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COVER STORY

Gear Grinding: The Backbone of Precision Gear Manufacturing

INDUSTRY VISIT

Inside TaeguTec India: Engineering the Future of Gear Manufacturing Through Precision Tooling

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Dear Readers,

As we present another edition of Gear Technology India, we would like to take a moment to reflect on the remarkable transformation taking place across the manufacturing landscape. What was once driven primarily by machines and manpower is now increasingly being shaped by intelligence, innovation, and adaptability. The gear industry, often regarded as the silent backbone of industrial progress, is today standing at the forefront of this evolution.

This issue places a special focus on gear grinding, a process that defines precision, reliability, and performance in modern gear manufacturing. From our cover story on the critical role of gear grinding to discussions around thermal distortion, lubrication behaviour, and AI-enabled inspection systems, the edition captures how technology is enhancing both quality and productivity across the industry.

At the same time, the conversations within these pages go beyond machines and processes. Through features such as From Scale to Intelligence and A Young Manufacturer's Perspective on Software-Defined Gear Manufacturing, we see how leadership thinking, digital transformation, and long-term vision are becoming equally important in shaping the factories of the future.

Our industry visit to TaeguTec offers valuable insight into how tooling innovation and engineering excellence continue to strengthen India's manufacturing capabilities. Likewise, updates from organisations, global exhibitions like HANNOVER MESSE 2026, and developments from leading companies remind us that collaboration and knowledge-sharing remain central to sustainable industrial growth.

What encourages us most is the confidence with which Indian manufacturing is embracing change. Whether it is the adoption of AI, smart inspection systems, advanced lubrication technologies, or next-generation heat treatment solutions, the industry is steadily moving from scale-driven growth to intelligence-driven competitiveness.

As publishers, our objective has always been to create a platform that not only informs but also inspires meaningful industry dialogue. We are grateful to our contributors, partners, advertisers, and readers who continue to support this mission and help us build a stronger, more connected manufacturing ecosystem.

We hope this edition provides valuable perspectives, fresh ideas, and meaningful insights for professionals across the gear and manufacturing community.

Warm regards,

Sushmita Das
Associate Editor
Gear Technology India

The demands on modern gear manufacturing are evolving rapidly. Higher efficiency requirements, tighter tolerances, lower noise levels, and greater durability are pushing manufacturers to adopt more advanced machining, inspection, and process control technologies. In this context, gear grinding has become a defining process in achieving the precision expected from next generation drivetrain systems.

In this edition of Gear Technology India, we explore the technical advancements shaping the grinding ecosystem, from thermal distortion compensation strategies and lubrication behaviour in high speed gears to AI driven inspection systems and intelligent grinding technologies. Together, these developments highlight how manufacturing is becoming increasingly data driven, adaptive, and process oriented.

Our cover story examines why gear grinding continues to remain the backbone of precision gear manufacturing, while features on smart inspection and software defined manufacturing reflect the growing integration of digital technologies into shop floor operations.

This issue also includes an insightful industry visit to TaeguTec, along with key global updates from HANNOVER MESSE 2026, showcasing the industry's continued focus on automation, precision engineering, and intelligent manufacturing systems.

We sincerely thank our contributors, industry experts, and readers for their continued support. We hope this edition delivers valuable technical insights and meaningful perspectives for the gear manufacturing community.

Happy Reading!

gear TECHNOLOGY INDIA

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

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Michael Goldstein founded Gear Technology in 1984 and served as Publisher and Editor-in-Chief from 1984 through 2019.
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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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- By Sushmita Das

In the world of precision engineering, gears remain one of the most critical mechanical components powering industries ranging from automotive and aerospace to wind energy, robotics, railways, mining, and industrial automation. As transmission systems evolve to meet demands for higher efficiency, quieter performance, and longer operational life, gear manufacturing technologies have also undergone significant transformation. Among all finishing processes, gear grinding stands at the pinnacle of precision manufacturing.

Gear grinding is no longer viewed merely as a finishing operation. Today, it has become a strategic manufacturing process that determines gear quality, operational reliability, energy efficiency, and overall drivetrain performance. With the rise of electric vehicles, Industry 4.0, automation, and AI-driven production systems, gear grinding technology is witnessing rapid innovation.

This cover story explores the importance of gear grinding, its evolution, latest technological trends, process types, challenges, and the future shaping the global and Indian gear manufacturing industry.

Fundamentals of Gear Grinding

Gear grinding is a precision finishing process used to improve the dimensional accuracy, tooth geometry, surface finish, and noise characteristics of gears. It is generally performed after heat treatment because hardening often causes distortion in the gear profile.

The process involves removing small amounts of material from hardened gear teeth using abrasive grinding wheels. This enables manufacturers to achieve extremely tight tolerances, accurate involute profiles, and superior surface integrity.

Gear grinding is especially essential in applications where precision and durability are critical, such as:

- Automotive transmissions
- Electric vehicle gearboxes
- Aerospace gear systems
- Wind turbine gearboxes
- Industrial reducers
- Robotics and automation systems
- Railway traction systems

As powertrain systems become more compact and efficient, the role of gear grinding becomes increasingly indispensable.

Significance of Gear Grinding

Modern industries demand gears that are quieter, stronger, lighter, and more efficient. Traditional machining methods alone cannot achieve the required level of precision after heat treatment. Gear grinding bridges this gap.

Key Benefits of Gear Grinding

1. Superior Accuracy

Gear grinding enables manufacturers to achieve micron-level accuracy in tooth geometry and profile

correction. This improves meshing characteristics and transmission efficiency.

2. Better Surface Finish

A high-quality surface finish reduces friction, wear, and heat generation during operation.

3. Noise Reduction

Ground gears significantly reduce vibration and transmission noise, a critical requirement in electric vehicles where drivetrain noise is more noticeable.

4. Enhanced Gear Life

Improved tooth contact and surface integrity increase load-carrying capacity and fatigue life.

5. Precision After Heat Treatment

Grinding compensates for distortions caused during carburizing, nitriding, or induction hardening processes.

Evolution of Gear Grinding Technology

The journey of gear grinding has evolved from manually operated machines to highly sophisticated CNC-controlled systems integrated with digital intelligence.

Conventional Era

Earlier gear grinding machines relied heavily on operator skill and manual setup. Productivity was limited, and repeatability remained a challenge.

CNC Revolution

The introduction of CNC gear grinders transformed the industry by enabling:

- Automated setup
- Profile corrections
- Higher repeatability
- Faster cycle times
- Complex gear geometries

Industry 4.0 Integration

Modern gear grinding machines now incorporate:

- Real-time monitoring
- IoT connectivity
- Adaptive control systems
- AI-assisted optimization
- Predictive maintenance
- Digital twin simulation

The combination of precision engineering and smart manufacturing has elevated gear grinding into a highly data-driven process.

Major Types of Gear Grinding Processes

Different grinding methods are used depending on gear geometry, production volume, and accuracy requirements.

Form Grinding

In form grinding, the grinding wheel profile matches the shape of the gear tooth space. The wheel grinds one tooth gap at a time.

Advantages:

- High flexibility
- Suitable for small batches
- Ideal for special profiles

Applications:

- Aerospace gears

- Prototype gears
- Large module gears

Generating Grinding

Generating grinding uses the meshing principle between the grinding wheel and gear. Multiple teeth are ground simultaneously.

Advantages:

- High productivity
- Excellent accuracy
- Suitable for mass production

Applications:

- Automotive transmission gears
- EV gears
- Industrial gears

Generating grinding is currently the most widely used process in high-volume gear manufacturing.

Internal Gear Grinding

This process is used for grinding internal gears commonly found in planetary gear systems.

Applications:

- Automatic transmissions
- EV planetary systems
- Aerospace gearboxes

Internal gear grinding demands extremely high machine rigidity and precision due to limited accessibility.

Worm Grinding

Worm grinding utilises threaded grinding wheels to generate gear tooth geometry continuously.

Key Features:

- High-speed operation
- Excellent consistency
- Efficient for automotive production

This process is particularly effective for hardened gears requiring large production volumes.

The Rise of Gear Grinding in Electric Vehicles

One of the biggest growth drivers for gear grinding today is the electric vehicle revolution.

Unlike internal combustion engine vehicles, EVs operate with significantly lower background noise. This means even minor gear whine becomes highly noticeable. Consequently, EV gears require:

- Higher profile accuracy
- Better surface finish
- Lower transmission error
- Superior noise optimization

Manufacturers are increasingly investing in advanced grinding technologies to meet these stringent NVH (Noise, Vibration, and Harshness) requirements.

Additionally, EV transmissions often operate at higher rotational speeds, placing further emphasis on grinding quality and thermal stability.

Grinding Wheel Technology Advancements

The performance of gear grinding heavily depends on grinding wheel technology.

Conventional Grinding Wheels

Traditional aluminium oxide wheels remain widely used for standard applications.

CBN Grinding Wheels

Cubic Boron Nitride (CBN) wheels have revolutionised gear grinding due to their:

- Higher hardness
- Longer wheel life
- Better thermal resistance
- Reduced dressing frequency
- Higher productivity

CBN grinding is particularly preferred in the automotive and aerospace industries.

Challenges in Gear Grinding

Despite its advantages, gear grinding remains a complex and demanding process.

Thermal Damage

Excessive heat generation can lead to grinding burn, affecting gear hardness and fatigue life.

Wheel Wear

Grinding wheels gradually lose their cutting efficiency, requiring dressing and monitoring.

Machine Rigidity

Even slight machine vibration can affect profile accuracy.

Skilled Workforce Requirement

Programming, setup, and process optimisation require specialised expertise.

High Capital Investment

Advanced CNC gear grinders involve substantial investment, making process optimisation crucial for profitability.

AI and Smart Technologies in Gear Grinding

Artificial Intelligence is now entering the gear grinding domain at an accelerated pace.

Modern grinding systems use AI for:

- Adaptive feed control
- Wheel wear prediction
- Process optimization
- Surface quality analysis
- Predictive maintenance
- Automatic defect detection

Machine learning algorithms can analyse vibration, acoustic signals, and spindle behaviour in real time to optimise grinding performance.

This shift toward intelligent grinding is helping manufacturers reduce scrap, improve productivity, and minimise downtime.

Automation in Gear Grinding

Automation has become central to modern gear production facilities.

Robotic Loading Systems

Robots are increasingly integrated for the automatic loading and unloading of gears.

Automatic Measurement Integration

In-process gauging systems enable automatic profile correction and compensation.

Closed-Loop Manufacturing

Grinding machines now communicate directly with inspection systems, creating fully closed-loop manufacturing environments.

This ensures consistent quality with minimal human intervention.

Role of Metrology in Gear Grinding

Precision grinding is incomplete without accurate measurement and inspection.
Modern gear metrology systems measure:

- Tooth profile
- Lead accuracy
- Pitch deviation
- Surface roughness
- Runout
- Transmission error

Advanced analytical software provides detailed feedback for process correction.

As gear tolerances tighten further, metrology integration is becoming increasingly critical.

Sustainability and Energy Efficiency

Sustainability is emerging as a major focus area in gear manufacturing.

Grinding machine manufacturers are now developing systems with:

- Lower energy consumption
- Efficient coolant systems
- Minimal lubrication technology
- Reduced grinding waste
- Eco-friendly filtration systems

Energy-efficient grinding not only reduces environmental impact but also lowers operational costs.

India's Growing Gear Grinding Market

India's gear manufacturing sector is rapidly expanding due to growth in:

- Automotive production
- EV manufacturing
- Defense
- Railways
- Aerospace
- Wind energy
- Industrial automation

Indian manufacturers are increasingly upgrading from conventional gear finishing methods to advanced CNC grinding systems.

Government initiatives such as "Make in India" and localisation programs are also encouraging domestic production of high-precision gears.

Several Indian gear manufacturers are now supplying globally competitive gears to international OEMs, requiring world-class grinding capabilities.

Future Trends in Gear Grinding

The future of gear grinding is being shaped by digitalisation, automation, and high-performance manufacturing demands.

Hybrid Machines

Future machines will combine multiple operations, such as grinding, skiving, and inspection into a single platform.

AI-Driven Optimisation

Self-learning grinding systems will automatically optimise process parameters.

Digital Twins

Virtual simulation models will predict machine behaviour and process outcomes before actual production.

Ultra-Precision Grinding

As industries demand tighter tolerances, nano-level precision grinding technologies will gain importance.

Sustainable Manufacturing

Environmentally conscious grinding systems will become standard across global manufacturing facilities.

The Human Factor: Skill Development Matters

Even with advanced automation, skilled manpower remains crucial.

Gear grinding requires expertise in:

- Machine setup
- Dressing technology
- Wheel selection
- Process optimization
- Inspection interpretation
- Thermal management

Training and upskilling will play a vital role in supporting the next generation of precision manufacturing professionals.

Industry-academia collaboration and technical training institutes must focus more on advanced gear manufacturing technologies.

Final Thoughts

Gear grinding has evolved into one of the most sophisticated and indispensable processes in precision manufacturing. As industries move toward higher efficiency, quieter systems, electric mobility, and intelligent automation, the importance of ground gears will continue to grow.

From EV transmissions and aerospace systems to industrial robotics and renewable energy applications, the demand for ultra-precise gears is driving innovation in grinding technologies at an unprecedented pace.

Today's gear grinding machines are no longer standalone production units; they are intelligent manufacturing systems integrated with AI, automation, analytics, and real-time quality control. The future belongs to manufacturers who can combine precision engineering with digital intelligence.

For India, the ongoing transformation presents a major opportunity. With increasing investments in advanced manufacturing, automation, and skill development, the country is well-positioned to become a global hub for precision gear production.

In the coming decade, gear grinding will not simply remain a finishing operation—it will define the competitive edge of next-generation manufacturing.

Sushmita Das
Associate Editor
Gear Technology India

Inside TaeguTec India: Engineering the Future of Gear Manufacturing Through Precision Tooling

- By Gear Technology India

The sound of high-speed machining, the steady movement of automated systems, the smell of cutting oil, and the precision with which every operation flowed across the shopfloor immediately reflected one thing: this was not merely a tooling facility, but an ecosystem built around advanced manufacturing engineering.

In an era where global manufacturing is rapidly transitioning toward automation, electric mobility, multitasking machining, and high-efficiency production systems, cutting tools have become far more than simple consumables. They are now critical productivity enablers capable of influencing cycle times, dimensional accuracy, machine utilisation, and overall manufacturing economics.

It was with this perspective that Gear Technology India recently visited TaeguTec India Pvt Ltd to gain a deeper understanding of the technologies, processes, and philosophies driving one of the world's leading cutting tool manufacturers.

