN DIA	6
SHAV. ALL./FLANK		0.032
RAD.CHAMF. SHAV.		0.2 x 40° (MAX.)
TIF DIA REQUIRED		125.450
TIF DIA AT HOBBING		125.94
TIF DIA AT SHAVING		125.48
FILLET RADIUS		1.150 (MIN.)

HOB DATA	
N.MODULE	3
N.PA	20°



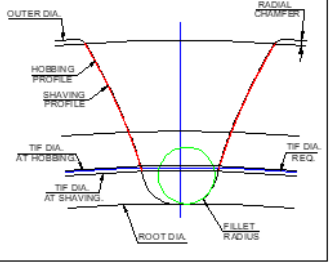
Picture 1 (Generation with Standard Design)

Corrected Lead hob Design: We reduce the pressure angle of Hob from 20° to 18° and generate the component. As is evident from Picture 2 below, the required TIF diameter is above TIF shaving as per the requirement of the drawing.

GEN.MODULE

COMP DATA		
COMP DWG No.		P05167(0.022.2088.0) 40T
NO OF TEETH		40
NORMAL MODULE		3
NORMAL P.A.		20°
HELIX ANGLE/HAND		23° LH
OUTSIDE DIA		136.540/136.700
ROOT DIA		122.307/122.428
DOP	HOBBING	140.72/140.75
	SHAVING	140.57/140.60
	PIN DIA	6
SHAV. ALL./FLANK		0.032
RAD.CHAMF. SHAV.		0.2 x 40° (MAX.)
TIF DIA REQUIRED		125.450
TIF DIA AT HOBBING		125.60
TIF DIA AT SHAVING		125.16
FILLET RADIUS		1.150 (MIN.)

HOB DATA	
GEN.MODULE	2.96415
GEN.PA	18°
SETTING ANGLE	20°38'



Picture 2 (Generation with Corrected Design)

Hence, the corrected lead hobs are necessitated to be designed due to limitations in achieving the component data.

Machine Settings

Corrected lead design hobs bring new challenges at the time of setting on Hobbing Machines. With the various kinds of machines in operation like Manual, Semi-CNC & Fully CNC machines, hob settings in each type of machines differ.

Important Points to keep in mind while setting on the Hobbing Machine.

Spur Gears: Lead Angle is the same as Set Angle. Hence, only Lead Angle will be marked on the Hob. Please refer to Picture 3.

Helical Gears: Hob set Angle is different from Hob Lead Angle, and both angles are marked on Hob. Both the Lead Angle & Set Angle are marked on hob. But for setting on Machine, only Set Angle should be referred. Please refer Picture 4.

Picture 3
Marking on Hob for Spur Gear)

Picture 4
Marking on Hob for Helical Gear

Manual Hobbing

Spur Gear: Hob Lead angle as marked on the Hob is to be manually set on the machine. For example, referring to picture 3, the value to be manually set on machine is 1˚18'06".

Helical Gear: Hob Set Angle (Not Lead Angle) as marked on Hob to be manually set on the machine. For example, referring to picture 4, the value to be manually set on machine is 20˚38'.

Semi-CNC Hobbing Machines (where the Hob lead angle is to be set Manually)

The procedure to set up the Angle remains the same as in Manual Hobbing Machines. However, you will find two files for inputting the data, one for component data and another for Hob data.

Component Data File: Input Original Module & Original Pressure Angle
(Module 3 & Pressure Angle 20 as in Picture 2).

Hob Data File: Input Corrected Module & Corrected Pressure Angle
(Module 2.96415 & Pressure Angle18˚ as in Picture 2).

CNC Hobbing Machines (where Hob lead angle is calculated by the Machine)

In this Case, there is no need to input the Lead Angle or Set Angle. The operator must ensure to input the values in both the component & Hob file.

Component Data File: Input Original Module & Original Pressure Angle
(Module 3 & Pressure Angle 20˚ as in Picture 2)

Hob Data File: Input Corrected Module & Corrected Pressure Angle
(Module 2.96415 & Pressure Angle18˚ as in Picture 2)

However, the operator must ensure that the Hob Set Angle calculated by the machine is the same as marked on Hob.

Incorrect settings or feeding incorrect values will lead to wrong component parameters, like the Root diameter and profile.

Hope the above article will help in bringing clarity about the necessity to design, how to use Corrected Lead Hobs and understanding machine settings based on the type of gear and machine.

Please write to me at esgi@esgitools.com for any challenges in the usage or selection of Gear Cutting Tools.

Sanjay Gupta | Director |
ESGI Tools Pvt. Ltd. | India |

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Systems

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

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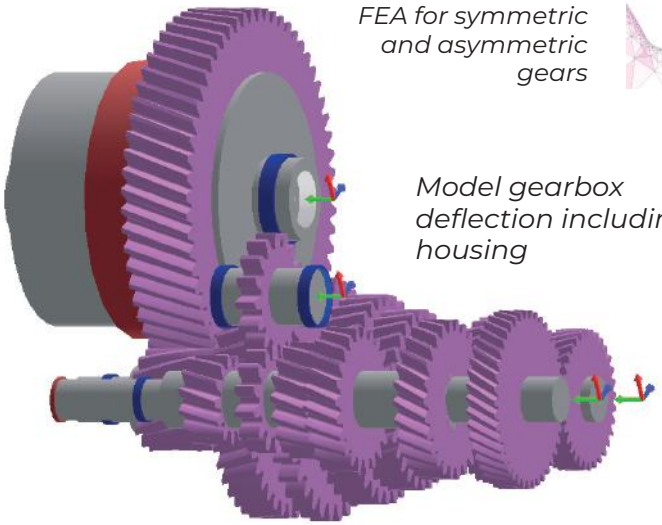
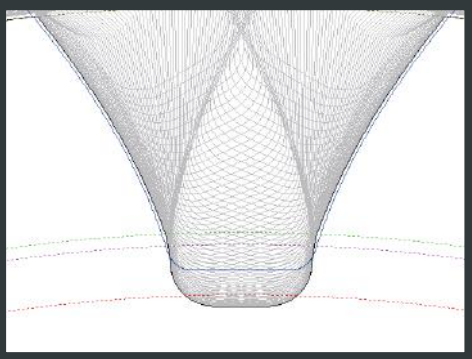
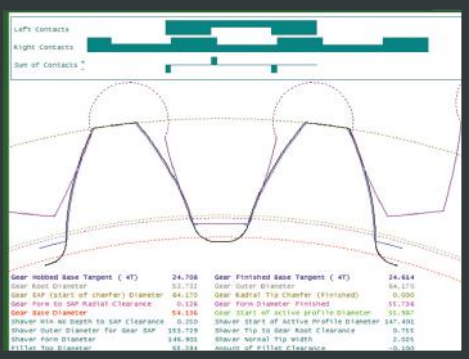


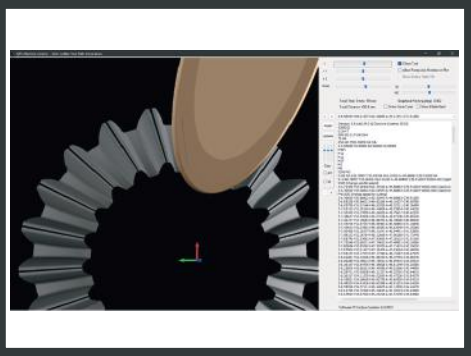
Model gearbox deflection including housing



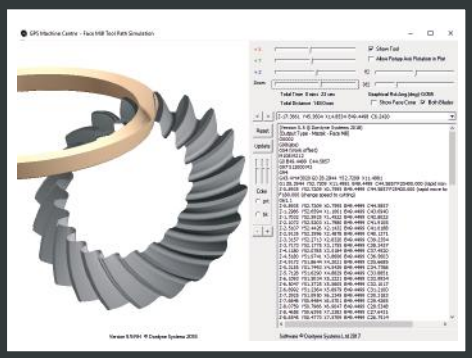
Hob / Grind Roll Out



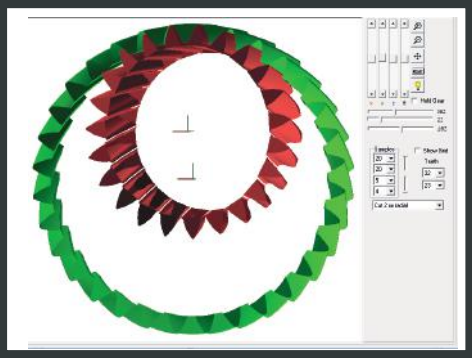
Shaving' and Shaping



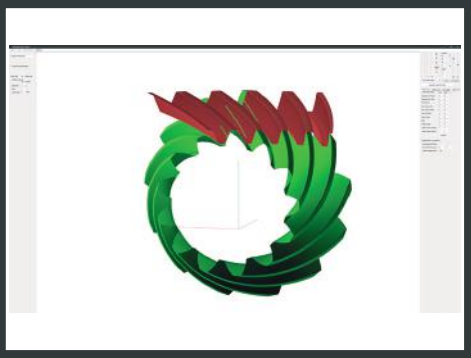
Coniflex CNC



End Mill / Face Mill CNC



Skiving



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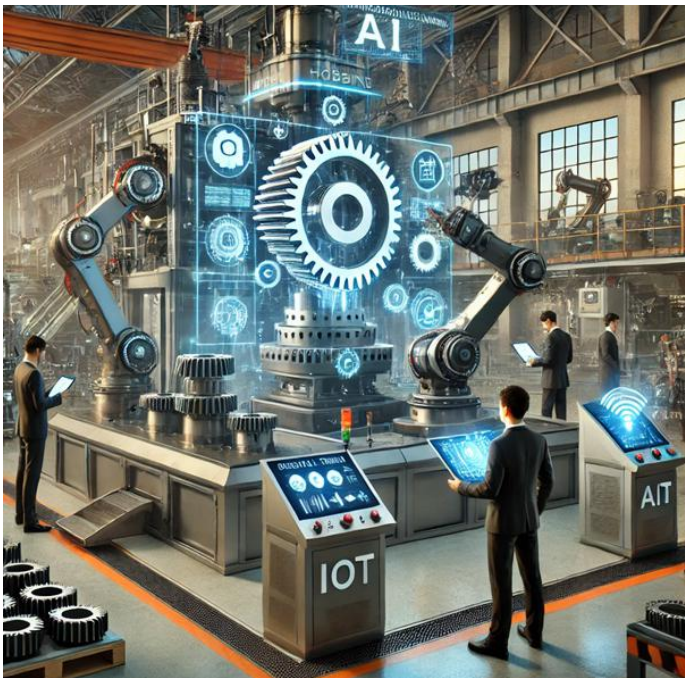
AI Meets Steel: How Smart Hobbing Machines Are Redefining Precision and Productivity

- By Sushmita Das

Exploring the synergy of artificial intelligence, predictive maintenance, and advanced CNC in the next generation of gear hobbing technology



Digital Revolution in Gear Cutting

Do you know that in the heart of every automobile, turbine, windmill, or heavy machine lies a component that never stops turning—gears? Yes, these mechanical marvels have been manufactured for centuries, but the methods for producing them are undergoing a radical transformation. As we are aware, gear hobbing, is one of the most critical and widespread gear cutting processes, is evolving in ways that were once the domain of science fiction.

Artificial Intelligence (AI), machine learning, IoT, and cyber-physical systems are entering the gear shop floor, breathing new life into traditional hobbing machines. The new generation of smart hobbing systems combines the brute precision of traditional mechanics with the intelligence of digital technologies to unlock unprecedented levels of productivity, consistency, and agility.

India's gear manufacturing sector—already an important global player—is witnessing this shift firsthand. In this article, we delve into how smart hobbing machines are reshaping manufacturing strategies, what technologies are leading the charge, and how Indian manufacturers are preparing for a future where AI meets steel.

The Evolution of Gear Hobbing: From Mechanical Mastery to Digital Dexterity

Gear hobbing is a continuous cutting process where a hob (a cylindrical cutting tool) rotates in sync with the gear blank to generate gear teeth. Since the early 20th century, hobbing machines have evolved from manually operated gear-driven systems to CNC-controlled machines capable of high-speed, high-precision cutting.

But the fundamental principle remained unchanged—until now.

The introduction of advanced sensors, edge computing, cloud analytics, and AI algorithms has allowed manufacturers to not just control the hobbing process, but to optimize, predict, and autonomously correct it in real time.

We are witnessing a transformation from:

- **Reactive to predictive maintenance**
- **Static to adaptive cutting strategies**
- **Operator-dependent to self-learning systems**

This is no incremental shift—it's a technological leap.

Core Technologies Behind Smart Hobbing

1. Artificial Intelligence and Machine Learning

Modern hobbing machines are now embedded with algorithms that monitor parameters such as spindle torque, vibration, temperature, and acoustic emissions. These systems "learn" from production runs and create digital fingerprints of optimal machining conditions. When something deviates—say, tool wear or material inconsistency—the AI flags it or autonomously adjusts parameters.

For example, a machine learning model can analyse historical data to determine the ideal feed rate for a specific gear size and material combination, improving both surface finish and tool life.

2. Industrial IoT (IIoT) Integration

Smart hobbing machines are part of an inter-

connected ecosystem. Data from each machine can be streamed to a central control system, where managers can monitor production metrics, tool usage, and maintenance needs remotely. This creates a fully transparent and agile manufacturing environment.

3. Digital Twin Technology

By creating a real-time virtual model of the hobbing machine and the workpiece, manufacturers can simulate gear cutting processes before running them on the shop floor. Digital twins allow for error prediction, design validation, and process optimisation without wasting raw material.

4. Closed-Loop Feedback Systems

Advanced hobbing machines now feature in-line measurement systems, such as laser scanning and probe touch sensors, that compare the actual tooth geometry against the design intent during the process. Deviations trigger automatic compensation without operator intervention.

Indian Market: From Catching Up to Leading the Way

India's gear manufacturing industry—valued at over 10,000 crore—is gradually embracing smart hobbing. Automotive giants, Tier-1 suppliers, and precision gear manufacturers are investing in intelligent machines to meet the growing demand for quality, efficiency, and traceability.

Case in Point: Bharat Gears Ltd.

Bharat Gears, one of India's largest gear manufacturers, has recently piloted a smart hobbing cell that integrates sensor-based monitoring with AI-driven adaptive control. According to their plant engineering team, tool life has improved by 18%, and machine downtime has been reduced by over 20% due to predictive maintenance algorithms.

"Digital hobbing isn't just about better gear quality. It's about having a system that tells us when to intervene and why. That's a game-changer for planning and quality assurance," says a senior manufacturing engineer at Bharat Gears.

SMEs Joining the Race

Even smaller job shops are exploring retrofitting older hobbing machines with smart add-ons. Companies like Aikon Technologies and Micromatic are offering modular IIoT kits that provide real-time insights without requiring a complete machine overhaul.

Key Benefits of Smart Hobbing: Unlocking Competitive Advantages

Improved Accuracy and Repeatability

Traditional hobbing machines—while reliable—often depend heavily on the operator's skill to maintain consistency in gear cutting. With AI-powered systems, this variability is drastically reduced. Smart hobbing machines use real-time data from torque sensors, spindle load, thermal variations, and vibration patterns to fine-tune the process on the fly.

This dynamic optimization enables tighter tolerance control, often within microns, which is especially critical in applications such as:

- Electric vehicle (EV) transmissions, where noise, vibration, and harshness (NVH) standards are extremely stringent.
- Aerospace gear systems, where even micro-deviations can compromise safety and performance.
- Precision robotics, where backlash-free gear operation is essential.

By reducing human-induced variation and enabling automatic in-process corrections, smart hobbing ensures every gear off the line is as precise as the first.

Increased Uptime Through Predictive Maintenance

In conventional gear manufacturing setups, machine maintenance typically follows a reactive or calendar-based schedule. This approach either leads to unplanned downtime due to sudden failures or premature servicing that wastes resources.

Smart hobbing machines equipped with predictive maintenance algorithms change the game. By continuously monitoring machine health indicators—like spindle temperature, lubrication flow rate, gear backlash, and tool vibration—AI systems can detect early warning signs of wear or failure.

This allows for:

- Just-in-time maintenance, preventing breakdowns without over-servicing.
- Reduced mean time to repair (MTTR) as alerts come with diagnostics.
- Higher overall equipment effectiveness (OEE) across the production floor.

Especially in India, where supply chain disruptions and service delays are common, predictive maintenance adds a vital layer of resilience.

Lower Operating Costs

Although the capital cost of smart hobbing machines is higher, their operating efficiency leads to significant cost savings in the long run.

Here's how:

- Tool Life Optimisation: By adjusting feed rates and cutting speeds based on real-time tool condition, smart machines reduce tool wear, extending hob life.
- Reduced Scrap Rates: AI prevents tolerance drift, ensuring fewer rejected parts.
- Energy Efficiency: Adaptive cutting conserves energy during low-load operations.
- Faster Setups: Digital twin simulations and automatic parameter tuning reduce setup time, improving throughput.

In high-volume production environments—like automotive component manufacturing or industrial gearboxes—even a 1–2% reduction in scrap or tool consumption translates into lakhs of rupees saved annually.

Workforce Upskilling

As smart hobbing becomes more widespread, the role of the machine operator is shifting from manual intervention to strategic oversight. Instead of tweaking knobs and adjusting backlash manually, operators are now expected to:

- Program CNC sequences based on AI recommendations
- Interpret dashboards and data trends
- Collaborate with maintenance and IT teams on machine diagnostics

This transition not only improves operational reliability but also opens doors for workforce development. In India, where the manufacturing labor force is extensive but unevenly skilled, this evolution represents a chance to bridge the gap between shopfloor work and smart manufacturing careers.

Vocational programs, government initiatives like Skill India, and OEM-led training centres can help accelerate this upskilling journey.

Challenges on the Road to Smart Hobbing

While the benefits are compelling, adopting smart hobbing technology is not without its roadblocks—especially for the small and medium manufacturers that form the backbone of India's gear industry.

High Initial Investment

A smart hobbing machine—with integrated sensors, closed-loop control, and cloud connectivity—can cost 30–50% more than its conventional CNC counterpart. For large OEMs and Tier-1 suppliers, this cost may be manageable, especially when justified through long-term ROI.

However, for MSMEs, which dominate India's gear manufacturing sector, such an investment poses a serious financial hurdle. While the payback in terms of productivity and quality is clear, it often takes 2–3 years to fully realize—an uncertain prospect for small businesses facing daily cash flow challenges.

Solution Paths:

- Government subsidies under Make in India or PLI (Production-Linked Incentive) schemes.
- Leasing or pay-per-use models from machine OEMs.
- Strategic co-investment with customers (e.g., automotive OEMs helping vendors modernize).

Skill Gaps

The move to smart hobbing isn't just about machines—it's about people. Operating AI- and IIoT-enabled systems requires a blend of mechanical knowledge and digital literacy. Many current operators, especially those trained in traditional machining, find it difficult to adapt quickly.

Key skill gaps include:

- Understanding sensor data and interpreting dashboards.
- Programming adaptive CNC cycles or integrating digital twins.
- Troubleshooting software-hardware interface issues.

Solution Paths:

- Collaboration between industry and academia to create tailored curricula.
- Manufacturer-led training programs (e.g., Gleason Academy, Siemens Mechatronic Systems Certification).

- Upskilling platforms like NSDC, Skill-Lync, and Coursera for Manufacturing.

Connectivity and Infrastructure

Smart hobbing relies on a robust digital infrastructure—reliable high-speed internet, secure cloud platforms, and cyber-resilient factory networks. Unfortunately, many industrial areas in India suffer from:

- Patchy internet coverage
- Lack of local IT support
- Weak cybersecurity awareness

Without this foundation, features like remote monitoring, cloud analytics, or firmware updates become infeasible.
Solution Paths:

- Private 5G and edge-cloud deployments in partnership with telecom firms.
- Cybersecurity frameworks as part of the machine purchase and installation.
- Government push for Digital Infrastructure in Industrial Clusters under the Smart Cities initiative.

Legacy Integration

Most Indian gear manufacturers still use older mechanical or semi-CNC hobbing machines, many of which are amortised but still functional. Replacing these machines entirely isn't always viable.
While retrofitting solutions exist—such as bolt-on sensors, PLC upgrades, and IIoT gateways—they often have limited scope:

- No real-time closed-loop control
- Limited compatibility with AI modules
- Partial or no integration with ERP/MES systems

Solution Paths:

- Tiered modernisation plans (Stage 1: retrofit; Stage 2: replacement)
- Partnering with retrofit specialists like Aikon, ifm India, or local automation vendors.
- Gradual rollout with pilot lines to demonstrate ROI before full-scale investment.

Looking Ahead: What's Next in Smart Hobbing?

As smart hobbing technology matures, we are moving beyond isolated machine intelligence to a fully integrated digital ecosystem. The future of gear manufacturing will not only be smarter—it will be autonomous, connected, adaptive, and sustainable. Here's a look at the

key innovations on the horizon:

1. Autonomous Machining Cells
"One-click gear production"—that's the vision.
Autonomous machining cells represent the next frontier in gear manufacturing. These integrated systems will combine:

- Robotic arms for loading and unloading gear blanks
- Smart hobbing machines with AI-driven adaptive control
- Inline measurement systems for real-time quality assurance
- Automated deburring, washing, and palletising
- ERP and MES integration for seamless production tracking

Once a work order is fed into the system, the cell will handle everything—from raw material to finished, inspected gears—without operator intervention. This model is particularly attractive for:

- EV gearboxes, where high volumes and low tolerances coexist
- Export-driven manufacturers, aiming for lights-out production
- Precision parts suppliers, who must meet strict traceability demands

Already, companies like FFG, Liebherr, and Gleason are developing modular automation kits for hobbing cells. In India, pilot lines in Pune and Chennai are experimenting with such configurations for Tier-1 suppliers.

2. Cloud-Based Manufacturing Intelligence

From smart machines to smart factories—and now, smart networks.

Cloud connectivity is transforming how gear manufacturers manage operations. By aggregating and analysing machine data across multiple plants and geographies, manufacturers can:

- Benchmark performance of machines, operators, and product lines
- Predict machine failures by comparing patterns

across installations

- Optimise tool inventory and logistics using real-time usage data
- Enable remote service and software updates over secure connections

Cloud-based analytics platforms—such as Siemens Mindsphere, Bosch Nexeed, and Rockwell FactoryTalk—are gaining traction in India. These systems offer dashboards that combine machine KPIs with business insights, allowing plant heads to make data-informed decisions across locations.

This is especially beneficial for:

- Multi-site gear producers managing assets in different cities or states
- OEMs with vendor oversight needs, ensuring supplier consistency
- Service-oriented manufacturing, where uptime is a contractual KPI

3. AI-Powered Design for Manufacturability (DfM)

AI won't just optimize how we cut gears—it will reshape how we design them.
Traditionally, gear designs are handed off from engineering to production, often leading to back-and-forth adjustments when manufacturability issues arise. But with the rise of AI-powered DfM systems, this handoff will become a collaborative feedback loop.

How it works:

- CAD software integrates with the hobbing machine databases
- AI evaluates gear geometries against cutting tool capabilities
- Design suggestions are made in real-time—for example:
- "Increase root radius for better tool life"
- "Change module size to reduce cycle time by 12%"
- Cost and time estimates are provided instantly based on past production data

This tight integration between design, process planning, and execution will shorten development cycles and reduce design-induced inefficiencies. It also enables mass customisation, where different gear profiles can be produced on the same machine with minimal downtime.

4. Sustainability Metrics and Environmental Intelligence

Smart hobbing isn't just good for productivity—it's good for the planet.

With increasing pressure to meet Environmental, Social, and Governance (ESG) goals, manufacturers are seeking ways to track and improve their sustainability performance. Next-gen hobbing machines will be equipped with real-time environmental monitoring features, such as:

- Energy usage per part produced
- Coolant consumption and recycling metrics
- Material scrap rate per gear batch
- CO2 footprint analysis linked to power source and process efficiency

These metrics will feed into sustainability dashboards, allowing companies to:

- Set reduction targets for energy and material waste
- Earn certifications (e.g., ISO 50001, ISO 14001)
- Respond to green supply chain mandates from global OEMs

Manufacturers that adopt these technologies early will not only reduce operational costs but also gain a competitive edge in securing international contracts—particularly in automotive and aerospace, where ESG compliance is becoming a selection criterion.

Furthermore, digital twin models can simulate the environmental impact of different production strategies, allowing gear manufacturers to choose the most sustainable (and cost-effective) path forward.

Closing Note: Embracing the Smart Hobbing Future

The transformation of hobbing machines from mechanical workhorses to intelligent manufacturing systems is more than a technological upgrade—it's a strategic imperative. As global demand for high-precision gears rises and tolerance for errors drops, manufacturers that adopt AI-enabled, data-driven hobbing technologies will be the ones to lead.

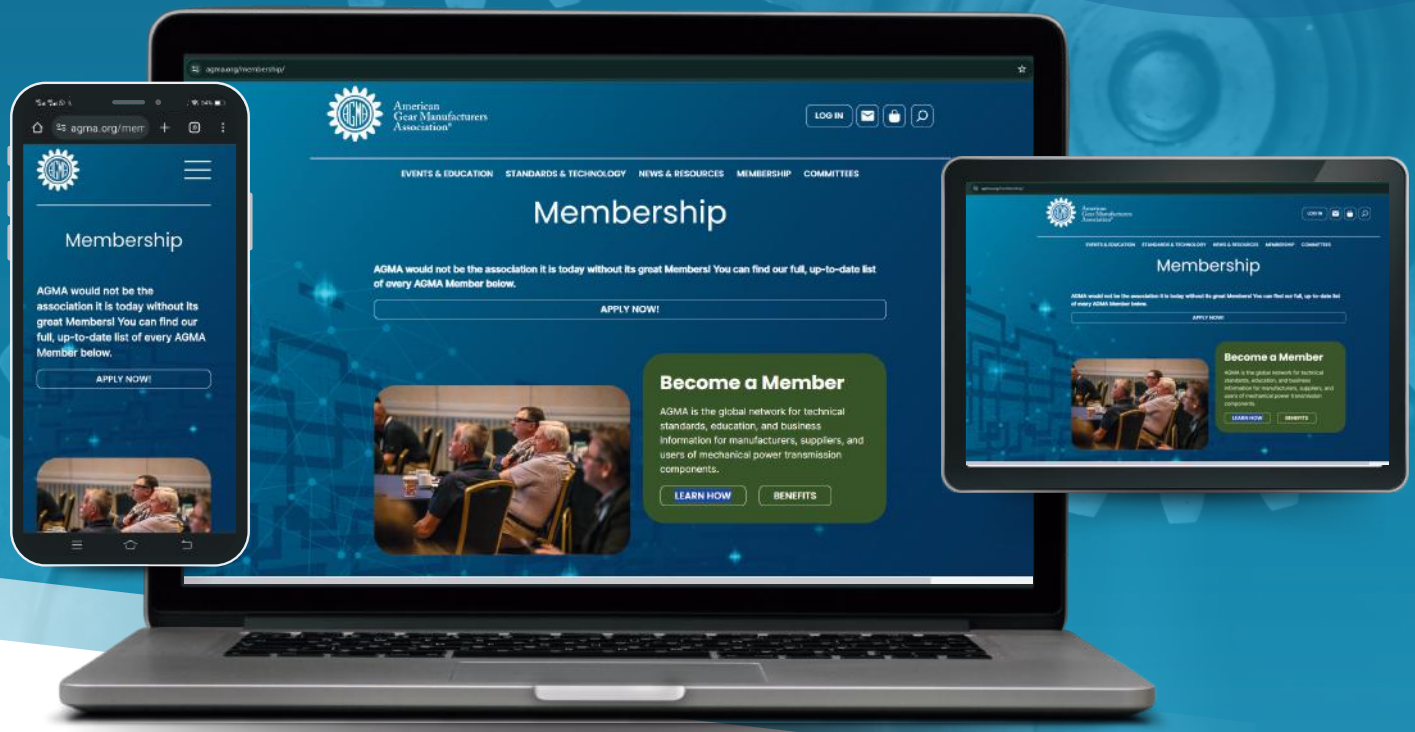
For India, the challenge is two-fold: modernise legacy systems and scale up smart manufacturing capabilities to match global benchmarks. The good news is that the building blocks are already in place—talent, innovation, and ambition.