The visit began with an interaction between Sushmita Das, Associate Editor of Gear Technology India, and Mr L. Krishnan, the Managing Director of TaeguTec India Pvt. Ltd., whose calm yet deeply insightful conversation immediately set the tone for the day.

Seated amidst discussions on manufacturing transformation, industrial growth, and evolving machining technologies, Mr Krishnan spoke extensively about TaeguTec's journey from its origins in South Korea to becoming a globally recognised cutting tool and tooling solutions provider under the IMC Group umbrella.

He explained how TaeguTec has steadily evolved from being a traditional cutting tool manufacturer into a technology-driven engineering partner for industries such as automotive, aerospace, railways, die & mold, wind energy, construction equipment, and industrial transmission manufacturing.

"Manufacturing itself has changed," he explained during the discussion. "Customers today are no longer looking only for a tool. They are looking for productivity, process integration, stability, and complete machining solutions."

That statement perhaps summarised the philosophy behind the company's growth.

Mr Krishnan elaborated on how the rise of electric vehicles, automation, multitasking machines, and flexible manufacturing systems has significantly altered the requirements of modern machining. Manufacturers are now under constant pressure to reduce setup times, improve machine utilisation, increase productivity, and machine more complex components in fewer operations.

According to him, this changing landscape has prompted tooling companies like TaeguTec to continually innovate in areas such as carbide grade development, insert geometries, modular tooling systems, advanced coatings, coolant delivery technologies, and high-rigidity cutter designs.

As the discussion progressed, it became increasingly evident that TaeguTec's expansion in India is closely aligned with the country's emergence as a global manufacturing destination. Mr Krishnan highlighted how India's growth in automotive, EVs, industrial equipment, railways, and renewable energy sectors is creating enormous demand for advanced machining technologies.

He also spoke about the company's strengthening presence in India through enhanced technical support, application engineering, customer-centric solutions, and localised operational capabilities aimed at supporting Indian manufacturers more efficiently.

Following the interaction, the shopfloor tour began under the guidance of Mr Prakash Kini, the Sr. Manager, Technical Support (Non Automotive and Gear), Taegu Tec India Pvt Ltd., who walked Sushmita through the facility while explaining the intricate processes involved in manufacturing high-performance cutting tools and tooling systems.

"The experience was far more than a conventional factory walkthrough"

Sushmita Das, the Associate Editor of Gear Technology India, along with Mr L Krishnan, the Managing Director & Mr Prakash Kini, the Sr. Technical Support (Non Automotive and Gear) at Taegu Tec India Pvt Ltd.

Every section of the facility reflected precision, discipline, and engineering depth. From raw material preparation to final inspection, the manufacturing flow demonstrated how modern tooling production combines metallurgy, materials science, CNC precision engineering, coating technologies, and quality control into one highly integrated process.

One of the most fascinating sections of the visit was the insert manufacturing process.

Mr Kini explained that carbide inserts, the actual cutting edges responsible for removing metal during machining, are produced using highly sophisticated powder metallurgy techniques.

The journey begins with ultra-fine tungsten carbide and cobalt powders. Tungsten carbide provides hardness and wear resistance, while cobalt functions as the binder that imparts toughness to the insert. Depending on the intended application, whether machining steel, stainless steel, cast iron, titanium, or superalloys, the composition of the carbide grade changes significantly.

Watching the process unfold gave a deeper appreciation of how much science lies behind what appears to be a small insert.

The powders are first mixed carefully using wet milling processes to ensure uniform particle distribution. Even microscopic inconsistencies at this stage can affect tool life and machining stability later during actual cutting operations.

The slurry then undergoes spray drying, transforming it into free-flowing granules suitable for compaction. These granules are pressed inside precision dies under immense pressure to create what is known as a "green insert." Although the insert already carries its final geometry, chip breaker profile, and mounting hole design, it remains soft and fragile at this stage.

Perhaps the most critical transformation occurs during the sintering process.

Inside vacuum furnaces operating at temperatures approaching 1500°C, the cobalt binder melts and fuses the tungsten carbide particles. Mr Kini explained how this process gives carbide inserts their exceptional hardness, wear resistance, and cutting capability.

Observing the scale and precision involved in this operation highlighted why carbide tooling is considered one of the most advanced products in modern manufacturing engineering.

Post-sintering processes involved highly accurate grinding operations where insert thickness, flatness, edge geometry, and dimensional tolerances are controlled within micron levels. Edge preparation processes further refine the insert depending on the intended cutting application.

Some edges are sharpened for low cutting forces, while others are reinforced for interrupted cutting conditions requiring higher toughness.

The next stage involved coating technologies, an area that has become increasingly important in modern machining performance. Mr Kini explained the difference between CVD and PVD coatings and how each serves different machining environments.

Modern coatings act as thermal shields capable of withstanding extreme cutting temperatures, reducing friction, improving wear resistance, and extending tool life. The inserts finally undergo laser marking, inspection, wear simulation testing, and traceability verification before packaging.

Equally impressive was the tool body manufacturing section.

Large CNC machines were engaged in machining cutter bodies, drill bodies, milling cutters, and holders with extremely high precision. Kini explained that the insert pocket, the location where the insert sits, is among the most critical features in any tool body.

Even the slightest variation in pocket geometry can influence cutting stability, surface finish, vibration, runout, and machining accuracy.

The machining of internal coolant channels also drew significant attention. These channels deliver coolant directly to the cutting zone, helping improve chip evacuation, reduce thermal distortion, and enhance tool life during high-speed machining.

The tool bodies undergo heat treatment before machining, followed by precision grinding, balancing, and extensive quality checks to ensure rigidity, dimensional stability, and high-speed performance.

As the tour progressed, the discussion shifted toward TaeguTec's extensive gear machining solutions portfolio, an area particularly relevant for the readership of Gear Technology India.

Mr Kini explained how modern gear manufacturing is undergoing a major technological transformation. Traditional production methods are increasingly being replaced or complemented by multitasking machining, complete machining strategies, and highly productive gear cutting technologies.

TaeguTec has responded to these changes by developing a comprehensive range of solutions covering power skiving, hobbing, gear shaping, gear gashing, spline machining, worm gear machining, rotor screw machining, and double helical gear applications.

Among these, power skiving emerged as one of the most significant technologies discussed during the visit.

Mr Kini described power skiving as one of the fastest-growing gear machining methods globally, especially for internal gears and EV transmission components. Unlike conventional shaping or hobbing processes, power skiving enables both internal and external gears to be machined efficiently on multitasking and 5-axis machines.

The process dramatically reduces cycle times while enabling turning, milling, and gear cutting operations to be completed in a single setup.

TaeguTec's GEARSKIVE systems include both head-changeable and indexable tooling concepts designed for different module ranges and applications. The modular approach not only improves flexibility but also reduces tooling inventory costs and setup complexity. The conversation then moved toward hobbing technologies.

Despite the growth of power skiving, hobbing continues to remain one of the most productive methods for external gear manufacturing. TaeguTec's GEARHOB portfolio includes mono body and segment hob systems equipped with advanced indexable inserts.

He explained how indexable hobs provide several advantages over traditional HSS hobs, including higher productivity, longer tool life, easier maintenance, and improved process economics.

Particularly interesting were the solutions developed for large module gears used in wind turbines, heavy construction equipment, and industrial transmission systems.

Further discussions covered gear gashing solutions, shaper cutters, worm gear tooling, and spline machining systems. Each product family reflected a clear focus on process flexibility, modularity, productivity, and machining stability.

Throughout the visit, one observation remained constant: TaeguTec's emphasis on engineering complete machining systems rather than standalone tools.

The company's approach clearly aligns with the direction modern manufacturing is heading toward, with fewer setups, higher automation, multitasking integration, hard machining capability, and improved operational efficiency.

As the tour neared its conclusion, the final stages of the manufacturing process further highlighted TaeguTec's uncompromising approach toward quality and consistency. After machining, coating, grinding, balancing, and assembly operations are completed, every insert and tool body undergoes rigorous inspection procedures before packaging.

Advanced measuring systems, optical inspection equipment, runout verification systems, coating adhesion checks, coolant flow testing, and dimensional accuracy evaluations ensure that every product leaving the facility meets stringent global quality standards. Only after passing these detailed quality checks are the tools approved for final packaging and dispatched to customers across various industries.

During the concluding discussions, another important aspect repeatedly emphasised by the TaeguTec team was the growing industry focus on cost per component reduction rather than merely tooling cost. Modern manufacturers today evaluate tooling performance based on overall productivity, machine uptime, cycle time reduction, tool life, setup minimisation, and process reliability.

TaeguTec's engineering philosophy is therefore centred not simply on selling cutting tools, but on delivering complete machining solutions capable of lowering the total manufacturing cost per component while improving productivity and operational stability.

Innovation also emerged as one of the strongest pillars of the company's long-term strategy. The team highlighted TaeguTec's strong emphasis on research and development, which continues to drive new product development, carbide grade advancements, insert geometries, coating technologies, and process optimisation solutions.

What stood out particularly was the company's continuous innovation cycle. As machining requirements evolve rapidly across industries such as EVs, aerospace, renewable energy, and precision engineering, tooling technologies are constantly upgraded to meet changing production demands. The company explained how components, tooling systems, and machining concepts continue to evolve continuously, with significant innovation and technological advancements typically emerging every three years to align with the next generation of manufacturing requirements.

As the visit concluded, conversations revolved around future trends shaping the manufacturing world, electric mobility, hard gear machining, digital manufacturing, AI-assisted production systems, and sustainable machining practices.

Walking out of the facility, one thing became abundantly clear: the future of gear manufacturing will not be defined solely by machines or materials, but by the intelligence embedded within tooling technologies themselves.
And in that evolving future, companies like TaeguTec are not merely supplying tools; they are engineering the foundation of next-generation manufacturing.

Technical Cleanliness in Gear Manufacturing: From Compliance to Competitive Advantage

- By Prashant Pachave

In the world of gear manufacturing, precision has traditionally been associated with geometry, surface finish, hardness profile, and metallurgical integrity. However, an increasingly decisive parameter is reshaping quality expectations across automotive and industrial transmission sectors — technical cleanliness. As gear systems evolve toward tighter tolerances, higher operating speeds, and electrified powertrains, microscopic contamination introduced during manufacturing, heat treatment, washing, handling, or assembly can become functionally significant.

Today, technical cleanliness is not merely a compliance requirement. It is increasingly becoming a competitive differentiator.

Why Technical Cleanliness Matters in Gear Technology

Gears operate under high contact stresses and precise lubrication regimes. Under critical operating conditions, hard metallic particles trapped between mating surfaces may accelerate wear, induce localised surface damage, or contribute to micro-pitting mechanisms. In high-performance transmissions and e-drive systems, contamination may additionally affect bearings, lubrication channels, seals, and magnetic systems.

The shift toward electric mobility has amplified this concern. EV drivetrain systems often operate at higher rotational speeds and lower background noise levels, making them more sensitive to contamination-related wear, bearing performance, and NVH concerns. Unlike internal combustion systems, where engine noise can mask mechanical irregularities, EV drivetrains expose even subtle gear defects. Consequently, contamination that may have once been tolerated can now become functionally significant.

For gear manufacturers, technical cleanliness directly impacts:

- Gear durability and fatigue life
- Wear and micro-pitting resistance
- Transmission efficiency
- NVH performance in EV applications
- Warranty risk and customer confidence
- Compliance with OEM supplier requirements

Increasingly, OEMs and Tier-1 suppliers specify contamination limits not only for assembled transmission systems but also for individual components such as gears, shafts, synchronizers, housings, and bearings.

In gear manufacturing, technical cleanliness assessment is increasingly applied after hobbing, shaving, grinding, superfinishing, washing, and assembly preparation stages. Components such as transmission gears, differential gears, shafts, synchro parts, bearing interfaces, and gearbox housings are often monitored to reduce contamination-related performance risks.

Understanding Technical Cleanliness Requirements

Technical cleanliness refers to the measurement and control of particulate contamination present on a component surface. The objective is to characterise and control particulate contamination so that cleanliness levels remain within customer-defined or functionally acceptable limits.

Most automotive and industrial gear manufacturers follow internationally accepted methodologies such as:

- ISO ISO 16232 – Standardised methodology for extraction, analysis, and reporting of particulate contamination on automotive components
- ISO ISO 4405 / ISO 4406 / ISO 4407 – Hydraulic fluid contamination evaluation methodologies and particle counting practices
- VDA VDA 19.1 – Inspection of technical cleanliness of functional parts
- VDA VDA 19.2 – Technical cleanliness in assembly environments

Although these standards originated in automotive applications, their adoption has expanded rapidly across industrial gearboxes, aerospace components, precision engineering, hydraulics, and energy systems.

A typical technical cleanliness workflow includes:

- **Extraction** – Removal of particles from the component using rinsing, pressure flushing, ultrasonics, or agitation methods.
- **Filtration** – Collected contaminants are filtered through membrane filters of specified pore sizes.
- **Microscopic Analysis** – Particles are analysed for size, count, morphology, and reflectivity.
- **Classification** – Differentiation between metallic, non-metallic, fibre, shiny, dark, or critical particles.
- **Reporting** – Generation of standardised cleanliness reports with defined acceptance criteria.

However, achieving reliable results is more complex than simply counting particles. Repeatability, contamination control during testing, extraction efficiency, and image analysis accuracy play equally important roles.

The Hidden Challenge: Measuring What Truly Matters

One of the major industry challenges is distinguishing between harmless contamination and functionally critical particles.

For example, a small soft fiber may be less harmful than a large hard metallic particle generated during grinding or machining. Similarly, contamination originating from shot blasting, honing, heat treatment scales, abrasive wear, or washing media must be interpreted differently depending on application risk.

In gear manufacturing, particular attention is often given to:

- Ferrous wear particles
- Grinding debris
- Abrasive particles
- Burr fragments from machining operations
- Oxides and scale residues
- Fibrous contaminants from packaging or cleaning

Modern technical cleanliness assessment, therefore, goes beyond particle counting. It increasingly focuses on particle characterisation, enabling engineers to identify root causes and improve manufacturing processes.

Instead of asking "How many particles are present?", quality teams are now asking "Where are these particles coming from, and what functional risk do they represent?"

This shift is driving new technological advancements in contamination analysis.

Advancements Reshaping Technical Cleanliness

1. Automated Microscopy and Intelligent Image Analysis

Traditional manual particle inspection was time-consuming and operator-dependent. Today, automated optical microscopy combined with intelligent image analysis has significantly improved consistency and throughput.