The future of gear hobbing isn't just about cutting teeth—it's about cutting-edge thinking.

American Gear Manufacturers Association

BECOME A AGMA MEMBER

A Global network of technical standards, education & business information for manufacturers, suppliers & users of mechanical power transmission components



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AGMA and ABMA Unite to Form the Motion and Power Manufacturers Alliance (MPMA)

- By Sushmita Das

A New Chapter Begins for the Gearing and Bearing Industry

Effective May 1, 2025, two of the most influential organizations in mechanical power transmission merge to drive greater value, unity, and innovation.

In a landmark development for the mechanical power transmission industry, the American Gear Manufacturers Association (AGMA) and the American Bearing Manufacturers Association (ABMA) have officially merged to form the Motion and Power Manufacturers Alliance (MPMA). The decision was ratified by a member vote during the AGMA/ABMA Annual Meeting held on April 24, 2025, in Austin, Texas. The newly established organizational structure went into effect on May 1, 2025.

A Strategic Union with Deep Roots

Together, AGMA and ABMA bring more than 215 years of combined industry leadership, with AGMA founded in 1916 and ABMA in 1917. While the merger signals a new era, both organizations will retain their well-established names in the marketplace, reflecting their historic significance and brand equity.

This strategic integration is a natural progression of a long-standing partnership between the two associations. Over the past 18 years, AGMA and ABMA have collaborated on numerous initiatives, including joint annual meetings and cross-organizational programs. Since 2019, AGMA has also managed the day-to-day operations of ABMA, laying the groundwork for a unified structure.

Expanding Value for the Power Transmission Industry

The formation of MPMA is designed to better serve an industry undergoing rapid transformation, marked by increasing demand, technology integration, and corporate consolidation. The alliance aims to enhance member value through:

- Expanded standards development under the AGMA and ABMA brands
- Advanced education and workforce development programs
- Strengthened supply chain connectivity through industry events
- Two dedicated publications representing gears and bearings
- Unified advocacy efforts at the federal level

With over 425 member companies, MPMA now represents a comprehensive ecosystem—from open and enclosed gear manufacturers to bearing innovators—serving both global giants and domestic enterprises across the power transmission spectrum.

Leading the Charge

Incoming MPMA Chair Sara Zimmerman, Vice President of Customer Experience and Product at Sumitomo Machinery Corporation of America, emphasized the significance of the merger:

"The creation of the MPMA comes at a crucial time in our industry, where we are seeing a growth in gearing and bearing sales, and a consolidation of the companies that create these mechanical power solutions. I look forward to working closely with Vice Chair Matt Frady from Dodge Industrial, and the entire Board of Directors as we forge a new path for this dynamic industry."
Zimmerman also underscored the alliance's long-term mission:

"This unified organisation holds incredible potential. I look forward to working collaboratively with both AGMA and ABMA members to ensure the MPMA not only thrives but also empowers our entire membership in the years to come."

A Future-Focused Alliance

The launch of MPMA symbolises more than just a merger—it represents a bold step forward in shaping the future of motion and power transmission. With united voice, integrated strategy, and broadened capabilities, MPMA is positioned to lead the industry into a new era of collaboration, innovation, and global competitiveness.
For inquiries, please contac Matt Croson, President, AGMA at 703-838-0050.

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.

Engineering India's Future: CMTI's Mission for Indigenous Innovation

- By Sushmita Das

Dr. Nagahanumaiah

Director at CMTI - Central Manufacturing Technology Institute

As India's manufacturing sector rapidly advances toward self-reliance and technological excellence, institutions like the Central Manufacturing Technology Institute (CMTI) continue to play a pivotal role in shaping the future of indigenous innovation. In this exclusive interview, Dr. Nagahanumaiah, Director of CMTI, speaks with Sushmita Das, Associate Editor of Gear Technology India, about the institute's legacy, its evolving focus areas, and the strategic initiatives driving next-generation manufacturing technologies. From special-purpose machines to smart manufacturing and semiconductor equipment, Dr. Nagahanumaiah offers a deep dive into CMTI's contributions to the nation's industrial growth.

Q1: Please introduce yourself and tell us about CMTI.

Dr. Nagahanumaiah: I am Dr. Nagahanumaiah, Director at Central Manufacturing Technology Institute (CMTI), a national R&D institute under the Ministry of Heavy Industry, Government of India. CMTI was established in March 1962. For the past 64 years, we have been focused on the design and development of advanced machines for various industrial applications.

Q2: What kind of technologies and services does CMTI offer?

Dr. Nagahanumaiah: CMTI has developed more than 500 technologies so far. Our work is primarily applied research, and our solutions are industry-ready. We work closely with around 15 DRDO labs, BARC, ISRO, and many engineering industries.

Our work is broadly categorised into four areas:

1. **Technology Gap Identification** – We identify gaps in Indian manufacturing and develop solutions to fill those voids, often funded by the government or in collaboration with industry.

2. **Sponsored Programs** – We solve specific problems posed by customers by developing custom machines or processes.

3. **TIC Services** – These include Testing, Inspection, Calibration, and Consultancy across materials, manufacturing, metrology, noise/vibration, and aerospace applications. We deliver around 3,000 services annually to over 700 customers.

4. **Training** – We conduct around 50 short-term training programs each year, along with customised corporate training programs tailored to industry needs.

Q3: Could you elaborate on the key research and technology centres at CMTI?

Dr. Nagahanumaiah: Yes, we have five major research centres:

1. Centre for Special Purpose Machines:
We develop both small tabletop machines and large custom machines up to 12 square meters in footprint, used across defence, aerospace, and engineering industries.

2. Ultra Precision and Smart Manufacturing (SMPM):
This group designs ultra-precision machines capable of micron to nanometre accuracy and develops Industry 4.0-enabled smart manufacturing solutions.

3. Micro-Nano Manufacturing & Precision Metrology:
We offer NABL-accredited dimensional metrology services and provide access to high-end micro/nano precision manufacturing equipment that industries may not afford on their own.

4. Centre for Aerospace and Additive Manufacturing:
Specialises in hydraulic and pneumatic LRU test rigs for aerospace giants like HAL, DRDO, GE, and Rolls-Royce. We test around 15 parametres and develop the protocols for designs.
In additive manufacturing, we're developing metal-based additive manufacturing machines.
We also build another machine that is for printing frozen food and engineered medical nutrition foods. We even have a polymer 3D printer already built.

5. Sensor and Vision Technology Centre:
Comprises two groups:

- Sensor Technology Development Center (STDC): Focuses on Micro Electronic Metal-based System (MEMS-based) sensor design, fabrication, packaging, and associated electronics.

- Vision Technology Group: Develops computer vision systems for measurement, inspection and defect detection, including AOI (Automatic Optical Inspection)

machines for PCB manufacturing.

Q4: What challenges do you face while working with industry clients?

Dr. Nagahanumaiah: A major challenge is that clients often cannot define their problems in engineering terms—they can only describe the application. Our scientists help translate that into engineering language.

We also assist in defining specifications, avoiding both over- and under-engineering. Many times, a well-designed product may be difficult to manufacture or may exceed customer needs. Our team balances all these aspects.

Q5: How do you approach problem-solving at CMTI?

Dr. Nagahanumaiah: We follow a 4P approach:

1. Product – Help clients with the engineering design of the product.
2. Process – Develop cost-effective and productive manufacturing processes.
3. People – Focus on end-user training and usability.
4. Production – Our strength lies in machine development, automation systems, and manufacturing management, including Industry 4.0, quality control, and assurance.

Q6: Are CMTI's products aligned with environmental sustainability goals?

Dr. Nagahanumaiah: Yes, sustainability is a key focus. We ensure products are designed for longer life, with possibilities for reuse and reconditioning. These aspects are integrated from the early stages of product development.

Q7: What is the vision for CMTI over the next few years?

Dr. Nagahanumaiah: We aim to develop machines that have not yet been engineered in India. While we began with basic workshop machines like lathes and grinders, we've moved into advanced areas:

- Metrology equipments

We aim to come up with:

- **Battery manufacturing machinery**
- **Indigenous CNC controllers**
- **Microsystem and semiconductor fabrication equipment**

We've identified 19 machines that we plan to develop over the next five years, many of which are currently being imported.

Q8: How is CMTI collaborating with industry on these developments?

Dr. Nagahanumaiah: Under the Capital Goods Scheme, the industry contributes 20% funding while the government supports 80%. We've developed several machines in collaboration with companies like Inatech, Acumac and many more.

Currently, we're working with 13 industry partners under our Industry Accelerator Program to develop 16 new machines not previously built in India. Ten of these were already developed and displayed during IMTEX 2025.

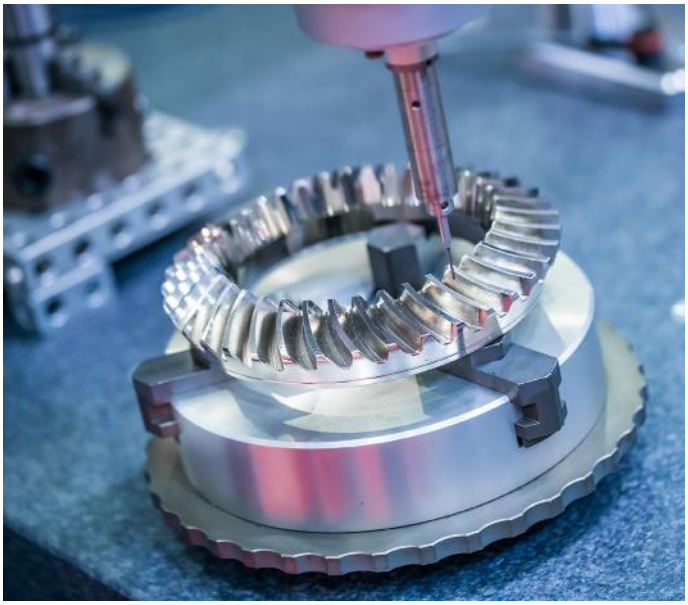
Q9: Any final thoughts you'd like to share?

Dr. Nagahanumaiah: CMTI continues to serve as a national centre of excellence in manufacturing technology. Through innovation, collaboration, and skill development, we aim to make India self-reliant in advanced manufacturing systems.

Ultra Precision Turning Machine(Nanoshape T250)

Closed-Loop Gear Manufacturing: Myth or Reality?

- By Nishant Kashyap



In today's highly competitive and precision-driven manufacturing environment, quality and efficiency are more important than ever. This is particularly true in the world of gear manufacturing, where even minute errors in gear geometry can lead to excessive noise, vibration, wear, and eventual failure in automotive, aerospace, and industrial machinery applications. Traditionally, gear production has been a sequential process involving design, cutting, inspection, and manual correction. However, the concept of closed-loop manufacturing has introduced a transformative approach — one that feeds inspection results back into the machining process in real time or near real time.

Closed-loop gear manufacturing promises to compress development cycles, increase precision, reduce human error, and standardise quality. Yet the question remains: is it a mature, widespread reality — particularly in India — or is it still an elusive ideal?

Understanding Closed-Loop Gear Manufacturing

Closed-loop manufacturing is a feedback-driven process where inspection results are automatically analysed and used to generate real-time adjustments to the machining operations. The goal is to create a self-correcting, intelligent manufacturing system capable of maintaining tight tolerances throughout production.

In gear manufacturing, a typical closed-loop system integrates three major components:

1. Gear Design & Simulation Software: to digitally simulate gear performance before physical production.
2. CNC Gear Cutting/Grinding Machines: to execute precise machining based on software-generated inputs.
3. Inspection & Feedback Systems: to measure actual gear geometry and feed corrections back into the system.

The result is a feedback loop that helps in iteratively refining gear geometries with reduced reliance on manual intervention or lengthy trial-and-error iterations.

Core Technologies Behind Closed-Loop Gear Manufacturing

Advanced Gear Design and Simulation

The closed-loop process begins even before any metal is cut. Using sophisticated software like Gleason's CAGE (Computer-Aided Gear Engineering), design engineers input key gear parameters—number of teeth, pressure angle, face width, etc.—and simulate contact patterns, motion smoothness, and load-bearing stresses. This helps in predicting gear behavior, enabling engineers to refine designs before proceeding to manufacturing.
In closed-loop environments, this design data is not siloed. It's directly linked to CNC code generation and machine parameters, bridging the gap between digital modeling and real-world machining.

High-Precision Gear Cutting and Grinding Machines

Machines such as Gleason's Phoenix 250HC series are equipped with multi-axis CNC systems (often using controllers like Fanuc), capable of executing complex geometries for bevel, spiral, or hypoid gears. These machines feature:

- Six-axis motion (three linear and three rotary).
- AC servo motors for simultaneous operations.
- High-speed encoders for real-time positional accuracy.

Once the digital design is finalized, the software automatically generates machine settings and tool paths. These are transferred directly into the CNC gear cutter or grinder for trial part production.

Inline/Offline Gear Inspection

Inspection is carried out using high-resolution Coordinate Measuring Machines (CMMs) like Zeiss or Hofler gear testers. Using 3D probes and automated positioning systems, these machines can:

- Measure both flanks of multiple teeth.
- Detects profile, lead, pitch, and runout deviations.
- Capture micro-geometry to sub-micron accuracy (e.g., 0.4–0.5 microns).

The inspection software (e.g., G-AGE by Gleason) compares the manufactured gear to the theoretical design, identifies deviations, and calculates corrective values.

Automated Feedback & Adaptive Correction

The measured deviations are used to automatically generate corrections to the machine settings. These corrections are either:

- Manually entered by the operator.
- Automatically transmitted into the machine controller via digital media or network protocols (e.g., OPC UA, MTConnect).

Subsequent gears are cut or ground with the updated parameters. In most cases, only one additional trial is needed before achieving design-accurate gears.