Modern systems can automatically detect, segment, classify, and measure particles based on morphology, brightness, aspect ratio, and reflectivity characteristics, improving repeatability and enabling practical differentiation of likely metallic and non-metallic contaminants.

2. High-Resolution Particle Characterisation

As gear systems become more precision-driven, the ability to analyse finer particles has become increasingly important.

Advances in optics, illumination, and digital imaging now enable reliable detection and characterisation of increasingly finer particulate contamination within practical inspection limits. Higher-resolution imaging helps improve identification of elongated metallic chips, sharp-edged contaminants, and wear-inducing particles — particularly valuable in EV drivetrain applications where contamination can influence acoustic behaviour and bearing performance.

3. Data-Driven Process Improvement

Technical cleanliness is gradually evolving from a quality inspection tool into a process optimisation instrument.

Instead of only generating pass/fail reports, manufacturers are using contamination data to:

- Improve washing efficiency
- Optimise machining parameters
- Validate deburring processes
- Evaluate packaging contamination
- Monitor heat treatment cleanliness
- Benchmark supplier quality

Trend analysis helps identify recurring contamination sources before they become field failures. In many advanced manufacturing environments, cleanliness data is increasingly integrated into broader digital quality systems.

Addressing Industry Needs: The Conation Approach

At Conation Technologies Pvt. Ltd., we have observed a clear shift in customer expectations. Manufacturers no longer seek only compliance-oriented inspection systems; they require reliable and repeatable technical cleanliness ecosystems capable of delivering trustworthy results.

One of the overlooked realities in technical cleanliness is that measurement accuracy begins long before microscopy. Even advanced particle analysis systems can produce inconsistent results if contamination is introduced during extraction, filtration, membrane handling, or sample preparation.

To address this challenge, Conation provides end-to-end technical cleanliness solutions covering extraction, filtration, microscopic evaluation, image analysis, and standardised reporting workflows.

A key strength is its specialised Contamination Test Cabinets (CTC), designed to minimise environmental contamination during critical preparation stages and improve repeatability in cleanliness testing aligned with ISO 16232 and VDA methodologies.

In addition, Conation solutions for Particle Analysis support automated particle detection, morphology-based analysis, reflective/non-reflective differentiation, and contamination source interpretation to help manufacturers correlate contamination with processes such as hobbing, grinding, heat treatment, washing, deburring, and assembly.

Our experience suggests that technical cleanliness delivers maximum value when treated as a manufacturing intelligence tool rather than a compliance activity. The goal is not simply to count particles, but to understand their origin, control their generation, and continuously improve process capability.

The Road Ahead

The future of gear technology will increasingly depend on invisible parameters. As powertrains become more efficient and electrified, acceptable contamination thresholds are expected to tighten further. Technical cleanliness will increasingly move from a supplier audit requirement to an integrated process engineering discipline, supported by automation, intelligent image analysis, and digitally connected quality systems.

For gear manufacturers, the challenge is no longer simply achieving dimensional precision — it is ensuring that microscopic contamination does not compromise macroscopic reliability.

Prashant Pachave

Head–Applications, Conation Technologies Pvt. Ltd., Pune


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Thermal Distortion in Gear Grinding: Modelling, Measurement, and Compensation Strategies

- By Vivek Singh

The modern manufacturing landscape is unforgiving. With the explosive growth of electric vehicles (EVs) and advanced aerospace transmissions, the tolerance for gear noise and vibration has vanished. The shop floor is no longer chasing simple dimensional accuracy; it is chasing "Noise, Vibration, and Harshness" (NVH) perfection. This requires gear tooth profiles accurate to the sub-micron level.

However, achieving sub-micron accuracy in gear profile grinding is not just about having a rigid machine or a perfectly dressed grinding wheel. There is a silent, invisible enemy that constantly undermines the process: heat.

Thermal distortion during gear grinding is one of the most complex, critical, and rarely discussed challenges in precision manufacturing. A temperature fluctuation of just a few degrees in the machine structure or the gear blank can warp the involute geometry enough to scrap a high-value component. Understanding how this heat is generated, how it travels, and how to compensate for it in real-time is what separates good gear manufacturers from world-class ones.

The Crucible of the Cut: Heat Generation During Profile Grinding

To understand thermal distortion, we must first look at the contact zone where the grinding wheel meets the gear tooth. Grinding is fundamentally a high-energy process. Unlike turning or milling, where a sharp cutting edge shears off metal efficiently, grinding relies on thousands of microscopic, randomly oriented abrasive grains.

When an abrasive grain interacts with the gear material, it goes through three phases:

1.Rubbing: The grain hits the metal and creates massive friction without removing material.

2.Ploughing: The grain pushes the metal aside, causing plastic deformation and intense internal friction.

3.Cutting: Finally, a chip is formed and removed.

The rubbing and ploughing phases are terribly inefficient and convert almost all their mechanical energy directly into thermal energy. In profile gear grinding, the contact area between the wheel and the workpiece is relatively large compared to other grinding operations. This creates a highly concentrated heat source moving along the flank of the gear tooth.

The Partitioning Problem

Once the heat is generated, where does it go? The thermal energy is partitioned between the grinding wheel, the chip, the coolant, and the workpiece (the gear). In an ideal world, the coolant and the chips would carry away 100 per cent of the heat. In reality, a significant percentage flows directly into the gear blank.

Additionally, grinding wheels spinning at high velocities create an aerodynamic boundary layer, a "wall" of air travelling with the surface of the wheel. If the coolant velocity and nozzle design are not perfectly optimised to break through this air barrier, the coolant simply bounces off, leaving the contact zone starved of lubrication and cooling precisely when it needs it most. The result is an instant temperature spike in the gear tooth, leading to localised thermal expansion right at the point of cutting.

The Silent Enemy: Machine Tool Structure Influence

It is a common misconception on the shop floor that thermal distortion only affects the gear being ground. In reality, the machine tool itself is a living, breathing structure that twists, bends, and grows as its temperature changes.

A high-end gear grinding machine is a complex assembly of cast iron, polymer concrete, steel guideways, and high-torque motors. Heat is continuously pumped into this structure from several sources:

- **Internal Sources:** The high-speed grinding spindle motor, axis drive motors, hydraulic pumps, and rotary table bearings all generate continuous heat.
- **Process Sources:** The heated coolant returning from the cutting zone transfers heat back into the machine bed.
- **Environmental Sources:** Changes in shop floor ambient temperature, drafts from open bay doors, or even direct sunlight hitting the machine enclosure.

The Bimetallic Strip Effect

Machine tools rarely heat up evenly. If the front of a machine column (facing the cutting zone) gets warmer than the rear of the column, the front will expand more. This causes the entire column to bow forward, subtly altering the position of the grinding wheel relative to the gear. This is known as the "bimetallic strip effect."

Because the tool centre point (where the wheel touches the gear) is often situated far away from the machine's structural base, a structural distortion of just a few micrometres at the base is amplified at the grinding wheel. A slight thermal bow in the machine column can easily shift the grinding wheel's position by several microns, significantly altering the depth of cut and compromising the gear's profile accuracy.

The Price of Heat: Impact on Sub-Micron Accuracy

When thermal distortion occurs, whether in the gear blank or the machine structure, it does not result in random, chaotic errors. It manifests as very specific, measurable deviations in the gear geometry that fall outside DIN or ISO quality standards.

- **Involute Profile Errors:** As the grinding wheel makes its pass from the root of the tooth to the tip, the heat builds up. The tip of the gear tooth, having less mass to absorb the heat, expands more than the root. The machine grinds this "swollen" tip to the correct dimension. But when the gear cools down and shrinks, the tip will suddenly measure undersized, resulting in a negative profile slope error.

- **Lead Twist (Bias Error):** This is incredibly common in helical gears. As the wheel traverses across the face width of the gear, the continuous heat input causes the gear blank to expand progressively. The machine continues to grind in a straight line, but the gear is moving. Upon cooling, the gear tooth will exhibit a "twist," where the profile at the top face of the gear is fundamentally different from the profile at the bottom face.

- **Pitch Variations:** If a gear is ground using a continuous generating process, the heat buildup from grinding the first few teeth can bleed into the unground teeth. By the time the machine reaches the final teeth, the entire gear blank has thermally expanded. This results in adjacent pitch errors and a highly noticeable runout condition when the gear cools.

In sub-micron manufacturing, standard dimensional tolerances are irrelevant. The focus is on topological mapping of the gear flank. Even a 1-micron thermal deviation can cause a high-speed EV gear to whine, leading to immediate rejection.

Mapping the Heat: Modelling and Measurement

To fix thermal distortion, you first have to "see" it. Because the heat cycles happen incredibly fast and within a flood of cutting oil, measuring it is notoriously difficult. The industry relies on a mix of empirical measurement and advanced digital modeling.

Measurement Strategies on the Shop Floor

Directly measuring the temperature in the contact zone is nearly impossible in production. Instead, engineers use proxy measurements:

- **Strategic Thermocouples:** High-precision PT100 temperature sensors are embedded in critical areas of the machine tool, the spindle housing, the main castings, and the coolant tank.

- **Coolant Tracking:** Monitoring the delta (difference) between the coolant delivery temperature and the coolant return temperature gives a strong indication of how much heat is being generated in the cut.

- **In-Process Metrology:** The most effective shop floor method is using the machine's onboard probing system. By probing a specific "master artefact" or the gear blank itself before and after grinding, the machine can measure the exact dimensional shift caused by heat.

Digital Modelling (The Digital Twin)

Academic and high-level R&D facilities use Finite Element Analysis (FEA) to simulate the heat flow. By inputting the properties of the wheel, the gear material, and the machine structure, software can predict how the system will warp.

However, FEA is computationally heavy and too slow for real-time shop floor corrections. Therefore, machine tool builders create "empirical models." They run the machine through various thermal cycles in a lab, measure exactly how the machine bends at different temperatures, and build a mathematical map. This map tells the machine: If the spindle sensor reads 25 degrees Celsius and the bed sensor reads 22 degrees Celsius, the grinding wheel has likely drifted 2 microns to the left.

Fighting Back: Real-Time Thermal Drift Compensation

Understanding the error is only half the battle; compensating for it dynamically during the grinding cycle is the bleeding edge of manufacturing technology.

Modern compensation strategies are split into passive and active methods.

Passive Compensation: Stopping the Heat

The first line of defence is preventing thermal gradients in the first place.

- **Chiller Synchronisation:** Advanced shop floors no longer just chill their coolant to a static temperature. They use smart chillers that track the ambient room temperature and adjust the coolant temperature to match it perfectly. If the coolant, the machine casting, and the room are all exactly the same temperature, structural warping is virtually eliminated.

- **Symmetrical Machine Design:** Modern gear grinders are designed with thermal symmetry. Heat-generating components are placed in a way that ensures, if the machine does expand, it expands in a straight line that does not affect the tool centre point, rather than bowing or twisting.

Active Compensation: Software to the Rescue

When passive methods hit their physical limits, active CNC compensation takes over. This is where the magic happens for sub-micron accuracy.

Using the empirical thermal models discussed earlier, the machine's CNC controller constantly monitors the array of temperature sensors across the machine structure. As the controller detects a temperature rise that corresponds to a 1.5-micron shift in the grinding wheel's position, it does not sound an alarm. Instead, it seamlessly offsets the machine's linear axes by exactly 1.5 microns in the opposite direction.

This happens in real-time, hundreds of times a second, completely transparent to the operator. The machine structure is physically warping, but the software is constantly shifting the axes to ensure the grinding wheel remains perfectly stationary relative to the ideal gear geometry.

Intelligent Probing Cycles

For the most critical aerospace gears, machines employ active "drift tracking." Before a finishing pass, the machine uses its probe to touch a fixed calibration sphere located on the worktable. If the machine's thermal growth has moved the probe's starting point, the CNC calculates the exact vector of the thermal drift and applies a dynamic offset to the final grinding pass. This ensures that the finishing cut is dead-accurate, regardless of how much heat the roughing passes generated.

Conclusion

Thermal distortion in gear profile grinding is not an abstract theory; it is a daily reality on the shop floor that dictates the difference between a perfect transmission and a scrap bin full of expensive steel. As the demands for zero-noise EV gears and ultra-reliable aerospace components continue to rise, the tolerance for thermal error is shrinking to zero.

Mastering this niche requires a holistic approach. It demands operators who understand coolant boundary layers, manufacturing engineers who respect the thermal kinematics of the machine tool, and programmers who can leverage active, real-time CNC compensation. By bridging the gap between thermodynamic theory and practical shop floor execution, manufacturers can finally tame the heat and guarantee sub-micron precision, part after part, shift after shift.

Vivek Singh
Technical Writer
Gear Technology India

From Scale to Intelligence: How Premium Group is Powering India's Next Manufacturing Leap

- By Premium Group of Companies

India is on track to become one of the world's largest manufacturing and renewable energy hubs, backed by ambitious capacity additions and a strong policy push under the Make in India initiative. At Premium Group, we believe the real differentiator is now shifting from how much we build to how intelligently and efficiently we operate.

The next phase of growth will be defined by precision engineering, optimised performance, and lifecycle reliability.

At Premium Group, this growth is being driven through two focused verticals- Premium Motion and Premium Care, each built to address evolving industrial requirements with specialised engineering and service capabilities.

This vision is rooted in the legacy of our flagship company, Premium Transmission Limited, which brings over six decades of expertise in power transmission and engineering. With advanced manufacturing facilities and government-certified technical and product development centres across India catering to domestic and global markets, Premium Group continues to strengthen its position as a trusted partner in delivering high-performance engineering solutions worldwide.

The inauguration of the new advanced manufacturing facility in Chakan, Pune, marks another important milestone in this journey. Developed in alignment with the Make in India initiative, the expansion enhances the Group's manufacturing capabilities, strengthens production capacity, and supports the growing demand for precision- engineered solutions across industries.

The facility was inaugurated on 8th May by Mr Karan Thapar, Chairman – Premium Group, in the presence of Mr Niraj Bisaria, MD, President – Premium Group, along with Board Members and the senior leadership team of the company.

Premium Motion: Engineering for Energy Yield and Performance Optimisation

As industries evolve, particularly in renewable energy, the focus is no longer limited to capacity creation. The priority is now maximising output from every installed asset.

Premium Motion is engineered for this transition. Moving beyond standalone components, it delivers application-specific motion solutions that directly impact system performance.

Through a portfolio of precision-engineered slew drives, dampers, linear actuators, and robotic cleaning systems, Premium Motion enables solar installations to operate with greater accuracy, efficiency, and reliability. These solutions ensure precise solar tracking, optimised motion control, and sustained module efficiency, even under demanding environmental conditions.