Benefits of Closed-Loop Gear Manufacturing

Closed-loop gear manufacturing offers transformative benefits that directly address long-standing challenges in precision and productivity. One of the most significant advantages is the reduction in design-to-production cycles. Traditionally, a gear production trial-and-error loop could take 3–4 days, but with real-time feedback and automated corrections, this timeline can shrink to just a few hours. The system also delivers high first-time accuracy, producing gears with minimal deviations right from the initial run, reducing the need for costly rework.

Another compelling benefit is repeatability and consistency across production batches. By minimizing manual interventions and standardizing inspection and correction processes, closed-loop systems ensure uniform quality throughout. This leads to reduced human dependency, cutting down on the risk of operator-induced errors and minimizing the demand for highly specialized manual inspection.

Moreover, closed-loop systems are particularly adept at supporting complex gear geometries, such as spiral bevel, hypoid, and high-load gears, which require tight tolerances and intricate machining. A real-world example of this in action is Arrow Gear Company in Illinois, USA. By integrating Gleason's closed-loop manufacturing system, the company was able to significantly cut down setup and iteration times while achieving improved consistency and precision in their spiral bevel gear production. This case underscores the real-world impact and scalability of closed-loop technology when effectively implemented.

Reverse Engineering and Legacy Gear Replication

One particularly innovative use of closed-loop systems is in reverse engineering legacy gear designs. For example, older gearmasters that were developed manually are now digitized using CMMs and analyzed with modern software. Their digital twins are then used to generate CNC machining instructions — enabling production of high-performance replicas using modern, efficient processes.

This is highly beneficial in automotive or aerospace sectors, where discontinued gear models still need servicing but cannot be sourced through conventional means.

Is India Ready for Closed-Loop Gear Manufacturing?

The Current Landscape

India is home to a diverse spectrum of gear manufacturers — from world-class exporters to Tier 3 suppliers working with basic manual hobbing machines. While some top-tier Indian companies, especially those in automotive and aerospace sectors, have started integrating elements of closed-loop systems, widespread adoption remains limited.

Challenges Hindering Adoption

1. High Capital Investment: Advanced CNC machines, CMMs, and integrated software require substantial upfront investment — a hurdle for SMEs.
2. Skill Gaps: Operating closed-loop systems requires a multidisciplinary understanding of gear theory, mechatronics, software, and data interpretation.
3. Fragmented Supply Chains: Many shops still outsource inspection or heat treatment, making seamless feedback integration difficult.

4. Limited Vendor Collaboration: Indian gear manufacturers often rely on siloed vendors for machines, inspection systems, and software, reducing the opportunity for integrated ecosystems.

Some Positive Developments

- Automotive Tier-1 suppliers like Bharat Gears and RACL Geartech are investing in 5-axis CNC and inline metrology.
- Institutions like CMTI (Central Manufacturing Technology Institute) are promoting smart manufacturing research.
- Indian subsidiaries of global players (e.g., Gleason Works India, Klingelnberg) are offering localised solutions, including training and after-sales support.

Myths and Misconceptions

"It's only for mass production"

While the benefits are magnified in high-volume operations, even small batch manufacturers of precision gears (e.g., aerospace, robotics) can benefit immensely from closed-loop systems, especially in reducing iteration cycles.

"It replaces skilled operators"

On the contrary, it elevates their role. Operators become process engineers, data analysts, and digital system managers, enabling higher productivity and job satisfaction.

"Too complex to integrate"

Modern software is increasingly modular, with user-friendly interfaces and standardised data formats. With proper planning and phased implementation, integration is achievable even in mixed-equipment environments.

The Road Ahead: From Concept to Reality in India

To transition closed-loop gear manufacturing from a conceptual ideal to a widespread reality in India, several foundational pillars must be addressed. First and foremost is technology accessibility. SMEs, which form the backbone of India's manufacturing sector, often struggle with high capital investments. Government-backed subsidies, leasing models, and financing schemes can make it easier for these companies to invest in critical technologies like precision inspection systems and adaptive manufacturing software.

Equally important is workforce training. The implementation of closed-loop systems demands a skilled workforce proficient in CNC programming, gear inspection techniques, and digital manufacturing tools. National initiatives like Skill India must evolve to include advanced modules on smart manufacturing to bridge this gap.

Next is the creation of robust vendor ecosystems. Collaboration between machine tool manufacturers, software developers, and inspection technology providers can drive the development of localized, cost-effective, and integrated solutions tailored to Indian manufacturing needs.

Further, the success of closed-loop systems depends heavily on data infrastructure. Real-time feedback and intelligent correction mechanisms require secure, high-speed factory networks, support for edge computing, and cloud-enabled platforms to allow seamless cross-machine data exchange.

Finally, pilot programs and demonstration cells are essential to inspire confidence and encourage adoption. Establishing these in technical institutions, industrial clusters, and MSME hubs can help manufacturers visualize ROI, test capabilities firsthand, and drive grassroots-level momentum toward smarter gear manufacturing practices.

Conclusion: Myth, Reality, or Imminent Transformation?

Closed-loop gear manufacturing is no longer a futuristic vision — it's a proven, scalable solution already delivering results across the globe. In India, while adoption is still in its early stages, the trajectory is promising. The convergence of digital design, automated inspection, and intelligent machining offers Indian gear makers a pathway to global quality standards, higher efficiency, and innovation readiness.

Whether you're an OEM pushing for zero-defect gears or an SME looking to modernise your shop floor, closed-loop manufacturing isn't a luxury — it's a strategic necessity.

The myth has been debunked. What remains is a choice: to observe or to embrace the future of gear manufacturing.

Next-Gen Lubricants for a High-Stress World of Gear Systems

- By Neha Basudkar Ghate

As industrial gear systems push boundaries in speed, load, and precision, lubrication technology is stepping up as a critical enabler. In this exclusive interaction, Neha Basudkar Ghate speaks with Navneeth Khandelwal, Executive Director and CEO of Continental Petroleums Ltd., to unpack how base oils, additive chemistry, and regulatory foresight are evolving to meet these challenges. Drawing from his deep industry experience and environmental engineering background, Mr. Khandelwal provides a nuanced view on enhancing gear system performance, sustainability, and lifecycle reliability.

1. How do lubricant base stocks and additive chemistries need to evolve to meet the increasing torque, load, and thermal demands in high-speed and high-precision gear systems?

To meet the escalating demands of modern gear systems, base stocks and additives must evolve synergistically. Group III+ and synthetic base oils with inherently higher oxidative stability, lower volatility, and superior viscosity-temperature characteristics are now essential. On the additive front, we need advanced anti-wear, extreme pressure, and friction-modifying chemistries that operate reliably under elevated temperatures and loads without causing corrosion. The emphasis is now on tailor-made molecular architectures that provide lubrication in fluctuating operating conditions.

2. In your experience, what are the critical failure modes in industrial gear systems that can be mitigated through advanced lubrication solutions, and how does formulation science address these?

Critical failure modes such as scuffing, wear, pitting, and lubricant degradation can all be significantly mitigated with optimized lubrication. Formulation science addresses these by creating stable oil films that resist rupture, incorporating anti-scuffing agents, and enhancing load-carrying capacity through high-performance Extreme Pressure (EP) additives. Additionally, the inclusion of detergents, dispersants, and oxidation inhibitors ensures long-term cleanliness and thermal resilience, directly impacting gear longevity and reducing unplanned downtimes.

3. With increasing operating speeds and tighter tolerances in gear-driven machinery, how should lubricant formulations adapt to maintain film strength without sacrificing thermal stability?

Maintaining film strength in high-speed, high-precision systems requires lubricants with high VI (viscosity index), shear stability, and excellent thermal conductivity. Advanced esters and PAO-based synthetics, combined with viscosity improvers resistant to mechanical shear, help maintain the correct film thickness under varying pressures and speeds. Simultaneously, modern antioxidant systems prevent thermal breakdown, ensuring the lubricant performs across extended operating ranges.

4. What role do synthetic and semi-synthetic lubricants play in extending maintenance intervals for enclosed gear systems in high-contamination environments such as mining or construction?

In high-contamination environments, synthetic and semi-synthetic lubricants provide unmatched performance. Their low pour points and oxidative resistance allow for extended drain intervals even in temperature-extreme or particulate-heavy conditions. These lubricants have better seal compatibility and demulsifying properties, reducing water ingress impact and wear. As a result, equipment in industries like mining or construction benefits from lower total lubricant consumption and reduced maintenance costs.

5. Do you see the need for more standardization or cross-industry collaboration between lubricant formulators, gear OEMs, and hazardous waste handlers to support circular economy models in manufacturing?

Absolutely. The complexity of modern lubricants and gear systems necessitates deeper collaboration among OEMs, formulators, and waste management stakeholders. Standardization of test methods, compatibility metrics, and re-refining specifications can significantly enhance the viability of circular models. Continental Petroleums supports collaborative platforms where R&D, manufacturing, and sustainability can intersect to build scalable, environmentally responsible systems for lubricant reuse and recovery.

6. How should gear-intensive industries develop safe handling protocols for waste lubricants that contain metal fines or degraded additives, particularly in jurisdictions with limited hazardous waste infrastructure?

Industries must adopt a proactive approach by implementing closed-loop lubricant management systems, integrating filtration, diagnostics, and safe containment practices at the plant level. Even in jurisdictions with limited infrastructure, decentralised treatment units, proper labelling, and documented handling protocols can

ensure safer disposal. Training personnel and working with certified hazardous waste disposal partners—such as those aligned with CPCB guidelines in India—is vital for regulatory compliance and environmental safety.

7. How are OEMs and lubricant formulators addressing the challenges of gear lubrication under mixed lubrication regimes, particularly in variable-load and start-stop applications?

In mixed and boundary regimes, where full film lubrication is inconsistent, the formulation focus is on high-performance friction modifiers and surface-active anti-wear additives like molybdenum compounds or organophosphates. OEMs are increasingly specifying lubricant properties like traction coefficient and film durability for stop-start applications. There's also a trend towards condition-based monitoring to dynamically assess lubricant health and adapt service intervals accordingly.

8. Given your background in environmental engineering, how should gear oil manufacturers adapt to global shifts in environmental regulations such as REACH or BIS mandates on lubricant toxicity and biodegradability?

Manufacturers must prioritize green chemistry—minimizing the use of SVHCs (substances of very high concern), adopting biodegradable ester bases, and ensuring compliance with local and global standards like REACH, BIS, and Ecolabel. The industry R&D should closely align with such regulations. The goal should be to invest in bio-based alternatives and low-toxicity additive systems that maintain performance while reducing ecological footprint, aiming to future-proof our offerings for an environmentally conscious market.

Navneeth Khandelwal, Executive Director and CEO, Continental Petroleums Ltd.

Precision Manufacturing Techniques in Gear Systems: From CNC Machining to Surface Finishing for Zero-Back lash Performance

- Yin Qian, Senior Engineer & Head, KAIBO Technical Team

In the realm of industrial automation and robotics, the demand for gear systems with zero backlash, minimal noise, and high torque efficiency has never been more critical. Precision manufacturing techniques have evolved far beyond conventional machining, integrating advanced processes like CNC micro-machining, automated gear grinding, and nanoscale surface finishing. This article explores how these techniques converge to create gearboxes that meet the stringent requirements of modern high-precision applications, from collaborative robots to aerospace actuators.

1. Ultra-Precision CNC Machining: Establishing the Baseline for Gear Geometry

CNC machining forms the backbone of gear production, but for zero-backlash systems, sub-micron accuracy is non-negotiable. Modern CNC machines, such as the German-made DMG MORI NHX 5000, leverage:

- **Thermal stability systems:** Maintaining temperature within ±0.1°C to prevent dimensional drift during long machining cycles.
- **Direct-drive motors:** Eliminating backlash in the machine's own transmission system ensuring precise tool positioning.
- **AI-driven tool path optimization:** Algorithms like Sandvik Coromant's PrimeTurning reduce material removal time by 30% while maintaining ISO 4 gear accuracy.

Case Study: Hobbing vs. Skiving for High-Precision Gears

Traditional hobbing is suitable for most applications, but skiving (also known as gear planing) excels in producing gears with <5μm pitch error, critical for zero-backlash systems. The chart below compares their performance:

Max Precision (ISO Class)	Material Removal Rate (cm³/min)	Ideal for	Max Precision (ISO Class)
CNC Hobbing	6-7	150-200	Medium-precision, high-volume
CNC Skiving	4-5	50-80	Low-volume, ultra-precision
Laser Texturing	N/A (surface treatment)	N/A	Friction reduction

Figure 1: Comparative Performance of CNC Gear Machining Techniques (Data Source: KAIBO Technical Center)

2. Gear Grinding: Achieving Micron-Level Surface Finish

Grinding is essential for refining heat-treated gears, where dimensional changes can exceed 50μm. Modern gear grinders like the KAPP NILES ZE 800 utilize:

- Electrochemical dressing (ECD): Maintains wheel sharpness within 1μm, enabling consistent grinding of hardened steels (up to 62 HRC).
- Active backlash compensation: During grinding, the machine measures real-time tooth thickness and adjusts the grind depth to eliminate backlash in the final assembly.
- Nanofluid cooling: Synthetic coolants with diamond nanoparticles reduce grinding temperatures by 40%, preventing thermal distortion and improving surface roughness to Ra ≤0.1μm.

3. Lapping & Honing: Eliminating Micro-Imperfections for Smooth Engagement

Even after grinding, microscopic surface defects

Figure 2: KAPP NILES ZE 800 gear grinder in KAIBO's 27,000m2 intelligent factoryCaption: The ZE 800's dual-spindle design allows simultaneous grinding of pinion and gear, achieving ISO 3 m2 accuracy in under 15 minutes.

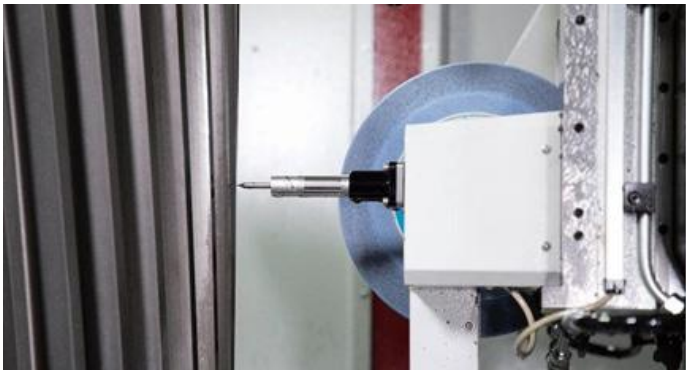


Figure 3: Grinding Wheel Detail
Caption: A close-up of the grinding wheel, highlighting the precision required in the dressing process to maintain sharpness and ensure accurate gear grinding.

can cause backlash and noise. Lapping (using abrasive pastes) and honing (with bonded abrasives) address this:

- **Planetary lapping machines:** Use multi-axis motion to evenly distribute abrasive particles, reducing tooth flank waviness to <2μm.
- **Electrolytic in-process dressing (ELID) honing:** Combines electrical discharge with honing to achieve mirror-like finishes (Ra ≤0.05μm), critical for high-speed gearboxes in aerospace.

4. Surface Treatment: Solving Wear and Noise Through Microstructure Optimization

Even micron-level geometric accuracy can fail due to surface defects. Our two-step surface treatment scheme delivers breakthrough performance:

- Lapping & Honing: Eliminating Micro-Waviness
- Planetary lapping machines use 3-axis motion to apply 80-120N/mm² abrasive pressure, reducing tooth flank waviness from 20μm to 1.5μm (Figure 3).
- ELID electrolytic honing combines material removal with electrochemical polishing, achieving a mirror finish (Ra ≤0.05μm) and reducing meshing impact noise by 12dB.
- **Coating & Texturing:** Building Functional Surface Layers
- **DLC Diamond-Like Carbon Coating:** A 2μm-thick layer deposited via magnetron sputtering increases surface hardness to 2000HV and reduces friction coefficient from 0.6 to 0.25, ideal for lubrication-free space robotics.
- **Laser Micro-Texturing:** 50μm-deep pit arrays on tooth surfaces increase oil storage by 30%, reducing lubrication failure risk by 40% and further lowering noise by 15dB in high-speed operations.

5. Gear Material Innovation: Redefining Performance Boundaries

The selection of materials plays a pivotal role in achieving optimal gear performance, and ongoing advancements in material science are addressing the evolving demands of modern industries:

1. High-Performance Alloy Development

Novel nickel-chromium-molybdenum (Ni-Cr-Mo) alloys have been engineered to exhibit a 25% higher tensile strength than conventional 20CrMnTi steel. These alloys undergo a three-stage heat treatment process—quenching at 860°C, tempering at 520°C, and cryogenic treatment at -196°C—to form a uniform martensitic structure, enhancing wear resistance by 40% and extending fatigue life by 30%. Such properties make them ideal for high-load applications, such as industrial robots carrying payloads exceeding 50 kg, where traditional materials often fail within 10,000 operating hours

2. Composite Materials for Lightweight Precision

In aerospace and medical robotics, carbon fiber-reinforced polymer (CFRP) composites are increasingly utilized in gear blanks. These materials offer a 40% weight reduction compared to steel while maintaining ISO 5-class dimensional accuracy. The composite structure is formed via autoclave curing at 120°C under 8 bar pressure, ensuring fiber orientation aligns with load paths to minimize deformation under 100 N·m torque. Experimental results show that CFRP gears exhibit a 60% lower vibration amplitude than their metallic counterparts at 5000 RPM, a critical advantage in noise-sensitive environments like surgical operating rooms.

3. Smart Materials for Self-Compensating Gears

The integration of shape memory alloys (SMAs) in gear teeth represents a cutting-edge innovation. By embedding Ni-Ti SMA wires within gear flanks, thermal adjustments of up to 5 μm in tooth thickness can compensate for wear-induced backlash. This self-healing capability extends gear service life by 20% in high-temperature environments (80°C and above), presenting a breakthrough for aerospace actuators and automotive transmissions where maintenance accessibility is limited.

6. Integrated Quality Control: From Metrology to Artificial Intelligence

Zero-backlash performance requires rigorous quality control. CNC detection equipment (see Figure 4) is a vital part of this process:

- 1-meter Gear Measuring Machines (e.g., ZEISS P900): Scan the entire gear surface with 0.5μm resolution to detect pitch, profile, and lead errors.
- AI-Driven Defect Prediction: Machine learning models analyze over 10,000 data points per gear to predict backlash issues before assembly, reducing rework by 40%.

Figure 4: CNC Detection Equipment

Caption: CNC detection equipment with a blue body, featuring related components on the workbench, used for high-precision measurement of gear parameters to ensure zero-backlash performance.

Real-World Application: Zero-Backlash Gearboxes in Surgical Robotics

In minimally invasive surgical robots, backlash can cause tremors during delicate procedures. A leading medical device manufacturer uses:

1. Skived gears (ISO 4-class) for primary reduction,
2. ELID-honed helical gears for secondary reduction,
3. DLC-coated worm gears for final motion transmission.

This combination achieves <5 arcseconds of backlash and 98% efficiency, enabling sub-millimeter precision in tissue manipulation.

7. Industry Application Expansion: Beyond Traditional Boundaries

1. Wind Energy: Reliability in Extreme Conditions

In 5MW offshore wind turbines, planetary-cycloidal hybrid gearboxes endure torque fluctuations of up to 2000 N·m and corrosive salt-laden air environments. The integration of carburized steel gears (60HRC surface hardness) and diamond-like carbon (DLC)-coated bearings extends maintenance intervals from 6 to 18 months—an essential improvement for offshore platforms where each hour of downtime incurs costs exceeding $50,000. This combination balances high-load capacity with resistance to environmental degradation, ensuring consistent performance in harsh marine conditions.

2. Semiconductor Manufacturing: Nanometer-Level Precision

For EUV lithography machines requiring ±0.01mm positioning accuracy, harmonic-cycloidal gearboxes achieve backlash ≤2 arcseconds. Teeth processed via ELID honing and ceramic ball screws ensure negligible thermal expansion within strictly controlled cleanroom environments (20±0.1°C), a critical factor for manufacturing 7nm semiconductor patterns without distortion. These gear systems enable the nanometer-level precision demanded by advanced lithography processes, where even minimal dimensional variations can compromise chip functionality.

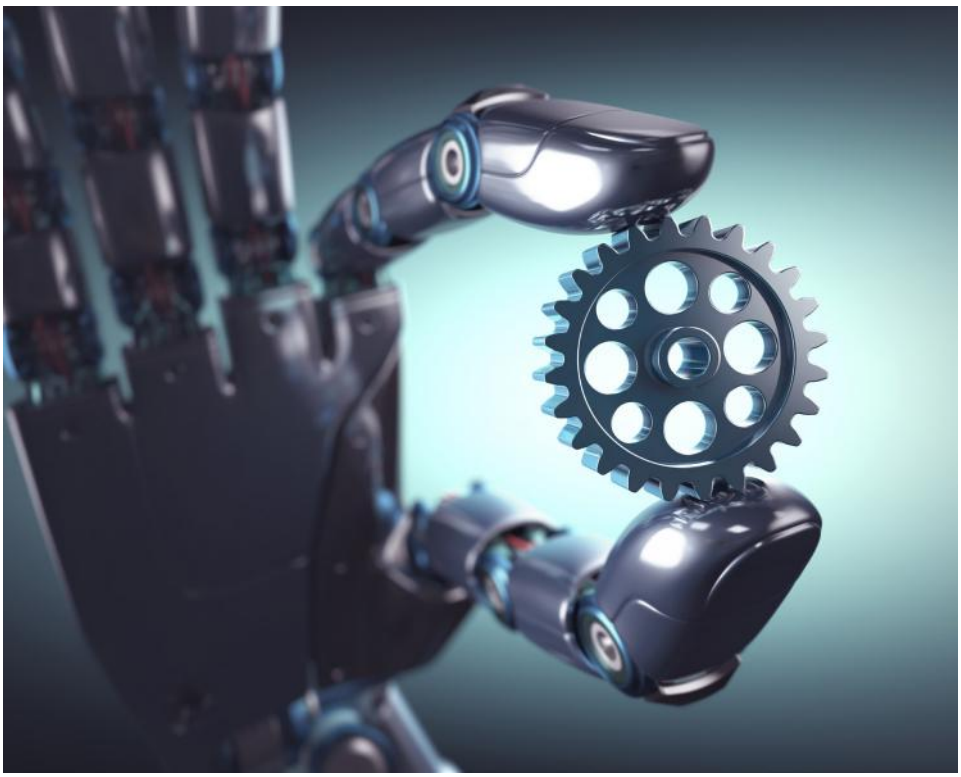
Conclusion

Zero-backlash gearbox manufacturing is a fusion of materials science, precision machining, and intelligent inspection. These innovations not only meet the strict demands of robotics and aerospace but also empower global customers with OEM solutions for equipment performance upgrades. As applications continue to push the boundaries of mechanical precision, whether for autonomous navigation, clean energy, or atomic-scale manufacturing; precision manufacturing techniques will remain the critical enabler of performance, durability, and functional superiority in gear systems.

Intelligent Gearboxes: The Role of AI and Embedded Sensors

- By Sudhanshu Nayak

The evolution of gearboxes has been a testament to the relentless pursuit of efficiency and reliability in mechanical systems. Traditionally, gearboxes functioned as purely mechanical devices, transmitting power between components with fixed operational parameters. However, the advent of digital technology has ushered in a transformative era where gearboxes are no longer passive elements but intelligent, data-driven subsystems.



This metamorphosis is particularly significant in industries that demand high performance, unwavering reliability, and predictive capabilities. In sectors such as electric vehicles (EVs), aerospace, wind energy, and robotics, the integration of artificial intelligence (AI) and embedded sensors into gear systems has become a pivotal strategy. These intelligent gearboxes not only enhance operational efficiency but also provide critical insights into system health, enabling proactive maintenance and reducing unexpected downtimes.

What Makes a Gearbox 'Intelligent'?

An 'intelligent' gearbox is characterised by the seamless integration of embedded sensors, real-time data processing units, and AI-powered analytics within the traditional mechanical framework. This amalgamation transforms the gearbox from a static power transmission component into a dynamic, responsive system capable of self-monitoring and adaptation. The embedded sensors continuously collect data on various operational parameters, which is then processed in real-time to assess the gearbox's condition. AI algorithms analyse this data to detect patterns, predict potential failures, and recommend corrective actions. This shift from reactive to predictive and adaptive systems marks a significant advancement in mechanical engineering. Instead of adhering to predetermined maintenance schedules or responding to failures after they occur, intelligent gearboxes enable a proactive approach. They anticipate issues before they manifest, allowing for timely interventions that enhance reliability, extend service life, and optimise performance.

Key Technologies Powering Intelligent Gearboxes

- Sensor Integration: Modern intelligent gearboxes are equipped with a variety of sensors that monitor critical parameters:
- Vibration Sensors: Detect anomalies in gear movement, indicating misalignments or wear.
- Temperature Sensors: Monitor thermal conditions to prevent overheating and assess lubrication effectiveness.
- Torque Sensors: Measure the rotational force, ensuring operations remain within safe limits.
- Rotational Speed Sensors: Track the speed of gear rotations, aiding in performance assessments and identifying irregularities. These sensors provide a comprehensive overview of the gearbox's operational state, facilitating early detection of potential issues.
- Edge Computing & Connectivity: To handle the vast amounts of data generated by embedded sensors, intelligent gearboxes utilise edge computing:

- Onboard Processors: Process data locally within the gearbox, enabling immediate analysis and response without the latency associated with transmitting data to centralised systems.

- Internet of Things (IoT) Integration: Facilitates seamless communication between the gearbox and other system components or remote monitoring centres, allowing for coordinated operations and centralised oversight. This combination ensures that critical decisions can be made in real-time, enhancing responsiveness and reliability.

Artificial Intelligence & Machine Learning: AI and machine learning algorithms are at the heart of the intelligence in these gearboxes:

- Pattern Recognition: Identify normal and abnormal operating behaviours by analysing historical and real-time data.

- Anomaly Detection: Spot deviations from standard performance, signalling potential issues before they escalate.

- Life Prediction Models: Estimate the remaining useful life of components, aiding in maintenance planning and resource allocation. These capabilities enable a shift from scheduled maintenance to condition-based maintenance, optimising resource use and minimising downtime.

- Digital Twin Applications: The concept of digital twins involves creating a virtual replica of the physical gearbox:
- Virtual Replicas: Simulate the physical gearbox's behaviour under various conditions, providing insights into performance and potential failure modes.

- Performance Simulation: Allows engineers to test different scenarios and predict outcomes without risking actual equipment.

- Failure Forecasting: Combines real-time data with simulation models to anticipate failures and plan interventions proactively. Digital twins serve as a bridge between the physical and digital realms, enhancing understanding and management of complex systems.

Use Cases Across Industries

- Electric Vehicles (EVs): In EVs, space and weight constraints necessitate compact yet efficient gearboxes. Intelligent gearboxes equipped with thermal and wear monitoring sensors ensure optimal performance and longevity. By continuously assessing conditions, they can adjust operations to prevent overheating and excessive wear, crucial for the reliability of EV drivetrains.

- Wind Turbines: Wind turbines often operate in remote and harsh environments, making maintenance challenging. Intelligent gearboxes in these systems utilise predictive maintenance strategies, analysing data from embedded sensors to forecast potential failures. This approach reduces the need for frequent manual inspections and minimises unexpected downtimes, thereby enhancing energy production efficiency.

- Industrial Robots: Precision and adaptability are vital in robotics. Intelligent gearboxes enable industrial robots to adjust to varying loads and operational conditions in real-time. By providing immediate feedback on performance metrics, these gearboxes facilitate precise movements and reduce the risk of mechanical failures, essential for maintaining high productivity in automated manufacturing processes.