Slew drives

Premium Bot

Linear Actuator

Damper

The result is a tangible higher energy yield, reduced operational losses, and improved long-term asset productivity. Beyond renewable energy, Premium Motion also supports critical industrial applications where torque, durability, and precision are essential.

Premium Care: Driving Reliability Through Lifecycle Intelligence

While performance is critical, sustaining it over time defines true operational efficiency.

Backed by the legacy of over six decades in the gearbox and power transmission industry, Premium Care delivers a proactive, customer-centric, and data-driven approach focused on maximising uptime, improving reliability, and extending asset lifecycle.

Its offerings include one-stop solutions for overhauling and reconditioning gearboxes of any make, preventive and predictive maintenance, condition monitoring, diagnostics, refurbishment, and customised service programs designed to ensure reliable equipment performance and operational continuity.

With strategically located Premium Care centres across India and a growing global service presence, Premium Care ensures faster response, localised support, and seamless service delivery to customers worldwide.

By combining deep engineering expertise with lifecycle support capabilities, Premium Care helps customers reduce downtime, optimise maintenance planning, and enhance long-term asset productivity. In today's uptime-driven industries, lifecycle management has become a strategic enabler of performance assurance.
Engineering the Next Phase of Growth

As India strengthens its global manufacturing position, the need for high-performance engineering solutions, reliable lifecycle services, and advanced manufacturing capabilities will continue to grow.

The new Chakan facility reflects Premium Group's long-term commitment to innovation, manufacturing excellence, and the Make in India vision. By continuously strengthening its engineering and service capabilities, Premium Group remains focused on delivering solutions that are designed in India, built in India, and trusted globally.

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Beyond the Blue: Implementing Absolute Analytical Inspection for Involute Worm Gears

- By Aroop Kumar Sen

This article is based on the pioneering research and development conducted by the Design Unit at the University of Newcastle upon Tyne, home to the UK's National Gear Metrology Laboratory. The primary research was spearheaded by J. Hu and R.C. Frazer, experts in analytical gear measurement, alongside J.A. Pennell. Their work has been instrumental in transitioning worm gear inspection from subjective contact marking to absolute, traceable CNC standards.

For decades, the production of involute worm gears has been a cornerstone of the power transmission industry. Yet, while manufacturers of spur and helical gears have long enjoyed standardised analytical inspection, worm gear producers have traditionally relied on "contact marking"—a process that often feels more like an art than a science.

As precision requirements tighten, moving from "matching a pattern" to "measuring a geometry" is no longer a luxury; it is a necessity for the future of gear technology.

While the involute worm itself is essentially an accurate screw thread and relatively simple to measure, the mating worm wheel presents a far more complex geometric challenge. Unlike parallel-axis gears, a mechanical inspection machine for worm wheels was historically considered unfeasible due to the intricate, non-linear nature of the tooth flank.

The Traditional "Trial and Error" Cycle

Worm wheel manufacturers have traditionally used a contact marking test procedure:

1. **Master Creation:** A "standard" worm is manufactured and verified for accuracy.
2. **Initial Cut:** A hobbing machine cuts the worm wheel using nominal calculated data.
3. **The Blueing Test:** The gear pair is meshed, and the worm is coated with soft marking blue to visualise the contact pattern and check backlash.
4. **Subjective Adjustment:** If the pattern is unsatisfactory, the operator adjusts the hobbing machine based on experience rather than theoretical knowledge and re-cuts the wheel.

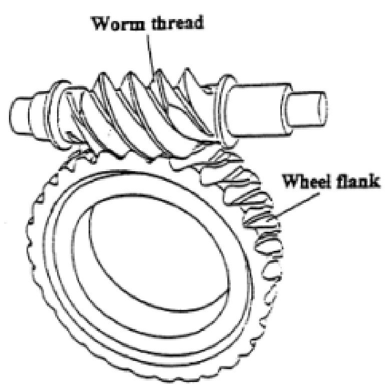
This process is repeatable but lacks diagnostic power. It cannot identify whether an error stems from the profile, pitch, or lead, making it nearly impossible to determine the true source of manufacturing deviations.

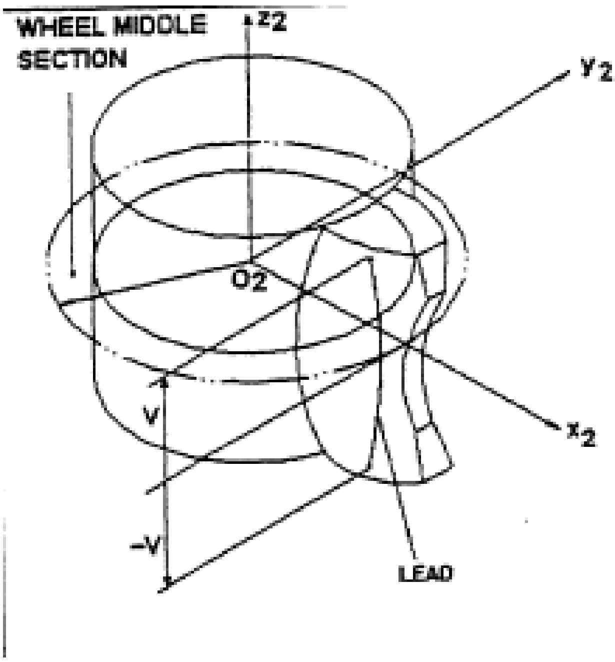
The New CNC Analytical Procedure

Developed at the University of Newcastle upon Tyne and validated at the UK's National Gear Metrology Laboratory, a new procedure allows for the absolute measurement of worm wheels. Unlike comparative measurements that merely check a part against a "master," this method inspects the wheel against its theoretical tooth form.

1. Defining the Mathematical Model

Before measurement begins, a kinematic model generates the theoretical tooth surface. This





model effectively simulates the manufacturing process, replacing the cutting tool geometry with the mating worm's geometry.

2. Simplified Inspection Strategy

The Mathematical Foundation of the Lead Curve

The core innovation of this absolute measurement method lies in how the software derives the theoretical tooth form. Unlike parallel-axis gears, the lead of a worm wheel is not a simple helix; it is defined by two primary factors:

- The Intersection Curve: The system calculates the 2D curve produced by the intersection of the worm helicoid with the pitch plane.
- Kinematic Rolling: This curve is then "rolled" around the pitch cylinder by calculating the corresponding rotation of the worm wheel.

By defining this spatial trajectory, the CNC probe can move simultaneously across linear and rotary axes to measure the resulting curve with absolute precision.

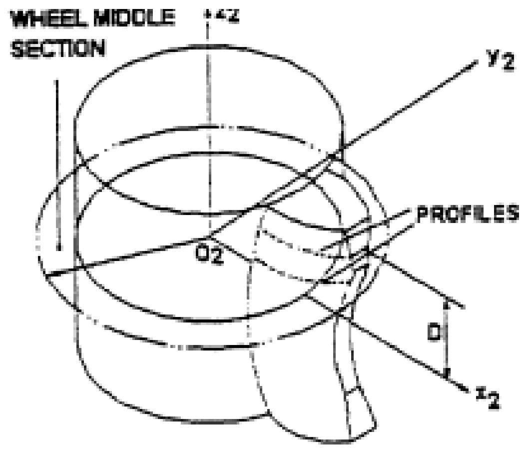
Measuring the total topography of the tooth would be too time-consuming. Instead, the procedure focuses on two critical areas:

- **Profile Errors:** Measured in user-defined transverse sections. Because worm wheel profiles vary significantly from section to section, multiple sections are typically inspected—a departure from standard spur gear methods.
- **Lead Errors:** Measured specifically at the worm wheel pitch cylinder. The software calculates the curve produced by the intersection of the worm helicoid with the pitch plane, then moves the CNC probe along that spatial trajectory.

Quantifying Precision: Data and Validation

The reliability of this CNC procedure is backed by rigorous validation using a standard 4-axis machine, such as the Gleason GMS 430.

- **Machine Uncertainty:** The Gleason GMS 430 maintains a calibrated uncertainty (U95) of ±1.5µm for profile and ±1.8µm for lead measurement.
- **Axial Datum Sensitivity:** Accuracy is highly dependent on the axial datum; a given error here results in an approximate 40% error in the lead measurement. To solve this, researchers bonded a calibrated ball to the datum, allowing it to be probed in the transverse plane for high-accuracy height determination.
- **Stylus Consistency:** Lead error results obtained using 1mm and 2mm diameter probes differed by less than ±1µm per 50mm face width, proving the robustness of the geometric calculations.
- **Torsional Wind-up:** When measuring large wheels, static friction can cause a 2µm ripple in the trace. This is mitigated by applying a ±2µm null-band range to the probe and filtering the signal.

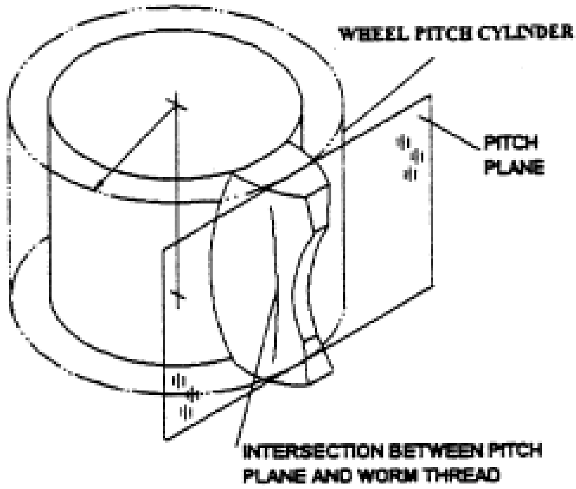


Diagnostic Power: A Case Study

Overcoming Mechanical Interference

While the mathematical model provides the theoretical path, physical mechanics introduces challenges during the measurement of large-diameter wheels.

- **Torsional Wind-up:** Static friction during the "nulling" of the probe can cause high-frequency ripples of approximately ±2µm on the lead error trace.
- **The Null-Band Solution:** To maintain validity without



affecting the measured result, a "null-band" range of ±2µm is applied to the probe.

- **Residual Accounting:** The residual probe reading is then accounted for as part of the measurement process, ensuring that the filtered signal accurately reflects the true gear geometry rather than system friction.

The true value of analytical data is demonstrated in troubleshooting. A passenger lift drive exhibited excessive noise and vibration. While traditional marking might show a poor pattern, the CNC inspection revealed large profile errors.

The data identified this as a tooling error (a faulty hob) rather than a design flaw. After the hob was re-ground and a new wheel manufactured, profile and lead errors were significantly reduced, and the lift operated within acceptable noise levels. This type of precision diagnosis is impossible with contact marking alone. (Hu et al., 1997).

Conclusion

Analytical measurement allows manufacturers to finally quantify the accuracy of worm wheels. By eliminating the confusion caused by previously unquantifiable errors, shops can optimise process capability, verify accuracy traceably, and significantly reduce the time spent on manual "trial and error" adjustments.

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MPMA Announces New Board, Officers, and More for 2026–2027

- By Gear Technology India

The Motion + Power Manufacturers Alliance (MPMA) today announces new Board, Officers, and other leadership changes for 2026–2027.

Joining the Board of Directors are Michael Kapp, General Manager of KAPP NILES and Jared Scott, National Training Manager, SEW-Eurodrive. MPMA members elected the two leaders at their Annual Meeting, held April 23-26 at the Sunseeker Resort in Port Charlotte, FL. They will begin their three-year terms at the August 2026 Board Meeting.

"We welcome Michael and Jared to the MPMA Board and look forward to their leadership as we continue to navigate an ever-changing power transmission industry," noted Jenny Blackford, President of MPMA. "These are the first additions to the Board following our May 1 merger between AGMA and ABMA, and we are excited to have them with us, ready to move forward."

In addition, the Board of Directors had voted for its Executive Committee Officers to serve two-year terms beginning on April 26; the Officers for 2026–2027 included:

Chair: Steve Janke, President, Brelie Gear

Treasurer: Alejandro Pardinas, President & CEO, Atlantic Bearing Services

Past Chair: Sara Zimmerman, VP, Customer Experience and Product, Sumitomo Drive Systems

Business Division: Michelle Maddox, Sales Director, B&R Industrial Gear and Machinery

Technical Division: Jason Daubert, Chief Engineer, Fuller

At Large: Brian Parsons, President and CEO, NSK Americas

"I look forward to stepping into the Chair role and appreciate all that Sara Zimmerman has done to connect the merged groups as she closes her year as Chair," notes Steve Janke, MPMA Chair and President of Brelie Gear. "I have previously served on the Board, as well as Show Committee Chair, and will now enter into the Chair role with the passion and respect for this wonderful organisation that will enter its 111th year in 2027."

MPMA appreciates the commitment of its leadership.

From Iron to Intelligence: A Young Manufacturer's Perspective on Software-Defined Gear Manufacturing

- By Yash Bright

I knew the names of machines before I knew what they did. Growing up, visits to the warehouse and shop floor meant navigating rows of hulking equipment - gear shapers, hobbing machines, VTL's, shavers and grinders - that my father and grandfather moved around like furniture. I could identify a Sykes or a Pfauter or a Gleason before I could tell you what any of them produced. By the time I was fourteen or fifteen, component names, machine types, and the rhythm of a shop floor had settled into the back of my mind without anyone formally teaching me any of it. It came from growing up around people who took machines seriously.

Then one day I heard the term CNC. I did not fully understand what it meant at the time, but I remember sensing that the people around me were treating it as something significant - a shift, not just a feature. Years later, having completed my postgraduate studies in the UK and come back to enter the business properly at 25, I understand what they meant. The industry was not just getting new machines. It was getting a new way of thinking about what machines could do.

Our family business spans three connected activities: we manufacture precision gears, we trade in used industrial machinery, and we retrofit older machines with updated control systems. That last part - retrofitting - is where the CNC question becomes most interesting. Because what we keep discovering, across every machine we rebuild and every customer we work with, is that the mechanical structure is rarely the limiting factor. What limits a machine is almost always the intelligence sitting behind it.

The Real Constraints Facing the Manufacturing SME

Before discussing the opportunity, it is worth being honest about the environment most small and mid-size manufacturers are actually operating in.

The first constraint is space. Most shops in this industry work out of facilities built thirty or forty years ago. There is no practical room to keep acquiring dedicated machines for every new job type that comes in.

The second is capital. New CNC gear cutting equipment is a significant investment that the ROI calculation for a short-run, mixed-specification order book rarely justifies. Most SMEs hold onto older machines far longer than industry brochures would suggest - not out of stubbornness, but out of commercial sense.