- Aerospace & Defence: In aerospace and defence applications, the reliability of gear systems is critical. Intelligent gearboxes offer real-time diagnostics and redundancy, ensuring that any potential issues are identified and addressed promptly. This capability is vital for mission-critical operations where mechanical failures can have severe consequences.

Benefits of Intelligent Gearboxes

The integration of intelligence into gearboxes yields several significant benefits. Firstly, it leads to increased uptime and reduced unplanned downtime. By continuously monitoring operational parameters and predicting potential failures, maintenance can be scheduled proactively, preventing unexpected breakdowns that disrupt operations. Secondly, intelligent gearboxes contribute to longer asset life through optimised maintenance. Condition-based maintenance ensures that components are serviced or replaced only when necessary, reducing wear and tear from both overuse and unnecessary interventions.

Challenges to Widespread Adoption

While intelligent gearboxes offer numerous advantages, their widespread adoption faces several challenges. Firstly, the cost and ROI justification pose a significant hurdle. The initial investment in sensors, AI systems, and integration can be substantial. Companies must evaluate whether the long-term benefits, such as reduced downtime and maintenance costs, outweigh these upfront expenses. Demonstrating a clear return on investment is crucial for stakeholders to commit to this technological shift.

Secondly, the harsh operating environments in which many gearboxes function present challenges for embedded electronics. Exposure to extreme tempera-

tures, vibrations, and contaminants can affect sensor accuracy and longevity. Ensuring that these components are robust enough to withstand such conditions without frequent failures or recalibrations is essential for reliable operation.

The complexity of data handling and cybersecurity concerns also cannot be overlooked. Intelligent gearboxes generate vast amounts of data that need to be processed and stored securely. Implementing systems capable of real-time data analysis while safeguarding against cyber threats requires sophisticated infrastructure and protocols. Protecting sensitive information from unauthorised access is paramount, especially as connectivity increases.

Lastly, integration with legacy systems presents a significant challenge. Many industries operate with existing machinery that lacks the capability to interface seamlessly with modern intelligent components. Retrofitting these systems or ensuring compatibility can be complex and costly, often requiring customised solutions to bridge the technological gap.

The Way Forward

To overcome these challenges and facilitate the adoption of intelligent gearboxes, several strategies can be employed. Developing modular smart components for retrofitting offers a practical solution for integrating intelligence into existing systems. By designing sensors and processors that can be added to current gearboxes, companies can enhance functionality without the need for complete overhauls, making the transition more cost-effective.

Integration with Industry 4.0 ecosystems is another critical step. Ensuring that intelligent gearboxes can communicate effectively within a connected factory environment allows for streamlined operations and data sharing across various platforms. This connectivity enhances overall system efficiency and enables more informed decision-making processes.

Establishing standardisation of protocols and interoperability is essential for widespread adoption. Developing universal standards ensures that components from different manufacturers can work together seamlessly, reducing compatibility issues and fostering a more collaborative industry environment.

Finally, building in-house digital capabilities within gearbox OEMs is vital. Investing in training and developing expertise in AI, data analytics, and sensor technology equips companies with the necessary skills to innovate and maintain intelligent systems. This internal competency accelerates development and implementation processes, positioning companies competitively in the market.

Conclusion

Intelligent gearboxes represent a significant advancement in mechanical engineering, transforming traditional components into proactive, data-driven systems. By integrating AI and embedded sensors, these gearboxes offer enhanced performance, predictive maintenance capabilities, and operational efficiency. Despite challenges related to cost, environmental conditions, data management, and system integration, strategic approaches such as modular retrofitting, embracing Industry 4.0, standardisation, and developing digital expertise can pave the way for broader adoption. As industries continue to evolve towards automation and digitalisation, intelligent gearboxes will play a crucial role in driving smarter, more reliable operations.

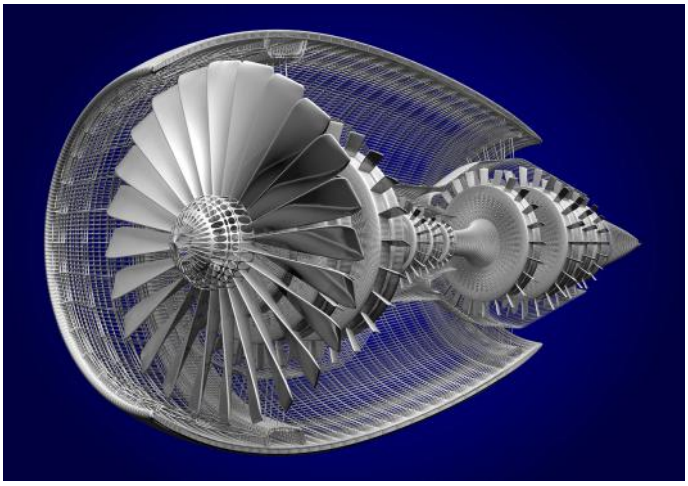
Sudhanshu Nayak, a dynamic mechanical engineer, is driven by a fervor for cutting-edge technologies like 3D printing, cloud manufacturing, & Industry 4.0. He has gained invaluable firsthand experience with 3D printing during his tenure at innovative startups. His youthful energy fuels a deep expertise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

Friction Stir Processing (FSP) for Advanced Strengthening of Gears

- By Vivek Singh

- How surface grain refinement through FSP enhances wear and fatigue life.
- Applications in high-load planetary gears and aerospace transmission systems.

Present-day industrial landscape is incredibly wide, and nearly every industry has a need for gears that provide increased durability, fewer failures, and better load-bearing efficiency. While the aerospace sector was historically the primary driver of demand, we are now witnessing an increase in automotive and heavy-duty industrial applications as well.



Usual high-performance gears are subjected to high stress, including surface wear, micropitting, and rolling contact fatigue, which can significantly limit their lifespan. Traditional hardening processes, including carburising and nitriding, enhance wear resistance, but they also produce tensile stresses that can cause gears to crack, particularly in high-torque and impact-heavy circumstances.

Friction Stir Processing (FSP) is a game changer for refining surface grains. It allows the development of ultra-fine microstructures with high hardness, compressive residual stress, and increased fatigue life. Unlike traditional diffusion-based hardening methods, FSP is a solid-state thermomechanical process. This means it can refine surface grains, remove porosities, and increase wear resistance without affecting the bulk material's properties.

This innovative technology meets the industry's increasing demand for gears that can handle extreme thermal, mechanical, and tribological stresses. It's truly a transformative solution for planetary gear systems, high-speed aerospace transmissions, and critical drive mechanisms. For gear manufacturers, embracing FSP not only extends the lifespan of components but also cuts down on downtime, maintenance costs, and overall system inefficiencies—essential elements in today's competitive, high-performance markets.

Friction Stir Processing: Mechanism and Effects on Gear Materials

Friction Stir Processing (FSP) is an interesting solid-state surface modification method. It employs a rotating tool and a non-consumable probe to produce localised severe plastic deformation. This dynamic recrystallisation process effectively alters the microstructure of gear materials, improving mechanical properties while leaving the bulk composition unchanged.

Grain Refinement: Strong shear forces and rapid strain rates break down larger grains into a super-fine structure, increasing hardness, wear resistance, and fatigue life. This is particularly critical for planetary gears and aeronautical transmissions.

Homogenised Microstructure: Friction Stir Processing (FSP) effectively eliminates segregation and refines carbide distribution, reducing material inconsistencies that can cause cracks during cyclic loading. This results in a more uniform stress distribution, which boosts the reliability of gears in high-speed and high-load situations.

Residual Compressive Stresses: This process creates beneficial compressive stresses in the surface layer, which enhances load-bearing capacity and helps delay crack initiation. This is a significant advantage compared to carburised or nitrided surfaces, which are more susceptible to failures due to tensile stress.

Oxide Dispersion Strengthening: The carefully managed thermomechanical cycle introduces finely scattered oxides, increasing thermal stability and oxidation resistance. This is critical for gears that must perform in harsh aerospace and deep-sea environments.

Performance Enhancement in High-Load Planetary Gears

Planetary gear systems face intense cyclic loads

that can cause issues like micropitting, surface fatigue, and material wear. While traditional hardening methods can enhance wear resistance, they often introduce residual tensile stresses that may accelerate crack development. Enter Friction Stir Processing (FSP), a game-changing alternative that enhances the microstructure in critical load-bearing areas, significantly boosting gear durability. The ultra-fine grain structure created by FSP helps minimize crack formation and growth, thereby prolonging fatigue life even under high torque conditions. Plus, FSP offers protection for gear tooth flanks and root fillets against premature failure, making it particularly valuable in aerospace and heavy-duty industrial settings.

FSP-treated surfaces perform exceptionally well in terms of fatigue resistance. They not only have a reduced coefficient of friction, resulting in less lost energy, but they also improve gearbox efficiency. This method ensures that hardness is evenly distributed, preventing those annoying localised stress areas that can weaken gears. Unlike the standard case-hardening approach, which produces different hardness levels, FSP delivers a uniform stress profile, improving load distribution and lowering the risk of failure. For gear makers, this is a game changer in terms of performance and longevity, positioning FSP as a new technology for high-load planetary gears.

Aerospace Transmission Systems: Mitigating Extreme Conditions

Aerospace gearbox systems require gears that can withstand tremendous torque loads, rapid temperature changes, and the challenges associated with lubrication hunger. While typical heat treatments might increase hardness, they frequently make materials more brittle, resulting in severe failures under repeated stress. Friction Stir Processing (FSP) refines the grain structure of gear materials, improving thermal and mechanical stability while preserving ductility.

This is particularly significant in high-altitude environments, where heat cycling can cause ordinary materials to degrade over time. Gears treated with FSP exhibit improved fracture resistance due to the creation of compressive residual stresses, ensuring their long-term reliability in aerospace propulsion and actuation systems. Beyond structural benefits, FSP also enables the inclusion of oxide dispersion-strengthened surfaces with self-lubricating properties. This is a significant achievement for the space and aviation industries, where lubrication difficulties can seriously impair gear performance. FSP's exact microstructure alterations assist reduce friction and wear, resulting in longer maintenance intervals and improved gearbox performance. For gear manufacturers, embracing FSP represents an opportunity to advance aerospace gear technology by providing performance upgrades that fit the industry's specialised needs.

Integration of FSP in Gear Manufacturing

Integrating Friction Stir Processing (FSP) into gear manufacture necessitates a strategic strategy that considers material compatibility, process control, and automation potential. Unlike traditional surface treatments, FSP is a solid-state method that uses extreme plastic deformation rather than melting, making it suitable for materials such as aluminium, titanium, nickel-based superalloys, and advanced steels.

These materials gain greatly from grain refinement, higher wear resistance, and increased fatigue strength, all of which are critical for gears operating in severe conditions. However, selecting the proper material-processing combination is critical to achieving peak performance while avoiding residual stresses that might compromise gear integrity.

Process optimisation is crucial for achieving a consistent surface modification. It's essential to carefully manage key factors like tool rotation speed, dwell time, and traverse speed to get the right microstructural refinement and hardness distribution. Today's gear manufacturing facilities can easily incorporate Friction Stir Processing (FSP) with CNC and robotic systems, allowing for scalable production with less manual effort. By automating FSP, manufacturers can improve process consistency, cut down on defects, and maintain high-quality gears. This move towards automation is in line with the industry's demand for advanced, high-performance gears that can handle the tough requirements of aerospace, automotive, and deep-sea applications.

Conclusion: A New Era for Gear Durability

Friction Stir Processing (FSP) is redefining gear durability by providing a solid-state, high-efficiency technology for surface enhancement that eliminates the disadvantages of traditional hardening processes. FSP increases the service life of gears working in harsh conditions by fine-tuning grain structures, producing residual compressive stresses, and enhancing wear resistance.

As industries seek lighter, stronger, and more fatigue-resistant components, gear makers must embrace new technology to keep up with performance and reliability expectations. Strategic investments in research and development, process optimisation, and industrial-scale adoption will be key to realising FSP's full potential and paving the way for the next generation of high-performance gears.

Global Unity, Local Strength: Mayr Power Transmission Expands to Spain and Champions Robotics Innovation

- By Gear Technology India

International exchange: Representatives from around 30 countries came together at Mayr power transmission's headquarter to find out more about new technologies, products and processes.

Bernd Merk, CSO of Mayr power transmission at the opening of the International Sales Meeting 2025. The focus was placed on the key future topic of robotics.

Reliable service and expert advice for customers are core values at Mayr power transmission – at all locations around the globe. This is why the renowned family business regularly invites international colleagues and partners to the headquarters in Mauerstetten to exchange ideas. At the beginning of April, representatives from around 30 countries came together to find out more about new technologies, products and processes. This year, the focus was placed on the key future topic of robotics. In addition, the company announced an expansion: with the complete takeover of EME Motor 2008, S.L., Mayr power transmission now has its own subsidiary in Spain.

Whether in our future everyday lives or already today in medical technology or industrial production halls – wherever humans and robots work more closely together, the risk potential also increases. If, for example, a power failure occurs during a working process, the robot arm performing the work step must be held immediately and accurately, so that the people in the vicinity are not harmed in any way. Slim, lightweight robot brakes manufactured by Mayr power transmission ensure the necessary safety. With the ROBA® servostop® series, the company has developed safety brakes for servo motors which are specially tailored to the high demands of the robotics sector – not only in the industry, but also in the field of medical technology, for example. Here, the company can draw on more than 20 years of experience from its cooperation with renowned research institutes. The new standard modular system provides a high degree of flexibility for the various installation situations.

International exchange: Many locations, one quality

This became particularly clear when the numerous robotics use cases were presented during the International Sales Meeting in Mauerstetten. The Managing Directors and Sales Managers of the Mayr subsidiaries and representative offices worldwide came to the headquarters at the beginning of April 2025 to find out how to work with new technologies, products and processes. After all, customers on all continents should benefit from reliable service and expert advice. To achieve this, Mayr power transmission trusts in motivated and highly skilled employees.

New subsidiary in Spain

During the event, the long-standing family business was able to announce an expansion: After opening a subsidiary in India last year, Mayr power transmission has now added a subsidiary in Spain to its international presence. After more than 30 years of successful cooperation on the Spanish market, the former commercial agency EME Motor, S.L. was fully integrated into the Group as the subsidiary Mayr Transmisiones, S.L. at the beginning of 2025. Thus, the Allgäu-based company is strengthening its global sales network and is gaining access to new growth potential in the region.