The third constraint is the one that gets discussed least: the disappearing machinist. Not just in terms of numbers, but in terms of depth. Setting up a conventional gear machine - selecting the right arbors, configuring spindle speeds, calculating change gears, dialling in the job from scratch - is a skill that took years to develop and is now genuinely rare. My father's generation understood these machines from the inside out. They did not just operate them; they could read them, argue with them, coax them into doing things the manual did not describe. That knowledge passed from person to person on the shop floor - never written down because it never needed to be. Today that chain of transfer has largely broken. Young people are willing to work CNC machines, and they are often good at it. But the foundational understanding of what is happening mechanically underneath the control interface is fading. When that generation retires, a very specific kind of knowledge goes with them.

These three pressures together - limited space, constrained capital, and a thinning skilled workforce - define the operating reality for most manufacturing SMEs today. Any honest conversation about where this industry is going has to start from here.

The Brain, Not the Body

Sitting across all three sides of the machine - manufacturer, trader, retrofitter - makes one thing very clear: for a large class of machines, the mechanical structure is not the limiting factor. What limits them is the control architecture.

The most visible example of this is the change gear. On a conventional gear shaper or hobbing machine, setting up a job meant physically selecting and mounting the correct combination of change gears to achieve the required cutting ratio, feed rate, and differential movement. It was a skilled, time-consuming process - and getting it wrong meant scrapped parts or worse. Today, a CNC retrofit replaces that entire mechanical calculation with software-defined axis control. The cutting ratio, the feed, the differential - all programmed digitally, recalled in seconds, repeatable to the same parameters every time. What once took an experienced setter an hour now takes minutes, without requiring the same depth of mechanical intuition.

Beyond change gears, CNC and PLC retrofits are automating axes that were previously manual or semi-manual - radial infeed, tangential feed, stroke length, cutter relief - bringing them under closed-loop software control. The practical result is significant on two levels.

Quantitatively this means faster changeovers, reduced setup time, higher utilisation, and fewer scrapped parts. Qualitatively it means consistent repeatability, stored job programs, and a machine that a competent CNC operator can run across a broad range of work without needing twenty years of mechanical experience.

A Sykes Gear Shaper that was once limited to a narrow operational range by its mechanical configuration can, with the right CNC retrofit and software programming, handle internal gears, external gears, step-gears, segment gears, helical gears and racks on the same platform - within the same floor footprint, with minimal changeover time between jobs. The iron has not changed. The capability envelope has expanded dramatically.

Across our experience working with manufacturers in India and internationally, even the largest OEM manufacturers - companies with the capital to buy new equipment - are choosing to convert their existing mechanical machines into software-enabled platforms instead. The economics are straightforward. A comprehensive CNC or PLC retrofit typically costs in the region of one-fifth of what a comparable new machine would require. The ROI case is not difficult to make, and the industry is making it. Software adoption in legacy machinery is not a niche workaround. It is becoming the mainstream strategy. The software is now the product.

What Software Is Actually Changing

It is worth being specific about what this shift looks like at the machine level - because the word "software" can obscure more than it reveals.

Modern PLC and CNC retrofits are not simply replacing one control panel with another. They are fundamentally restructuring how a machine understands and executes a job. Multi-axis synchronisation - coordinating cutter stroke, rotary feed, and radial movement simultaneously - which once relied entirely on mechanical gear trains and operator feel, is now managed digitally with micron-level precision. Job parameters that previously lived in a setter's memory or a handwritten notebook are now stored as repeatable programs, transferable across shifts and operators. Real-time alarms, diagnostics, and feedback loops that conventional machines never had are now standard outputs of a well-executed retrofit.

The result is a manufacturing environment where quality is more consistent, throughput more predictable, and dependency on a shrinking pool of specialist mechanical knowledge significantly reduced. This does not mean the mechanical understanding becomes irrelevant - a retrofitted machine still requires people who know what it is doing physically. But it lowers the barrier enough that a broader base of operators can run a broader range of jobs, which is precisely what the current labour reality demands.

The direction is clear. The question for Indian manufacturers is not whether software will define the next generation of gear production - it already is. The question is how quickly businesses recognise that the machine they already own, rebuilt with the right intelligence, may be exactly what they need to compete in it.

The author is a fourth-generation professional working across gear manufacturing, industrial machinery trading, and CNC retrofitting, with experience across Indian and European manufacturing markets.

Yash Bright Marketing and Operations Head;

JK Gears and Machinery & Kunark Hitech Machining

Forest City Gear Promotes Schreiner to Floor Inspection/First Piece Inspector

\- By Gear Technology India

Forest City Gear promoted Emmajean Schreiner to floor inspection/first piece inspector for the ID/OD and Secondary Departments.

Schreiner joined Forest City Gear in July 2025 as a Hobbing operator on third shift, where she quickly demonstrated a sharp attention to detail and a natural instinct for quality.

In her new role, Schreiner will be on the front lines of quality assurance, verifying that parts meet internal standards and customer requirements before production runs full speed ahead. By inspecting first pieces and monitoring work directly on the floor, she helps identify potential issues early, reducing risk and ensuring compliance every step of the way.

"Emmajean has an eye for quality and a drive to learn new things," Quality Assurance Manager Amy Sovina said. "Having her on the floor will help catch issues early and ensure compliance to both our internal and customer requirements."

Precision Under Pressure: Navigating the New Realities of Gear Manufacturing

- By Neha Basudkar Ghate

Krishnan Sreenivasan
CEO
INDWEL Precision Gears Private Limited

At a time when precision, reliability, and adaptability define the future of gear manufacturing, few voices capture the industry's evolving realities as clearly as Krishnan Sreenivasan, CEO of INDWEL Precision Gears Private Limited. In this insightful interaction with Gear Technology India, he offers a ground-level yet strategic perspective on how manufacturers are navigating increasing complexities—from supply chain disruptions and material transitions to ultra-tight tolerances demanded by defence, aerospace, and electric vehicle applications.

Drawing from years of hands-on experience in precision gear production, Sreenivasan highlights a clear shift in the industry's mindset—where process discipline, data-driven decision-making, and rigorous validation protocols are no longer optional but essential. Whether it is adapting to stricter aerospace specifications, maintaining DIN 2/3 accuracies in CNC hobbing and grinding, or managing distortion through advanced heat treatment processes, the conversation reflects a sector that is steadily moving towards higher accountability and technological maturity.

The interview also sheds light on the human side of this transformation. Upskilling the workforce, redefining operator roles, and building technical expertise around machine behaviour and inspection analytics have become critical to sustaining competitiveness. At the same time, evolving customer expectations—especially from global markets—are pushing Indian manufacturers to deliver not just precision components, but also robust, repeatable processes backed by statistical confidence.

From large-diameter gear manufacturing to micro-geometry control in aerospace pinions, and from hydraulic applications to high-speed EV gears, this discussion captures the breadth of challenges and innovations shaping the gear ecosystem today. It is a compelling read for industry professionals looking to understand how experience, discipline, and forward-thinking leadership are coming together to redefine precision engineering in India.

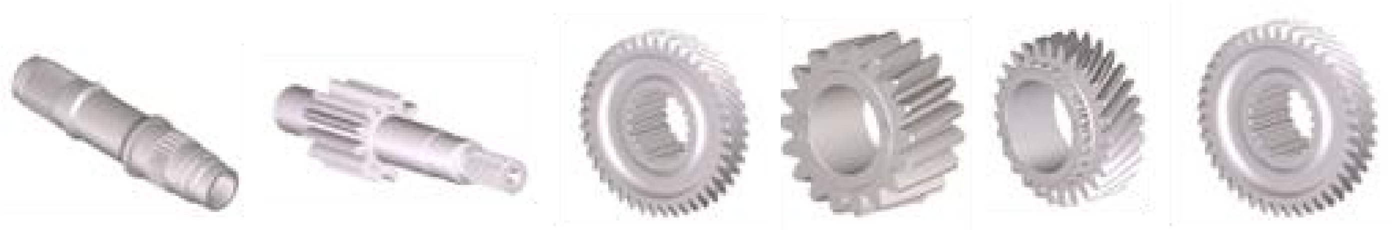
Q1. What strategies are helping the gear sector handle supply chain disruptions for carburised blanks right now?

The most significant change has been reducing dependence on a single source. Alternate suppliers, particularly local ones, have been developed to avoid long lead times. For critical blank sizes, buffer stock is maintained, and production planning has become more flexible so that operations continue smoothly even if one delivery is delayed.

Q2. How is the industry adapting production to stricter defence and aerospace specifications for helical gears?

Defence and aerospace requirements have compelled the industry to adopt far greater discipline in production. There is now a stronger focus on profile and lead control, case depth consistency, and managing post-heat-treatment distortion. Closed-loop machining and detailed gear inspection have become standard practices. Furthermore, any change, whether in process, tooling, or machinery, must undergo re-validation to ensure compliance with these stringent specifications.

Q3. What leadership approaches are shaping responses to lighter material trends in hydraulic gears across India?



Material changes are never rushed. Leadership decisions are primarily data-driven, with FEM analysis, fatigue life assessments, and NVH studies conducted before any material is introduced into production. New materials are phased in gradually, an approach that reduces risk while still achieving weight reduction targets.

Q4. How are gear manufacturers prioritising upskilling for advanced CNC hobbing amid demands for DIN 2/3 precision?

In the past, operators were primarily responsible for running machines. Today, the requirements are far more advanced. Operators must understand machine kinematics, electronic gearbox accuracy, and hob shifting. They are also expected to interpret inspection reports and make lead or profile corrections accordingly. Training now places significant emphasis on the thermal behaviour of machines, which has become a critical factor in achieving DIN 2/3 precision.

Q5. How do manufacturers balance capacity growth for large-diameter gears with quality in high-volume production?

Roughing and finishing are usually separated, which helps control deflection and cumulative error. Fixtures are reviewed thoroughly, and inspection processes are strengthened before increasing production volumes. Automation is introduced, where it enhances consistency, particularly in handling, but quality remains the highest priority at every stage.

Q6. What key lessons from scaling precision gear production apply to meeting defence sector demands today?

One clear lesson is the importance of process discipline. Once a process is qualified, it is frozen. Statistical process control on profile, lead, and runout is carried out continuously rather than on a sample basis. Any change in the 4Ms, i.e., man, machine, material, or method, triggers full re-validation. This level of rigour is exactly what defence customers expect.

Q7. How do years in gear manufacturing influence decisions on adopting sealed quench heat treatment for distortion control?

Experience has shown that sealed quench provides far better distortion control. Ovality, lead distortion, and size variation become more predictable under this process. The choice of sealed quench is not driven by the pursuit of higher hardness, but by the need for dimensional stability, which is far more critical in precision gear manufacturing.

Q8. What challenges from hydraulic pump gear projects stand out in balancing 5-axis hobbing with quality tolerances?

The primary challenge lies in maintaining flank accuracy. Even minor axis synchronisation errors can lead to waviness in the lead or pitch issues, both of which directly impact pump noise and efficiency. As a result, precise calibration and thorough tool path validation become critically important to ensure quality tolerances are consistently met.

Q9. How has experience with large-diameter gears up to 500 mm informed approaches to aerospace pinion customisation?

Work on large gears highlights the critical importance of stiffness and deflection control. The same principles apply to aerospace pinions. Although these components are smaller, alignment and rigidity matter more than size. Customisation in this context is primarily about precise micro-geometry control, which ensures performance and reliability under demanding aerospace conditions.

Q10. What shifts in workforce training for CNC gear grinding have you observed over your career in the sector?

Workforce training in gear grinding has undergone a complete transformation. Operators today are expected to focus on dressing strategies, burn prevention, and avoiding thermal damage. They must also be able to analyse inspection data and manage stock effectively. Importantly, grinding is now treated as a true finishing operation rather than a corrective step, reflecting the higher precision and discipline demanded in modern gear manufacturing.

Q11. How do supply chain realities in South India impact raw material choices for high-

volume spur gear runs?

Material consistency is the most critical factor. Variations in chemistry or poor cleanliness are immediately reflected as a distortion in the finished component. In many cases, reliable local suppliers outperform imports in terms of stability. For high-volume production, consistency and reliability take precedence over material cost, ensuring quality remains uncompromised.

Q12. What common pitfalls arise in profile shifting during high-helix gear shaving for automotive transmissions?

A frequent mistake is poor alignment between the cutter geometry and the required profile shift. Another common oversight is underestimating elastic deformation during the shaving process. Both issues can compromise flank form and lead to increased transmission noise. Once these errors occur, correcting them later becomes extremely difficult, making careful planning and validation essential from the outset.

Q13. How are export demands from European hydraulics clients influencing tolerance specifications below 5 microns?

At tolerance levels below 5 microns, every factor becomes critical. Temperature control, machine repeatability, and tool wear must all be managed with precision, as none can be overlooked. European customers place emphasis not only on results but also on process capability. In many cases, a Cpk value above 1.67 is expected, underscoring the need for consistent, high-quality production standards.

Q14. What role does vibration control play in achieving Ra 0.02 finishes on spur gears post-grinding?

At Ra 0.02, vibration control becomes absolutely critical. It is no longer limited to aerospace applications; even non-aerospace customers now demand such finishes. Spindle condition, wheel balance, dressing consistency, and fixture rigidity all play decisive roles. These controls must be applied consistently across customer programs to ensure the required surface quality is achieved.

Q15. How has the rise of electric vehicle gears changed module ranges in recent production planning?

Electric vehicle gears operate at much higher speeds, which has led to finer module ranges in production planning. Micro-geometry control and NVH considerations have become critical factors. Bias grinding is increasingly adopted to manage contact patterns and reduce gear whine, ensuring smoother performance and meeting the stringent requirements of EV applications.

Q16. What daily calibration routines on Kapp Niles machines help sustain DIN 3 accuracy over long runs?

Daily routines include checking master gears, verifying backlash compensation, and aligning dressing rolls. Machines are allowed to thermally stabilise before extended production runs, and probes are carefully calibrated. These practices are essential to sustaining DIN 3 accuracy consistently over long cycles.

Grinding Gets Smarter: AI's Expanding Role in Gear Manufacturing

- By Tushar Gupta, Director, S.S. Tools

The gear manufacturing industry has always been defined by precision. From automotive transmissions to industrial gearboxes, the performance of an entire system often depends on micron-level accuracy in gear geometry. For decades, manufacturers have invested in advanced machines, cutting tools, and metrology systems to achieve this precision.

Today, however, the industry stands at the threshold of a new transformation—AI-driven inspection.

While automation and CNC technologies revolutionised how gears are produced, Artificial Intelligence has the potential to redefine how they are measured, validated, and continuously improved. In our view, AI-driven inspection is not just an incremental upgrade—it is poised to become a foundational pillar of next-generation gear manufacturing.

The Growing Complexity of Modern Gear Systems

Modern applications, especially in electric powertrains and high-performance industrial systems, are pushing gears to operate under increasingly demanding conditions:

- Higher speeds and loads
- Lower noise and vibration requirements
- Compact and lightweight designs

These requirements translate directly into tighter tolerances, more complex geometries, and stricter quality benchmarks. Traditional inspection methods—though highly accurate—are often:

- Time-intensive
- Dependent on sampling rather than 100% inspection
- Limited in their ability to provide predictive insights

As production volumes increase and tolerances tighten, the need for faster, smarter, and more adaptive inspection systems becomes critical.

What AI-Driven Inspection Brings to the Table

AI-driven inspection systems go beyond conventional measurement. By leveraging machine learning algorithms and data analytics, these systems can:

- Detect patterns and deviations that may not be immediately visible through standard inspection
- Analyse large datasets across batches to identify trends
- Predict potential defects before they occur
- Enable real-time feedback into the manufacturing process

Instead of simply answering "Is this gear within tolerance?", AI shifts the question to:

"What is causing variation, and how can it be corrected proactively?"

This transition—from reactive quality control to predictive quality assurance—is where the true value lies.

The Often Overlooked Foundation: Process Consistency

While AI-driven inspection is powerful, its effectiveness depends heavily on one critical factor: the consistency of the manufacturing process itself.
In gear production, this consistency begins with the cutting tools.

Gear hobs, gear shaper cutters, shaving cutters, broaches, milling cutters, and master gears form the backbone of the manufacturing process. Each of these tools plays a specific role in defining geometry, surface finish, and functional accuracy. Any variation in tool performance—whether due to wear, profile deviation, or inconsistency—directly affects the final gear.

From an AI system's perspective, inconsistent tooling introduces noise into the data. This makes it harder to distinguish between:

- Natural process variation
- Tool-induced deviations
- Machine-related inaccuracies

Without a stable and predictable process, even the most advanced AI system cannot deliver reliable insights.

The Interplay Between Tooling and AI

This is where the relationship between precision tooling and AI-driven inspection becomes crucial.

For AI systems to function effectively, the manufacturing process must exhibit:

- High repeatability
- Stable tool performance over time
- Accurate and consistent geometry generation

When these conditions are met, AI can:

- Accurately identify micro-level deviations
- Correlate defects with specific process parameters
- Enable closed-loop corrections

For example:

- Variations detected in gear profiles can be linked back to tool wear patterns
- Trends in surface finish can indicate the need for tool reconditioning
- Dimensional drift can be traced to process instability

This creates a feedback loop where inspection is no longer the final step, but an integral part of continuous process optimisation.

Towards Software-Defined Manufacturing

AI-driven inspection is also a key enabler of what is increasingly being referred to as software-defined manufacturing.

In such environments:

- Machines, tools, and inspection systems are interconnected
- Data flows seamlessly across the production chain
- Decisions are driven by real-time analytics rather than manual intervention

Inspection systems evolve into intelligent nodes that:

- Continuously monitor output quality
- Feed data back into machine controls
- Support adaptive adjustments during production

However, the success of such systems depends on the reliability of every upstream element—especially tooling.

Our Perspective: Integrating with the Future of Manufacturing

At S.S. Tools, we see AI-driven inspection not as a standalone advancement, but as part of a larger transformation towards data-driven and interconnected manufacturing ecosystems.

As a company built on strong technical expertise across gear hobs, shaper cutters, shaving cutters, broaches, and master gears, our focus is on ensuring that tooling remains fully compatible with the evolving digital manufacturing landscape.

Our approach moving forward is centred around three key directions:

- **Enhancing Tool Consistency and Repeatability** Delivering tools that maintain profile accuracy and performance over extended production cycles, enabling reliable data generation for AI systems.
- **Supporting Process Stability** Working closely with customers to ensure that tooling contributes to stable and predictable manufacturing processes, which are essential for meaningful AI-driven insights.
- **Aligning with Data-Driven Manufacturing Practices** Understanding how tooling performance interacts with inspection data, and evolving our engineering approach to support closed-loop manufacturing environments.

Rather than viewing AI as separate from tooling, we believe the future lies in tight integration—where precision tools and intelligent systems work in alignment to achieve higher efficiency, accuracy, and predictability.

The Road Ahead

The gear industry has always evolved through the integration of new technologies—be it CNC machining, advanced coatings, or high-precision metrology. AI-driven inspection represents the next phase of this evolution. As manufacturing moves towards greater digitalisation, the ability to:

- Predict rather than react
- Optimise rather than correct
- Integrate rather than isolate

will define competitive advantage.

Conclusion

AI-driven inspection is set to become a transformative force in gear manufacturing. However, its success will not be determined by algorithms alone. It will depend on the strength of the underlying processes that feed these systems with reliable data.

From our perspective, the future lies in harmonising advanced inspection technologies with robust and consistent manufacturing practices. When precision tooling and intelligent systems work together, the result is not just better gears—but smarter, more efficient, and more predictable manufacturing.

And in that future, tooling will not just be a means of production—it will be a critical enabler of intelligent manufacturing.

HANNOVER MESSE 2026: Industry Points the Way to a Competitive Future

- By Gear Technology India

The manufacturing world gathered once again at HANNOVER MESSE 2026, where innovation, collaboration, and technological transformation took centre stage. Despite global economic uncertainties and travel disruptions caused by airline and public transportation strikes, the event reaffirmed its status as the world's leading industrial technology platform, attracting approximately 110,000 visitors from across the globe.

While attendance was slightly lower compared to the previous edition, the energy on the show floor and the quality of interactions demonstrated that industry stakeholders remain focused on one objective: building a smarter, more competitive, and sustainable industrial future. Around 40 per cent of visitors travelled from outside Germany, with strong participation from China, Brazil, the United States, Japan, and South Korea, underlining the truly international character of the exhibition.

According to Jochen Köckler, the event served not only as a technology showcase but also as a platform for inspiration and strategic direction for industry leaders worldwide. The message throughout the exhibition halls was clear — industry already possesses the tools required for transformation; the focus must now shift toward faster implementation and large-scale adoption.

AI, Automation and Robotics Lead the Industrial Transformation

One of the defining themes of this year's edition was the growing convergence of artificial intelligence, robotics, automation, and digitalisation. Exhibitors demonstrated how advanced technologies are increasingly being integrated into manufacturing environments to enhance productivity, reduce operational inefficiencies, and improve competitiveness.

Visitors witnessed AI-supported production systems capable of automating workflows, monitoring machine performance, and predicting failures before downtime occurs. Humanoid robots performing complex motion sequences highlighted the next stage of industrial automation, offering a glimpse into future production and service applications. Energy-efficient technologies and innovative grid infrastructure solutions also drew significant attention as industries continue their journey toward carbon neutrality.

The event attracted a strong lineup of global policymakers and industry leaders. German Chancellor Friedrich Merz and Brazilian President Luiz Inácio Lula da Silva were among the prominent dignitaries present at the exhibition. Industry leaders, including Roland Busch and Christian Klein also participated in discussions focused on industrial competitiveness, digital transformation, and the future of manufacturing.

Industry Calls for Faster Reforms

A recurring discussion throughout the exhibition was the need for improved regulatory conditions across Europe. Industry representatives highlighted concerns around rising operational costs, geopolitical uncertainties, and increasing regulatory complexities that are affecting industrial competitiveness.

However, the event also demonstrated that manufacturers are actively investing in advanced technologies and innovation-driven solutions to address these challenges. Exhibitors reported strong international interest, productive business discussions, and several concrete project opportunities during the fair.

Dr Gunther Kegel, President of the German Electrical and Digital Industry Association (ZVEI) and Chairman of the HANNOVER MESSE Exhibitor Advisory Board, praised the new exhibition concept and particularly highlighted the success of the Centre Stage platform. He emphasised the importance of reducing barriers and accelerating deregulation to strengthen Europe's position in industrial AI and advanced manufacturing technologies. Similarly, Thilo Brodtmann stated that the machine and plant engineering sector demonstrated remarkable resilience in responding to global industrial challenges. He pointed out that AI and humanoid robotics emerged as the defining technologies of the exhibition while stressing the importance of political support for industrial SMEs and long-term industrial reforms.

Brazil Strengthens International Cooperation

As the official Partner Country, Brazil played a significant role at the exhibition, showcasing its strengths in industrial manufacturing, energy, and digitalisation. The country positioned itself as a reliable global partner and a growing industrial market with strong collaboration opportunities for European and international companies. The participation of Brazil also reflected the increasing importance of diversified global supply chains and closer economic cooperation between Europe and Latin America. Organisers highlighted that the upcoming Mercosur agreement is expected to further strengthen trade relations and create new industrial business opportunities.

Enhanced Exhibition Experience

Beyond technological innovation, the 2026 edition also introduced several improvements to the exhibition format. The redesigned hall layout enabled smoother visitor movement and improved accessibility across the showgrounds.

New networking initiatives and Masterclass sessions received positive responses from both exhibitors and visitors. These compact knowledge-sharing sessions allowed companies to present practical solutions while engaging directly with potential customers and partners. The Center Stage platform emerged as one of the major attractions of the event, drawing nearly 30,000 visitors over the course of the exhibition. The platform hosted high-level discussions, presentations, and knowledge sessions focused on industrial transformation, sustainability, AI, and automation.

Looking Ahead to HANNOVER MESSE 2027

Building on the momentum of this year's edition, organisers announced several strategic developments for the next edition of the exhibition. One of the key additions will be "Europe Energy Week," organised in collaboration with dmg events. The initiative aims to bring together energy producers, industrial companies, infrastructure providers, and policymakers to accelerate discussions around Europe's energy future.

Another major change will be the revised exhibition duration. Starting from 2027, the event will run from Monday to Thursday, focusing on the days that traditionally attract the highest business activity and visitor engagement. Organisers believe this streamlined format will further improve efficiency and business opportunities for exhibitors and attendees alike.

Looking ahead, Jochen Köckler emphasised that the future direction of the exhibition will increasingly focus on the practical implementation of AI in industrial systems. The integration of artificial intelligence with real-world manufacturing processes and machinery is expected to shape the next phase of industrial evolution.

With its strong focus on innovation, collaboration, automation, and sustainability, HANNOVER MESSE 2026 once again demonstrated why it remains one of the most influential industrial trade fairs in the world.

Disclaimer: This event report has been compiled using official information and press materials provided by Deutsche Messe AG and the organisers of HANNOVER MESSE 2026. The content has been editorially adapted for publication purposes.

Supercool Neat 250 XL: Precision Cutting for Today's Gear Manufacturing Challenges

- By Kunal Marathe

Pratap Tex-Chem Pvt. Ltd. (PTCPL), based in Pune, has grown from a textile business founded in 1979 into a trusted multi-sector manufacturer of metalworking fluids, industrial lubricants, and speciality greases. Since its formal incorporation in 1999, the company has built a strong reputation for performance-driven solutions that serve both domestic and export customers across demanding industrial applications.

With a modern manufacturing setup, an annual installed capacity of 6000 KL and a used capacity of 4800 KL, PTCPL combines scale with technical depth. Its advanced facility, in-house R&D and tribology laboratory, and quality-focused production systems support continuous innovation in speciality fluids designed for real shop-floor conditions.

Backed by a team of more than 100 skilled professionals and a growing pan-India as well as international reach, PTCPL continues to focus on solutions that improve productivity, reliability, and process consistency. For manufacturers in gears, automation, e-mobility, and precision machining, this means a partner that understands both the technical and practical side of metalworking.

At the heart of Pratap Tex-Chem's growth is Lubeco Green Fluids, the flagship brand built for modern manufacturing needs. From metalworking fluids and neat cutting oils to rust preventives, VCI packaging, industrial lubricants, and surface cleaners, Lubeco delivers complete shop-floor support under one trusted name. With more than 150 product variants, it is designed to help manufacturers improve machining performance, protect components, and maintain cleaner, more efficient operations.

Lubeco®
GREEN FLUIDS

Lubeco®
FUTURISTIC GREASES

Alongside Lubeco Green Fluids, the company's other brands strengthen its presence across multiple industries. Lubeco Futuristic Greases brings nano-technology driven performance for high-temperature, high-load, wire rope, conveyor, open gear, and synthetic lubrication needs, while Fluidmate focuses on smarter oil management, sump cleaning, filtration, and fluid health. Together, these brands reflect PTCPL's approach of combining performance, reliability, and practical problem-solving for demanding industrial environments.

FLUIDMATE®

SUPERGEN®
Automotive Lubricants

PTCPL also serves the automotive sector through Supergen, a brand built to meet the needs of OEMs, fleets, and dealers with engine oils, transmission and gear oils, coolants, brake fluids, and speciality lubricants. In agriculture and dairy, Krushagra offers biofertilizers, biopesticides, dairy cleaners, water-soluble fertilisers, and micronutrients, helping users improve productivity while supporting cleaner and more sustainable practices. This broad portfolio allows the

KRUSHAGRA®
FARM SUPPLEMENTS

company to address the needs of industry, mobility, and agriculture with the same focus on technical quality and trust.

In gear manufacturing, the smallest detail can make the biggest difference. Whether it is gear hobbing, shaping, shaving, deep hole drilling, or sliding head operations, manufacturers are constantly looking for a cutting fluid that can keep pace with higher speeds, tighter tolerances, and increasing productivity demands. Supercool Neat 250 XL is designed for exactly this environment — where clean cutting, stable performance, and reliable tool support are not optional, but essential.

This synthetic neat cutting fluid is formulated from GTL base oils with specially designed ester additives, giving it a strong balance of boundary lubrication and cooling performance. Unlike conventional mineral oil-based cutting fluids, Supercool Neat 250 XL is mineral oil-free, low viscosity, and built with a high viscosity index, which helps maintain performance even under demanding cutting conditions. For manufacturers working with modern gear processes and precision components, that translates into smoother machining and better control over heat generation.

One of the key strengths of Supercool Neat 250 XL is its versatility across critical applications. It is suitable for deep hole drilling, thread tapping, rolling, turning, fastener manufacturing, gear hobbing, cutting, shaping, shaving, mist lubrication, and bar cutting in sliding head machines. In practical terms, that means one fluid can support multiple shop-floor operations while helping reduce the need for frequent product changes and process interruptions.