The management of Mayr Transmisiones will remain with the current EME Managing Director Oscar Moncàs Miralles, while CEO Ferdinand Mayr and CFO Christian Illig will assume responsibility for the business as direc-

tors on behalf of Mayr power transmission.

Foundation for a new era in the region

The brothers Pere and Òscar Moncàs Miralles, the founders and directors of EME Motor, approached us some time ago to discuss the future of our collaboration. For both of them, this was also about the further development of their company," explains Ferdinand Mayr, CEO of Mayr power transmission. "In the ensuing discussions, a takeover proved to be the best scenario for both sides. I am convinced that our new Mayr Transmisiones subsidiary is ideally positioned for further growth in Spain and Portugal. And I believe we have laid the foundations for a new era in the region with this takeover."

Focus on stability and continuity

EME Motor was founded in 1988 and has been distributing Mayr power transmission products in Spain and Portugal since the mid-1990s. Òscar Moncàs intends to uphold the extensive shared experience and, in some cases, long-standing customer relationships under the new flag: "It is particularly important to me to continue the successful sales work in the region, but also to provide our employees with reliable prospects," says the Managing Director of Mayr Transmisiones. "The takeover of EME Motor by Mayr power transmission ensures both. We have even been able to recruit a new employee for Technology and Sales – we are on track for growth. I look forward to further strengthening the mayr® brand in Spain and Portugal." Mayr Transmisiones currently employs 4 people at its Castelldefels site (Barcelona) supporting customers in Spain and Portugal.

Management at Mayr Transmisiones, S.L. (f.l.t.r): Òscar Moncàs Miralles (Manager Mayr Transmisiones, S.L.), Ferdinand Mayr (CEO Mayr power transmission), Christian Illig (CFO Mayr power transmission)

Federal Chancellor and Minister of Economics visit Flender at Hannover Messe

- EVENT REPORT

- Digital transformation and AI as the key to competitiveness: Flender presents digital solutions in mechanical engineering to Federal Chancellor Olaf Scholz
- Federal Minister of Economics Habeck receives XXL wrench in recognition of his efforts to expand wind energy in Germany
- CEO Andreas Evertz: "We show how digital innovation in mechanical engineering can create advantages in global competition."

German Chancellor Olaf Scholz (center) and Lower Saxony's Prime Minister Stephan Weil (left) look at the Flender app on the smartphone ofFlender CEO Andreas Evertz. Digital intelligence makes the transmission transparent and delivers live data and recommendations for action directly to the app.

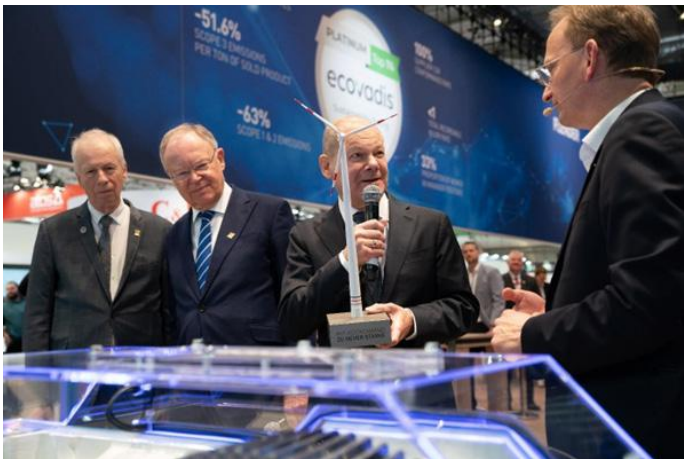
German Chancellor Olaf Scholz visited the booth of drive specialist Flender as part of his opening tour of Hannover Messe 2025. Together with the Prime Minister of Lower Saxony, Stephan Weil, and the Canadian Ambassador to the EU, Stéphane Dion, the Chancellor gained an insight into the digital transformation of the Bocholt-based company and its contribution to strengthening Germany's competitiveness as an industrial location. Thanks to the complete digitalization of the engineering process and the use of AI, Flender is now able to achieve what was previously considered impossible: A fully individualized, tailor-made gearbox that can be configured in just five clicks - "as fast as checking out on Amazon," as Andreas Evertz, CEO of the Flender Group, describes it.

Evertz showed the high-ranking guests how Flender, a mechanical engineering company, has made the transition to a digital company. The focus was on the gearbox intelligence AIQ, with which Evertz demonstrated live on his smartphone how Flender makes gearboxes "transparent". The Chancellor was able to see how customers can monitor the condition of their drives at any time while on the road, read operating data in real time, and how the system automatically recognizes and displays the relevant component in the transmission in the event of impending,
damage. Customers receive proactive recommendations for service or maintenance long before a failure can occur.

Chancellor Scholz was impressed by the company's innovative strength and interested in the customization of drive solutions. Thanks to complete digitalization, Flender is able to manufacture tailor-made gearboxes for each individual application with the efficiency of series production. A revolution in drive technology.

Habeck and Evertz look back on successful cooperation

One day after the Chancellor, Federal Minister of Economics Robert Habeck also visited the Flender booth. Together, Habeck and Flender have pushed the expansion of wind energy in recent years. "Germany is now a pioneer in the expansion of wind energy in Europe and a leader in the approval of new wind projects. We would like to thank you and your ministry for this. In recent years, you have always listened to our concerns and supported the needs of the industry.



Flender thanked the Chancellor by presenting him with a wind turbine as a symbol of the German government's success in expanding wind energy.

Together we have achieved a great deal," Evertz said.

In addition to industrial drives, Flender is one of

Federal Minister of Economics Habeck receives an XXL wrench from Flender assembly as a thank you for his commitment. Carolin Wilmink (right) and Nina Steinbrink (left) presented the wrench on behalf of the Flender trainees, who had engraved a personal dedication for the minister.

the world's leading suppliers of wind energy. As a symbol of the good cooperation, Evertz presented the Minister of Economic Affairs with a giant wrench from the Flender gear assembly plant. During his last visit to Flender, Habeck had enthusiastically held the wrench in his hands and lent a hand in the assembly department.

Digital intelligence in action

At Hannover Messe, Flender is showing how its AIQ technology makes gearboxes intelligent. Every Flender One gearbox comes standard with AIQ, an intelligent sensor system connected to the cloud. This predictive maintenance solution can reduce unplanned downtime by up to 70% and maintenance costs by up to 40%.

Most impressively, data analysis showed that industrial gearboxes were previously oversized by an average of 50%. Precise dimensioning by Flender One not only saves material and energy but also makes Flender's products more attractive in terms of price in the global competition, without compromising on quality.

"In a way, we have become a Google for industrial data," explains Evertz. The collected operating data from all industries enables proactive service and targeted optimization recommendations - often before the customer even recognizes the potential for improvement. The semi-transparent drive exhibit gave Chancellor Scholz and others a live experience of how the AIQ sensor technology works.

"Not knowing the actual loads in operation is a thing of the past. Thanks to our digitalization strategy, we can now supply customized gear units, save resources and make our customers faster, more flexible and more efficient. By combining mechanics with sensor technology and digital services, we are setting new standards in drive technology," Evertz told the high-ranking visitors.

A spirit of optimism for the industry in Germany and Europe

Germany as a business location and its competitiveness in the global environment was also a recurring theme at the fair. For Andreas Evertz, digital transformation and the innovations presented in Hannover are the key to the future: "For us, digital transformation is not an end in itself, but the key to greater competitiveness - for us and our customers. We have digitalized and automated every process - from the first customer contact, through engineering and production, to operation in the plant. This allows us to create drive solutions that are precisely tailored to the application and make our customers more successful and efficient. With innovation, we are creating the much-needed spirit of optimism for industry in Germany and Europe."

In Hanover, the drive manufacturer is showing how it is creating competitive advantages for its customers as a pioneer of digital transformation. Previously impossible: by completely digitizing the engineering process, Flender builds fully individualized, tailor-made gearboxes that can be configured in just five clicks - "as fast as checking out at Amazon".

Eplan L!VE to Showcase Eaton's Digital Engineering & Manufacturing Success on 14 May

- By Gear Technology India

With its worldwide online "Eplan L!VE" event on 14 May, this time around, solutions provider Eplan is a guest at Eaton in Hengelo. Enquiring minds can gain first-hand experience about how Eaton´s facility in the Netherlands has optimised all its processes in engineering and manufacturing for maximum efficiency. In just two-and-a-half hours, online attendees will get a compact overview of how new ideas and tried-and-tested solutions for greater productivity look on the ground. News on Eplan's portfolio and strategies round off the programme.

Eplan L!VE, the worldwide online event, is being broadcast from Eaton's production facility in Hengelo in the Netherlands.

How can processes in engineering and switchgear system manufacturing be designed to be highly efficient? How can manufacturing be further automated? These are questions that Eaton in Hengelo asked itself years ago. The Dutch facility saw the benefits of a data-driven approach and converted its entire engineering methodology, including its processes, to work with Eplan. Eplan L!VE, now in its third round as an online format, will provide fascinating insights into this. Under the motto of "Forward Thinking from Design to Manufacture" will be streaming directly from Eaton's production facility. Attendees from around the world are invited to this online event to discover new manufacturing approaches that generate greater profitability in engineering and manufacturing. By the way, these approaches are in no way restricted to just larger corporations, but are also tailored for SMEs. Eaton took a "one step at a time" approach, and, depending on the task at hand, it can all be implemented at smaller control and switchgear system manufacturers.

An in-depth look into engineering and manufacturing

Well over 1,500 attendees from around the globe will be tuned in online when the Eaton specialists will be showing how the in-house control and switchgear system design and manufacturing has been optimised for a high degree of automation and efficiency. The Eplan solutions used here play a decisive role – ensuring that a standardised foundation of data based on the digital twin is available from first designs all the way through to manufacturing. And if that weren't enough, Eaton also uses Eplan Engineering Configuration (EEC) to automatically generate schematics, bills of materials, terminal diagrams and cabling lists – based on a new design meth-

Eplan L!VE: Insights into Engineering & Manufacturing at Eaton

odology using functional engineering. Whereas the effort previously involved in updating documents linked to the schematics, including bills of materials, terminal diagrams and wiring lists, was immense, now these are all automatically kept up to date with Eplan. This is possible because everything goes back to a centralised source of data. The company's deep integration of manufacturing into this process is also bearing fruit – using Eplan Pro Panel, control cabinet layouts are designed in 3d, completely digitally, and the data provided is used for automatic cable routing. The Wire Terminal WT from Rittal Automation Systems can produce up to 1,000 wires per day, all fully automatically. The processing of copper rails can also be simplified with machines from Rittal Automation Systems. All the processes for wiring and manufacturing are designed to be extremely efficient and overall processes benefits from greater consistency based on the data from Eplan.

Sneak preview and strategy

These in-depth insights into Eaton's design and manufacturing processes will be rounded off with a sneak preview of the upcoming Eplan Platform 2026. As just one example, on 14 May attendees with get a first look at how the different views in Eplan Pro Panel accelerate 3D navigation. Also of interest is the direct access to device data in the Data Portal from Eplan Electric P8 in the future. Last but not least, the new single-line technology in Eplan Preplanning is interesting for users who want to logically link symbols and components in the preplanning phase. Online event attendees can also expect a glimpse into the future of engineering: Eplan CEO Sebastian Seitz will be presenting Eplan's future strategy and some highlights on future topics – including use cases on the topic of artificial intelligence.

Background

Eaton as the global intelligent power management company, has been a technology partner in the Eplan Partner Network since 2023 and specialises in the development, production and sales of power distribution systems, LV and MV switchgear systems and control devices at its facilities in Hengelo in the Netherlands. Eaton additionally provides a large number of its energy systems and components via directly integrated selectors in the Eplan Data Portal. The manufacturer also uses Eplan solutions for its in-house control system and switchgear system design and construction. Machines from Rittal Automation Systems simplify the company's manufacturing processes – including the Rittal Wire Terminal WT and machines for processing copper rails.

EMO Hannover 2025 showcasing production technology for the modern factory

- By Cornelia Gewiehs

A wealth of inspiration for innovative machine and plant manufacturers

Frankfurt am Main, 29 April 2025. - From ice cream machines to wheel loaders: the spectrum of engineering products is as broad as the market itself. However, nearly all producers are facing the same major challenges: modernising production, developing strategies to combat the shortage of skilled workers, implementing solutions for a more circular economy and improved resource efficiency. Under the banner of "Innovate Manufacturing", EMO Hannover 2025, the world's leading trade fair for production technology, will be offering engineering companies a wide range of inspiring innovations and solu- tions. Furthermore, companies will also be able to find suitable partners at the EMO who can provide expert support for their modernisation processes. This saves time and minimises investment risks.

Embracing new technologies

It is now crucial for the sector as a whole – and not just small and medium-sized enterprises – to embrace new technologies and solutions. Ideally, these should be scalable, have already proven their effectiveness, and raise efficiency levels right from the outset. EMO offers direct access to the leading manufacturers and suppliers of customized production solutions in engineering, and showcases advances in metalworking. Visitors can experience machine tools in action at the fair. They can discuss and confer with industry experts and specialists on the trade fair stands as well as in presentations, workshops and live demonstrations.

"The EMO is unique among the trade fairs in presenting the entire metalwork- ing value chain – from machine tools, production systems and additive pro- cesses through to precision tools, automation, metrology, quality assurance, software and accessories," emphasizes Dr. Markus Heering, Executive Direc- tor of EMO organizer VDW (German Machine Tool Builders' Association). The EMO motto "Innovate Manufacturing." is therefore more than just a slogan, says Heering, it is a call to suppliers and users to be bold in exploiting the possibilities opened up by the new technologies.