What makes this product especially relevant for gear and transmission manufacturers is the way it supports clean and stable machining. Its excellent heat transfer property helps control temperature during cutting, while its low viscosity improves fluidity and chip removal. The fluid also offers almost zero smoke formation, which improves operator comfort and helps maintain a cleaner work environment around the machine. The clear-to-pale yellow appearance gives better workpiece visibility, which is always valuable when precision and inspection matter. Another important benefit is its smooth cutting action. By reducing vibration and noise levels, Supercool Neat 250 XL supports more stable machining, especially in high-speed and precision applications. Its non-sticky nature also helps minimise carry-over losses, while excellent thermal stability supports longer and more consistent performance in the system. For shops looking to improve productivity without compromising cleanliness or operator ease, these features create a meaningful difference.

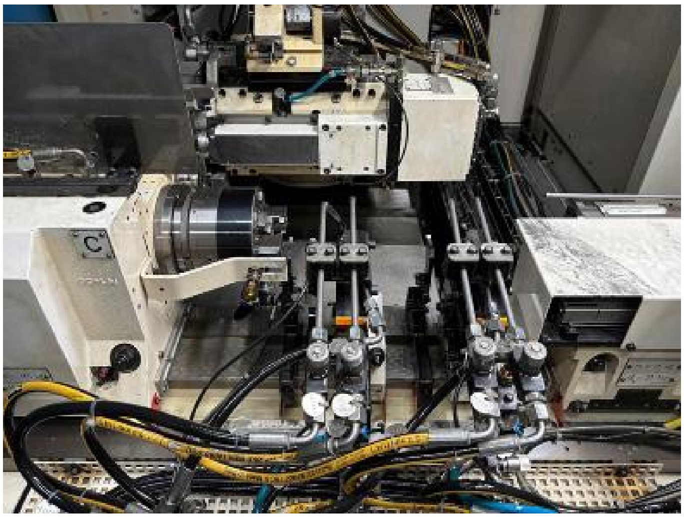
In the end, machining is not only about removing metal. It is about protecting tools, maintaining accuracy, improving finish quality, and creating a smoother experience for the people running the machines every day. Supercool Neat 250 XL brings that mindset into one fluid — practical, clean, and engineered for the pace of modern gear production.

Success Story: Bringing Stability to Precision Grinding

In precision grinding, small process variations can create big problems. For manufacturers supplying the gear and power transmission industry, even a slight rise in noise, vibration, or surface inconsistency can lead to rejection at the quality stage and affect customer confidence. One leading multinational manufacturer of precision camshaft components in Pune faced exactly this challenge while grinding on advanced German grinding machines.

During final inspection, several components were failing the Noise Analyser test due to values crossing the acceptable range. This created pressure not only on production output but also on export-quality acceptance. After closely studying the grinding process, machine behaviour, and fluid performance, the application team identified the need for a more stable lubrication chemistry that could support both cooling and boundary lubrication under high-precision conditions.

That is where SUPERCOOL NEAT 250 XL made the difference. Developed as a synthetic neat cutting fluid with GTL base oils and specially designed ester additives, it was implemented after detailed trials to improve EP lubricity, process stability, and grinding consistency. The result was a more controlled machining environment with better surface finish, reduced residue formation, and improved cleanliness around the machine.



Machine Fixture Cleanliness

Results That Mattered

Machine Electrical parts Cleanliness

The impact was visible on the shop floor and in QC. With SUPERCOOL NEAT 250 XL, the customer achieved better grinding stability, lower noise analyser rejection levels, and more consistent acceptance in the required QC range. The process also became more reliable during continuous production cycles, helping reduce rework pressure and support smoother output.

Key improvements included:

- Better process stability during precision grinding.
- Reduced rejection risk in Noise Analyser testing.
- Improved surface finish and machining consistency.
- Cleaner machines with lower residue build-up.
- Stable performance in continuous production conditions.

Why This Matters

Today's manufacturing environment demands more than just cutting performance. It requires fluids that support precision, cleanliness, and repeatability — especially in applications like gear grinding, camshaft grinding, carbide grinding, honing, and high-speed machining. SUPERCOOL NEAT 250 XL fits this need by helping manufacturers move closer to consistent quality without compromising productivity.

For industries moving toward automation and e-mobility, this kind of fluid support is no longer optional. It becomes a practical contributor to component reliability, lower rejection rates, and better process control. SUPERCOOL NEAT 250 XL is built with that reality in mind — helping manufacturers keep quality stable when the margin for error is extremely small.

For more information or technical support, write to info@lubecogreenfluids.com or visit www.lubecogreenfluids.com.

Kunal Marathe

CEO & Director

Pratap Tex-Chem Pvt. Ltd

SECO/WARWICK Strengthens Iberian Heat Treatment Capabilities with Advanced Vacuum Furnace Delivery

- By Gear Technology India

Portugal: In a significant development for the European heat treatment sector, SECO/WARWICK has delivered a state-of-the-art Vector single chamber vacuum furnace to Treatnorte. The system, equipped with FineCarb technology and low-pressure carburizing (LPC), marks a major step in enhancing advanced heat treatment capabilities across Portugal and Spain.

This delivery is one of two vacuum furnaces ordered by Treatnorte and represents a strategic investment aimed at strengthening regional industrial infrastructure. The furnace will primarily support tool steel heat treatment while enabling a wide range of precision-driven applications.

Advanced Technology for High-Precision Processing

The medium-sized Vector furnace is designed to offer maximum process flexibility. Its round heating chamber allows for the treatment of relatively large components, while its integration of high-pressure gas quenching (HPGQ) up to 15 bar and LPC technology enables complete and efficient heat treatment cycles.

Engineered for precision, the system ensures excellent temperature uniformity, convection heating at lower temperatures, and directional cooling—critical factors for maintaining dimensional accuracy in complex geometries.

At the core of this solution is FineCarb technology, a modern low-pressure carburizing method carried out in a vacuum atmosphere. By introducing carbon in controlled pulses, the process delivers superior layer uniformity, reduced distortion, and shorter cycle times compared to traditional carburizing techniques.

According to Maciej Korecki, "FineCarb enables precise shaping of the carbon profile in carburized layers, ensuring optimal performance for high-precision components such as gears, shafts, and pins. Additionally, its environmentally friendly design, with no open flame and reduced gas consumption, aligns with modern sustainability goals."

Expanding Capabilities with PreNitLPC

The furnace supplied to Treatnorte also includes PreNitLPC pre-nitriding technology, further broadening its processing capabilities. This addition allows for tailored surface layer properties, making the system suitable for a diverse range of industries—from tooling and stamping to high-fatigue automotive components.

Paweł Okińczyc emphasised that the configuration was selected to support Treatnorte's long-term growth. "A furnace with a comprehensive package of options not only meets current production needs but also creates opportunities to expand service offerings in the future," he noted.

Boosting Iberian Market Competitiveness

Founded in 2021 and headquartered in Celorico de Basto, Treatnorte has rapidly emerged as a technology-focused partner for precision engineering and the automotive sectors. The company's ongoing investments, supported by the InovMetalTreat project co-financed by European Union funds, aim to establish a modern and competitive heat treatment facility.

Commenting on the development, Nuno Carvalho stated, "The ability to perform vacuum hardening and carburizing in-house enhances our operational independence, shortens supply chains, and ensures better quality control. This technology positions us to secure more demanding projects in both Portugal and Spain."

A Milestone for Regional Modernisation

The introduction of LPC technology in Portugal signals a broader shift within the European heat treatment landscape. Once limited to large industrial players, advanced vacuum carburizing solutions are now becoming accessible to agile regional companies.

For SECO/WARWICK, the project underscores its role not just as an equipment supplier, but as a partner in technological development. The deployment of the Vector furnace with FineCarb is expected to serve as a benchmark for the Iberian market, accelerating the adoption of high-efficiency, environmentally sustainable heat treatment solutions.

As regional players like Treatnorte embrace advanced technologies, the Iberian Peninsula is poised to elevate its position within Europe's competitive manufacturing ecosystem.

Regal Rexnord Announces Aamir Paul as Next CEO

- By Gear Technology India

Regal Rexnord Corporation recently announced that its board of directors has appointed Aamir Paul to serve as chief executive officer (CEO) commencing no later than July 1, 2026, upon the conclusion of his responsibilities with his current employer, Schneider Electric SE. The board has also determined that Paul will serve as a member of the board of directors effective upon the commencement of his employment with the company, with an initial term continuing until the company's 2027 Annual Meeting of Shareholders.

As previously disclosed on October 29, 2025, the board initiated a comprehensive search to identify a successor to current CEO, Louis Pinkham. To help ensure continuity and a smooth leadership transition, Pinkham will remain CEO until Paul's start date, at which time Paul will succeed him. Pinkham will also resign from the board of directors effective on his last day as CEO.

Paul, age 48, is a recognized leader with deep global experience across sales, strategy, and operations management having lived and worked in Europe and the U.S. He joins Regal Rexnord from Schneider Electric, a leading global energy management and automation company, where he serves as president of North America. Paul took over the North America business in 2022, at which time he also joined the executive committee, and proceeded to grow the business at double digit rates through 2025. In 2025, the business generated over $17 billion (USD) in revenue, employed over 43,000 people, and ran over 35 manufacturing facilities.

Paul joined Schneider Electric in 2013 and, during his tenure, held multiple senior leadership roles of increasing responsibility across sales, business operations, and commercial execution. Prior to Schneider Electric, Paul spent over 13 years at Dell Technologies in sales roles with increasing seniority, ultimately serving as senior vice president, global server solutions sales, where he led Dell's worldwide go-to-market strategy for servers and oversaw global sales for Data Center Solutions and High-Performance Computing.

"After a comprehensive search, the board concluded that Aamir is an exceptional leader who is well-prepared to guide Regal Rexnord through its next phase of growth" said Rakesh Sachdev, non-executive chairman of Regal Rexnord's board of directors. "The board is excited about many aspects of Aamir's background, but in particular, his long track record driving growth across complex global businesses, his commitment to building strong teams and developing talent, his ability to foster an innovation culture, and his deep experience in the core strategic Regal Rexnord growth markets, including data center and discrete automation. He also brings a strong appreciation for how leadership in energy efficiency and sustainability creates long-term value for a company's key stakeholders."

Sachdev continued, "On behalf of the Board, I want to again thank Louis Pinkham for his outstanding leadership and many contributions to Regal Rexnord. Part of Louis's enduring legacy will be the strength of Regal Rexnord's values, talent, and transformed portfolio, which we believe position the Company well for continued success. We wish him the very best in his future endeavors."

Added Paul, "As I have come to know Regal Rexnord, I have become increasingly excited about the tremendous growth potential of the Company's portfolio, its unique scale and scope, and its market-leading technologies. I look forward to further capitalizing on Regal's 80/20 operating philosophy to drive continued focus, execution, and value creation across the enterprise. I am eager to work with the talented team at Regal Rexnord and leverage my commercial and operational experience to help ensure the Company maximizes its full potential for its customers, its people, and its shareholders."

Paul holds a B.S. in chemical engineering from Northwestern University and has completed advanced management studies at The University of Chicago Booth School of Business and INSEAD. He serves as a board member of USG Corporation, a privately held manufacturer of building materials and innovative solutions. He is also actively involved in industry and civic leadership, serving on the boards of organizations including the National Association of Manufacturers (NAM), the National Electrical Manufacturers Association (NEMA), the National Association of Electrical Distributors, and the Executives' Club of Chicago.

Lubrication Starvation in High-Speed Gears: CFD-Based Insights into Oil Flow Behaviour

- By Sudhanshu Nayak

The automotive landscape is undergoing a silent but violent mechanical shift. In the era of the internal combustion engine (ICE), gearboxes rarely had to manage input speeds exceeding 7,000 to 8,000 revolutions per minute (RPM). Today, the electric vehicle (EV) revolution has rewritten the rulebook. Modern EV traction motors routinely spin at 15,000 to 20,000 RPM, and the next generation is pushing toward 30,000 RPM.

At these hyper-velocity speeds, the physical behaviour of both the gearset and the oil inside the transmission changes entirely. The gears no longer just spin; they act like high-powered centrifugal fans. The air inside the gearbox becomes a dense, fast-moving barrier, and the lubricating oil transforms from a helpful fluid into a chaotic mix of flying droplets, mist, and foam.

This environment breeds a hidden and catastrophic enemy for transmission engineers: lubrication starvation. When oil fails to reach the critical gear mesh points, friction spikes, temperatures soar, and microscopic surface failures quickly cascade into total mechanical breakdown. To combat this, engineers have turned to Computational Fluid Dynamics (CFD), a technology that provides "x-ray vision" into the chaotic storm of a high-speed gearbox.

This article explores the mechanics of lubrication starvation, the complex battlefield of air-oil interaction, the limitations of old design rules, and how advanced CFD is reshaping the architecture of modern EV gearboxes.

The Anatomy of Starvation in Compact EV Gearboxes

To understand lubrication starvation, we first must understand the job of oil in a high-speed gear mesh. The oil must form a microscopic barrier, an elastohydrodynamic film, between two metal teeth crashing together under immense torque. This film is thinner than a human hair, but it carries the entire load of the vehicle's acceleration. Furthermore, in high-speed applications, oil acts primarily as a coolant, carrying away the intense heat generated by friction.

Why EVs are Uniquely Vulnerable

In a traditional, lower-speed gearbox, engineers could rely on "splash lubrication." The bottom gears sit in a bath of oil, and as they spin, they splash the fluid around the casing, naturally coating the upper gears and bearings.

In a compact EV gearbox, splash lubrication is a liability. At 20,000 RPM, dragging a gear through a bath of oil creates massive "churning losses", a form of fluid drag that robs the vehicle of battery efficiency and range. It also whips the oil into a thick foam, drastically reducing its ability to lubricate and cool.

To solve this, EV gearboxes are highly compact and utilise "dry sump" or targeted injection systems, where oil is sprayed directly at the gears through pressurised jets, and the bulk oil is quickly scavenged away from the spinning components.

Defining the Starvation Zone

Starvation occurs when these targeted oil jets fail to penetrate the gear mesh. A "starvation zone" is a localised area on the gear tooth flank where the oil film thickness drops below the critical minimum threshold.

Because EV gearboxes are designed to be extremely compact to save weight and space, the internal clearances are incredibly tight. This means heat is concentrated in a very small physical volume. If a starvation zone forms, the local temperature on the gear tooth skyrockets in milliseconds. This leads to "scuffing" (where micro-welds form and tear apart between the teeth) and "micro-pitting" (where the hardened surface of the gear fatigues and flakes away). Once starvation begins, catastrophic failure of the EV transmission is only a matter of time.

Oil Jet Dynamics and the Air-Oil Battlefield

If starvation is the enemy, why not simply point an oil jet directly at the gear teeth and pump it at high pressure? The answer lies in the intense aerodynamic forces generated by high-speed gears. This is the phenomenon known as windage.

The Windage Barrier

Imagine a large industrial fan spinning at maximum speed. Now, imagine trying to spray a garden hose directly into the blades of that fan. The air rushing off the blades will catch the water, deflect it, and scatter it before it ever touches the metal.

This is exactly what happens inside a high-speed EV gearbox. The teeth of the gears act like fan blades, accelerating the air around them to near-hurricane velocities. This creates a high-pressure, high-velocity "air curtain" wrapping tightly around the perimeter of the gear.

Penetration Depth and Droplet Deflection

When an engineer points an oil nozzle at the gear mesh, they are firing a stream of fluid into this air curtain. As the oil jet leaves the nozzle, it begins to break apart into individual droplets due to the friction of the surrounding air.

If the velocity of the oil jet is too low, the aerodynamic drag from the spinning gear's windage will simply blow the oil droplets off course. The oil will deflect off the air barrier and hit the gearbox casing, completely missing the crucial mesh zone.

Even if the jet manages to pierce the air curtain, it faces the problem of centrifugal force. As the oil strikes the rapidly spinning gear tooth, the extreme rotational speed acts to immediately fling the oil outward and away from the root of the tooth. Ensuring the oil has enough kinetic energy to reach the deepest part of the gear tooth (the root) before being flung outward is known as achieving adequate "penetration depth."

The Out-of-Mesh vs. Into-Mesh Debate

Engineers must carefully decide whether to spray oil into the mesh (where the teeth are coming together) or out of the mesh (where the teeth are pulling apart).

- Spraying into the mesh is excellent for cooling, as the oil is forced directly into the friction zone. However, if too much oil is trapped between the teeth as they engage, it creates "squeezing losses," where the gears have to waste energy physically crushing the oil out of the way.
- Spraying out of the mesh avoids squeezing losses and is great for carrying away heat after the friction event. However, it requires the oil jet to fight against the air being expelled from the parting teeth, making penetration incredibly difficult.

Understanding this chaotic, multiphase battlefield of mixing air and oil is virtually impossible using traditional engineering mathematics.

The Old Guard vs. The New Standard: Empirical Design vs. CFD

For decades, transmission engineers relied on empirical design methods. These were formulas, charts, and rules of thumb built upon years of physical testing and historical data.

The Limits of Empirical Formulas

Empirical methods dictate jet placement and oil flow rates based on simple parameters like pitch line velocity (the speed at which the gear teeth are moving) and the physical geometry of the gears.

However, these formulas assume a relatively stable, predictable environment. They fall completely flat when applied to a 20,000 RPM EV motor. Empirical formulas cannot account for the complex, three-dimensional aerodynamics of the gearbox casing. They cannot predict how oil will bounce off a nearby structural rib, or how the air pressure will change dynamically as the vehicle accelerates. Relying on empirical data for hyper-speed EVs often leads to engineers over-engineering the oil pump "just to be safe," which wastes energy and reduces the vehicle's driving range.

Enter Computational Fluid Dynamics (CFD)

To truly understand high-speed lubrication, the industry has embraced CFD. CFD uses massive computational power to simulate the flow of liquids and gases in a virtual environment.

For gearboxes, engineers use a specific type of CFD modelling called the Volume of Fluid (VOF) method.

VOF is a multiphase modelling technique that allows engineers to track the boundary between two different fluids, in this case, the liquid oil and the gaseous air.

Instead of guessing where the oil goes, an engineer can build a 3D digital twin of the gearbox, set the gears to spin at 20,000 RPM in the simulation, and inject virtual oil. The CFD software calculates the pressure, velocity, and trajectory of millions of tiny control volumes within the gearbox.

The Power of Virtual Diagnostics

CFD allows engineers to see the invisible. Through colour-coded visual maps, they can literally watch the high-pressure air curtain form around the gears. They can trace the exact path of an oil jet, watching it deflect off the windage barrier. They can measure the precise percentage of oil that actually makes it into the gear mesh versus the oil that is wasted against the casing walls.

Most importantly, CFD highlights the starvation zones in red. It shows engineers exactly where the gear teeth are running dry, long before a physical prototype is ever cut from steel. This transition from “guess and check” physical testing to predictive virtual modelling has dramatically accelerated EV development timelines.

Design Implications for Gearbox Architecture

Armed with the insights provided by CFD, automotive engineers are fundamentally changing the physical architecture of gearboxes. The casing of an EV transmission is no longer just a structural box to hold the gears and bearings; it is a highly tuned aerodynamic environment.

Shrouding and Baffles: Managing the Air

Because CFD proved that windage is the primary enemy of jet lubrication, modern gearboxes are designed to manage the air as much as the oil. Engineers are implementing internal shrouds and baffles.

These are closely fitted metal or plastic shields that wrap around the spinning gears. By placing a shroud very close to the tips of the gear teeth, engineers can physically “strip” the high-pressure air curtain away from the gear before it reaches the oil jet. This creates a low-pressure wake, allowing the oil nozzle to fire its stream directly into the gear mesh without aerodynamic interference.

Strategic Jet Placement and Geometry

CFD has revolutionised nozzle design. Instead of standard circular nozzles, engineers are experimenting with flattened, fan-shaped nozzles that spread the oil precisely across the width of the gear face.

Furthermore, the placement of these jets is no longer dictated by where there is convenient space on the casing. CFD dictates the optimal angle of attack. Jets are often angled to match the velocity vector of the spinning gear, allowing the oil droplets to slip smoothly into the tooth spaces rather than crashing violently against the gear tips.

Active and Dry Sump Lubrication

To entirely eliminate churning losses and foaming, high-performance EVs are moving toward true dry sump architectures. The bottom of the gearbox casing is designed with complex, funnel-like geometries (optimised by CFD) to instantly catch and drain oil away from the spinning gears. Scavenge pumps actively suck the oil out of the casing, ensuring the gears never sit in a fluid bath.

The lubrication systems are also becoming active. Using electronic sensors and pumps, the vehicle can dynamically adjust the pressure and flow rate of the oil jets based on the current speed and load of the motor. At low speeds, the flow is reduced to save energy. During a high-speed highway pull, the system ramps up the pressure to guarantee penetration depth and prevent starvation.

Conclusion

The transition to high-speed electric mobility has pushed mechanical engineering into a new frontier. Speeds of 20,000 RPM and beyond have transformed the seemingly simple task of putting oil on a gear into a complex battle against extreme aerodynamic forces, windage, and centrifugal deflection.

Lubrication starvation is a silent, rapid killer of compact EV gearboxes, and the traditional, empirical rules of thumb are no longer sufficient to prevent it. By adopting advanced multiphase Computational Fluid Dynamics, engineers have gained the ability to visualise, understand, and control the chaotic air-oil interaction inside the casing.

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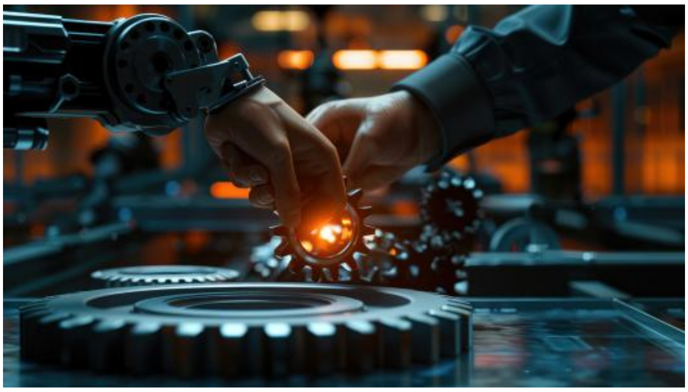
Detecting Micro-Defects in Gear Teeth Using AI Vision Systems: Where It Works in Indian Manufacturing

- By Neha Basudkar Ghate



In most Indian gear shop floors, inspection is a well-established, precision-driven process. CMMs, profile testers, and surface measurement instruments ensure that gears are within strict dimensional tolerances. In terms of geometry, the industry is extremely capable and conforms to worldwide standards.

However, the precision gear industry is facing a challenge that extends beyond geometry. Conventional inspection technologies do not always detect micro-defects such as grinding burns, micro-cracks, or early-stage pitting. These are surface-level, pattern-based anomalies that are typically found by eye inspection rather than organised measurement. And that's where the variation comes in.

In many setups, detection still depends on:

- Operator experience
- Visual inspection under magnification
- Judgement calls made under time pressure

This leads to an inconsistency that machines alone have not yet solved.

At the same time, manufacturing realities are constantly increasing pressure. Most gear makers in India use sampling-based inspection rather than 100% tests due to volume and time restrictions. While economical, this approach implies consistent quality across batches, which micro-defects do not always adhere to. What makes this more important today is the shift in application expectations. EV drivetrains, increased operating speeds, and export-driven quality requirements all reduce tolerance for tiny surface flaws. Despite these expanding expectations, AI-driven vision systems for gear inspection are still in their early stages in India. Adoption remains low, not due to a lack of understanding, but due to practical constraints such as data availability, integration issues, and uncertain ROI.

This results in a distinct industry gap. Inspection techniques are precise, but not yet scalable or consistent in detecting micro-level flaws. And, while AI vision is frequently presented as a solution, its role in the Indian gear industry is still evolving, not entirely proven, but also difficult to neglect.

What AI Vision Systems Actually Bring to Gear Inspection

If traditional inspection defines what to measure, AI vision adds a layer of what to notice. An AI vision system fundamentally follows an approach. There are only four characteristics that dominate and govern this system. High-resolution cameras scan gear surfaces; controlled lighting exposes subtle imperfections; machine learning algorithms are trained to detect problem patterns; and the system classifies parts in real time as defective or acceptable.

Notice how the system focuses on the pattern that produces the issue rather than the defect itself. This system does not alter the purpose of inspection but rather allows it to be performed on a vast scale.

In a usual gear shop, visual inspection is primarily dependent on the operator's attention span, experience, and consistency across shifts. AI removes that variability. It doesn't get exhausted, does not miss patterns, and doesn't see problems differently from batch to batch.

This brings three immediate shifts on the shop floor:

- Consistency: Every gear is evaluated against the same standard, every time
- Speed: Inspection can move in line with production, reducing bottlenecks
- Traceability: Each decision can be backed by image data, creating a digital quality record

More importantly, AI vision allows for 100% inspection without slowing down production, which is a challenge for traditional systems. But it's important to remain grounded here.

AI does not replace CMMs or profile testers. It does not change inspection standards. It fills a very specific need: standardising surface-level fault detection at scale. In that sense, AI vision is less about "automation" and more about giving consistency to what was previously changeable.

Where It Works and Where It Doesn't

The application of AI vision in gear inspection in India is not universal. It is extremely dependent on where and how it is used. It shows clear value in high-volume manufacturing settings, particularly automotive and EV components. These setups work with repeating geometries and common defect patterns, making them ideal for training and deploying vision models. In such production lines, inspection often creates a bottleneck, delaying throughput or limiting the transition to 100% inspection. AI systems can improve speed, uniformity, and constant monitoring without increasing the number of people.

The case becomes stronger for export-driven gear shops, where traceability and documented quality are non-negotiable. AI vision enables image-based records and standardised defect detection, helping reduce variability across batches and inspectors.

However, this relevance drops sharply in other parts of the industry. In low-volume or job-shop environments, where each gear may differ in size, geometry, or application, defect patterns are not consistent enough for AI systems to learn effectively. Similarly, many gear shops in India still operate under limited digital infrastructure, where data collection itself is a challenge, making AI deployment impractical.

Cost also plays a decisive role. In operations where rejection rates are already low and inspection is not a constraint, the return on investment for AI vision remains unclear. The takeaway is straightforward: AI vision is not a one-size-fits-all solution for gear inspection in India; rather, it is a focused tool that is only effective in certain production contexts.

The Reality Check: ROI, Challenges & The Way Forward

While AI vision is at times viewed as the next step in gear inspection, its adoption in India is dictated less by technology than by practical constraints on the factory floor.

The first barrier is data. Most manufacturers do not have structured, labelled image collections for problems. Without this, AI systems cannot be properly trained. The difficulty of integration is closely linked. A major part of the gear manufacturing industry still relies on old machinery with minimal digital connectivity, making it challenging to integrate vision systems into existing processes. On top of that, there is a talent gap not just in using AI tools, but also in understanding how to install and maintain them effectively.

Because of these factors, ROI becomes the deciding factor in the integration of AI vision in the Indian gear industry. To increase the relevance of AI vision in India, some factors must align first. The cost of defects or rejections is high, production runs are large and repetitive, and customers demand consistent, traceable quality.

In contrast, for smaller operations with stable processes and low rejection rates, the investment may not justify itself. The way forward, therefore, is not large-scale adoption but focused applications. Leading manufacturers are shifting to a more focused and practical strategy, focusing on specific defect types such as grinding burns or surface cracks, launching pilot projects on certain production lines, and progressively building useful data and internal capabilities.

This planned evolution reduces implementation risk while allowing AI systems to demonstrate their worth in real-world settings.

The direction is becoming clear, even if the speed is slow. The future of gear inspection does not remove human skill but rather adds it with machine consistency.

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Dunkermotoren Introduces Noise-Optimised E90R LN Spring-Applied Brake

- By Gear Technology India

With the redesigned E90R LN spring-applied brake, Dunkermotoren expands its brake portfolio with a solution that delivers quieter operation, precise control and uncompromising safety, even in the most demanding applications.

The E90R LN is based on the proven fail-safe principle: when de-energized, the brake engages automatically and securely holds the load. When power is applied, a magnetic field pulls the armature plate, releasing the braking force. This ensures maximum operational safety, particularly in the event of power failure or emergency stop scenarios.

As part of the latest design update, Dunkermotoren placed a strong focus on acoustic performance. A newly optimised driver design significantly reduces play between the driver and the armature plate. This minimises vibration and rattling, resulting in noticeably smoother and quieter operation. The improved acoustic behaviour enhances not only user comfort, but also the perceived quality of the entire drive system.

“In many modern machines, noise has become a decisive quality criterion – especially in sensitive environments such as medical technology," says Michael Burgert, product manager brakes at Dunkermotoren. “With the E90R LN, we offer a spring-applied brake that combines proven safety and durability with a clearly perceptible reduction in operating noise."

Thanks to its compact design, the E90R LN integrates easily into existing drive concepts. Typical applications include medical devices, automation and packaging machinery, conveyor systems and all applications where smooth motion, precision and acoustic comfort are essential.

With the noise-optimised E90R LN spring-applied brake, Dunkermotoren once again demonstrates how engineering precision, fail-safe functionality and user-oriented design come together to create reliable, high-quality drive solutions.


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