Digitalization is revolutionizing engineering

This applies in particular to the megatrends of automation, digitalization and artificial intelligence. Advancing digitalization is revolutionizing engineering, the VDW believes. A decisive factor here is the networking of all machines in the process chain. The opportunity to experience this live is what makes EMO unique. Machine

tools now come pre-equipped with extensive sensor and monitoring systems. Exhibitors need to dispel trade visitors' concerns about the possible loss of data sovereignty or the threat of cyberattacks. The exhibiting companies believe it is important to facilitate the transition to data-driven production. Systems that run exclusively on or in individual machines and within the customer's own network will be on display. It is entirely up to users to decide whether they allow the exchange of data, for example, with external parties, such as the machine manufacturer or partners in or outside the value chain, either now or at some point in the future. Genuine added value is created when maintenance cycles can be predicted, downtimes can be minimised, or data for documenting the carbon footprint within the supply chain can be issued at the touch of a button.

Machine learning, a sub-area of artificial intelligence, opens up a new dimension of self-organising production. This allows companies to respond more flexibly to changes in the market and to individual customer demands. It is a crucial prerequisite for maintaining innovatively and competitiveness in the long term.

Addressing skilled labor shortages

Digitalization and automation of production can be combined with strategies aimed at countering the shortage of skilled workers in engineering. Automated assistance systems, for instance, can support machine operators while simultaneously increasing productivity, quality and efficiency. In addition to technical solutions, EMO is also addressing the question of how the training programs for the next generation of skilled workers can best be adapted to meet the latest requirements regarding technological development, digitalization and artificial intelligence.

The changes affecting engineering also include sustainability. More and more countries are taking measures to protect the climate and invest in green transformation of their industry. In production, there is a stronger focus on consuming resources more sparingly, using energy-efficient machines and production processes, and setting up circular economies for products and materials. As the VDW reports, immensely high visitor interest in this topic was already apparent at EMO 2023. The Sustainability Area at EMO 2025 will provide a focal point for modern solutions aimed at bringing about the sustainable production of the future and at answering visitors' questions. This is a topic which is clearly at the top of the agenda when it comes to the modernisation of production.

In the lead-up to the trade fair, EMO exhibitors can find out what they have to offer their customers from the mechanical and plant engineering sector on the landing page for mechanical engineering. Here, EMO exhibitors will successively report on what visitors from the mechanical and plant engineering sector can expect at their stand until the end of the EMO from 22 to 26 September 2025.

Author: Cornelia Gewiehs

Caption

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Mechanical and plant engineering is one of the largest customers of production technology worldwide. Accordingly, many of the more than 1,400 EMO exhibitors will be addressing this sector with their machines, solutions and services.

Source: EMO 2023/VDW

EMO Hannover 2025 – World's Leading Trade Fair for Production Technology

Under the banner Innovate Manufacturing, EMO is set to showcase the entire metalworking value chain from 22 to 26 September 2025. This includes cutting and forming machine tools, manufacturing systems, precision tools, automated material handling, computer technology, industrial electronics and accessories. The EMO is held every two years, rotating between Hanover-Hanover, Milan. The event is celebrating its 50th anniversary in 2025. The 2023 EMO drew more than 1,800 exhibitors and just over 92,000 visitors from all over the world to Hanover.

Standing for Innovation, EMO is the number one platform for metalworking: It is a driving force and global leader when it comes to new products, manufacturing solutions and services. Internationality: International market leaders from 45 countries exhibit at EMO. The EMO trade visitors come from around 140 countries and represent all the major industries, including machine and plant construction, the automotive industry and parts suppliers, aerospace, precision engineering and optics, shipbuilding, medical engineering, tool and mold making, steel and lightweight construction. Inspiration: No other trade fair presents the full breadth and depth of international manufacturing technology like EMO. Highly experienced exhibitors and visitors come together to discuss the megatrends in manufacturing, share their views with international production researchers, and develop solutions to existing challenges. The future of metalworking: The quest to Innovate Manufacturing remains a constant challenge for industry. EMO highlights the limitless possibilities of industrial production.

AGMA Announces Award Winners at 2025 Annual Meeting

- Event Report

The American Gear Manufacturers Association (AGMA) honored seven members at the 2025 AGMA/ ABMA Annual Meeting in Austin, Texas last week. One member received the Lifetime Achievement Award. Also awarded were the Chair and Distinguished Service awards. Three outgoing AGMA Board members received Directors Awards.

Lifetime Achievement Award

Dr. Ulrich Kissling, President at KISSsoft was recognized with the Lifetime Achievement Award for his continuous dedication and contribution to the industry.

The Lifetime Achievement award is given by AGMA to rare individuals who have given years of service to AGMA and the global gear industry. Dr. Kissling's practical experience and theoretical know-how, complemented by a passion and dedication to the world of gearing has helped him create KISSsoft into one of the most widely used gear design software products globally.

"Dr. Kissling has spent his entire career focused on gear and bearing accuracy, actively participating on ISO technical working groups, providing test data and methodology, and for ultimately creating a software system used globally be leading power transmission companies in order to design world class power transmission solutions," noted Michael Cinquemani, Chair of AGMA and CEO of Master PT. Cinquemani presented the award to Dr. Kissling at the banquet dinner. "Kisssoft continues to be one of the go-to resources for gear design, and the industry will leverage what Dr. Kissling created for decades to come."

Chair Award

Greg Estell, Founder and Managing Partner, The Estell Group was honored with the 2025 Chair Award.
The award is presented by the American Gear Manufacturers Association to an individual who has contributed in a meaningful way to the promotion of the gear industry, acted above and beyond the call of duty to support AGMA. Greg has served in leadership roles on both the AGMA Board and the Foundation Trustee Board. In these positions, he has always made himself available to his peers and AGMA staff members to help make industry connections, international connections, and more.

"Greg doesn't just serve on a board, he gives both his time and money to support the activities of whatever he is engaged in," added Cinquemani. "During his time at the AGMA Foundation, he provided unique opportunities for members to engage, and support the efforts of the Foundation, especially scholarships. We can't thank Greg

enough for his efforts to support the PT sector."

Distinguished Service Awards

Prakash Kadam, Managing Director of Pragati Transmission and Fred Eberle of Strattec (retired) received the Distinguished Service Award for their dedication to the association and the industry.
Prakash Kadam has advanced the gear industry significantly through his hands-on involvement in all processes within his company. His vast knowledge, innovative thinking, and passion for quality have directly influenced the industry by setting higher standards for gear manufacturing. Prakash will accept his award later this year at MPT EXPO.

Fred Eberle has worked for decades in the advancement of plastic and powder metal gearing in the automotive actuator market by developing new applications using these types of gears that have created value for end users of these products.

In terms of the gearing industry, Fred's has worked with AGMA on several committees over the years, including twice serving as chair of the Powder Metal Committee and also serving as chair of the Plastics Gearing Committee.

"Both Prakash and Fred distinguished themselves with their long-time support and commitment to the industry and the sector," added Cinquemani. "Volunteers come from all over the world, and both of these AGMA leaders are wonderful examples of giving back."

Board of Directors Awards

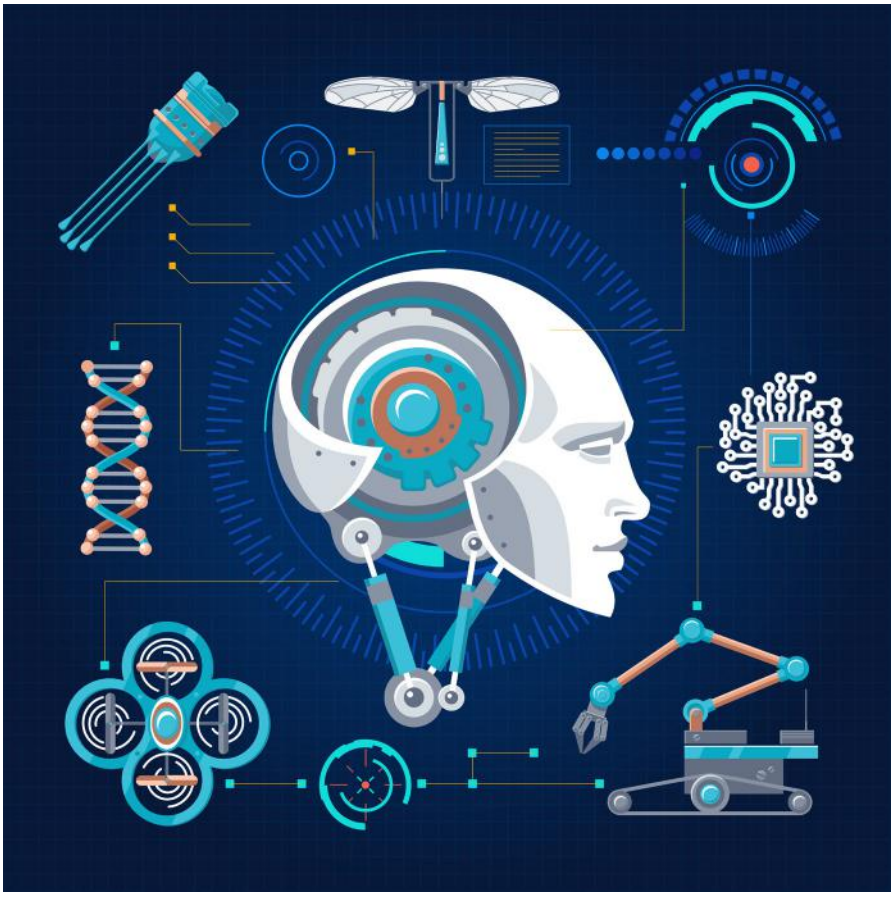
During the AGMA Member Business Session, the following leaders were given Board of Directors Awards:

- Joe Goral, Director of Sales and Marketing, Bourn & Koch, Inc.,
- Nicole M. Wolter, President & CEO, HM Manufacturing, and
- Scott Yoders, Vice President – Sales, Liebherr Gear Technology, Inc.

Each served three-year terms on the AGMA Board and played important roles in developing new programs for AGMA, including advocacy and EV training. "We thank them for their commitment and service to the industry, and we look forward to Scott Yoder's continued leadership as he takes on a new industry volunteer leadership as the AGMA Foundation Chair beginning in May."

Gears and the Human Brain: A Design Dialogue Between Mechanics and Intelligence

- By Sushmita Das



In mechanical engineering, gears are the fundamental building blocks of motion, precision, and power transmission. In the biological world, the human brain is the ultimate design marvel—processing information, coordinating movement, and enabling emotion, logic, and creativity. At first glance, these two systems—gears and the brain—might seem to exist in completely different realms. But when we look closer, the parallels between gear design and brain functionality are not only fascinating but deeply insightful.

1. Complexity in Design: From Gear Mesh to Neural Networks- the analogy behind

Gears are rarely used in isolation. Like neurons in the brain, gears work in systems—each interacting with another in a precise way to deliver the desired output. The meshing of gears—with considerations for backlash, tooth profile, and contact ratio—is similar to how neural networks are designed, ensuring optimal communication and minimal signal loss.

Just as gear designers ensure smooth torque transfer by choosing the right tooth geometry and pitch, nature has optimized synaptic connections in the brain for efficient signal transmission and processing. Both systems thrive on the balance between complexity and harmony.

2. Precision and Tolerance: The Language of Accuracy

Gear design demands precise tolerances and alignment. A minor deviation can lead to noise, wear, or failure. The brain operates similarly, with neuronal firing thresholds, chemical balances, and timing mechanisms that must be finely tuned. Cognitive disorders, much like gear failures, often stem from tiny deviations in this precision system.

In both systems, accuracy is not a luxury—it's a necessity.

3. Load Distribution: Sharing the Stress

In a well-designed gearbox, the load is shared across multiple teeth to avoid premature failure and ensure durability. The brain, too, distributes its tasks—memory, motor skills, emotions—across different regions. When one region is damaged, others sometimes compensate, showcasing a resilience very similar to load-sharing mechanisms in gear trains.
This concept of redundancy and adaptability is vital both in gear design and neurological function.

4. Efficiency and Energy Conservation

Gear engineers constantly strive for higher efficiency—optimizing contact surfaces, lubrication, and transmission ratios to reduce power loss. The human brain, surprisingly, consumes only about 20 watts of power, yet performs trillions of operations per second. It is perhaps the most efficient "machine" ever designed.
Both systems are designed to do more with less—whether it's transferring torque or processing thought.

5. Evolution and Innovation: Design is Never Static

Gear design has evolved from simple wooden wheels to high-precision CNC-cut helical gears with specialised coatings and materials. Similarly, the brain has evolved over millennia, developing complex regions and functionalities.

In engineering, we adopt finite element analysis (FEA) and AI-driven design optimisation. In biology, evolution plays a similar role—refining the brain's architecture based on feedback and survival needs.

6. Feedback Systems: The Heart of Control

Closed-loop control systems in gear drives—like servo motors and encoders—help maintain performance under dynamic conditions. The brain too is built on feedback—sensory inputs, reflex arcs, and adaptive learning mechanisms ensure constant self-correction and regulation.

Without feedback, both systems become inefficient, erratic, or even dangerous.

Concluding Thoughts: Bridging Mechanics and Mind

The intricate parallels between gear systems and the human brain underscore a profound truth: the most effective designs—whether mechanical or biological—are those that prioritize precision, integration, adaptability, and efficiency. By drawing connections between neural pathways and mechanical linkages, between synaptic transmission and torque transfer, we reveal a shared design language that transcends disciplines.

This interdisciplinary lens not only deepens our appreciation for traditional gear engineering but also inspires innovation through biomimicry. Just as the brain refines its processes through feedback, learning, and evolution, modern gear design is embracing smart technologies, real-time monitoring, and adaptive control. The convergence of neuroscience and mechanical engineering may well hold the key to future advancements in intelligent systems, robotics, and machine learning.

Ultimately, exploring the brain through the prism of gears—and vice versa—reminds us that great design is never isolated. It is a dialogue between disciplines, a fusion of insight and innovation, and a continuous pursuit of harmony between complexity and control.

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.

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250 Virgo House, 7th Main, Amarjyoti Layout, Domlur Extension, Bangalore 560 071, India
+91 97406 11121 | www.virgo-comm.com

WWW.GEARTECHNOLOGYINDIA.COM

For Editorial : editor@geartechnologyindia.com
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