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COVER STORY- FEATURED INTERVIEW

GEAR METROLOGY: FROM INSPECTION TO EXCELLENCE

Featuring Prasad Kizhakel, Chief Sales Officer & Executive Board Member, Klingelnberg Group



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As we present **GTI Vol. 4, Issue 6, 2026**, we turn our focus to metrology, a critical pillar of precision gear manufacturing. This edition explores how advanced inspection technologies, digital solutions and intelligent manufacturing practices are strengthening quality, efficiency and reliability across the industry.

Our cover story features an exclusive interview with Mr Prasad Kizhakel of Klingelnberg Group, offering insights into how gear metrology is evolving beyond inspection to drive manufacturing excellence.

Alongside this, we bring you industry developments, technology updates, event reports, expert perspectives and a market outlook on India's potential in the global TBM supply chain.

Through every edition, Gear Technology India remains committed to connecting the supply and demand sides of the gear and power transmission industry, while bringing knowledge, innovation and opportunities closer to our readers.

Warm regards,





Sushmita Das
Associate Editor
Gear Technology India

Precision in gear manufacturing extends far beyond dimensional accuracy. It encompasses profile and lead deviations, pitch accuracy, surface integrity, runout, noise behaviour and the ability to maintain consistent quality across production batches. As gear systems become more demanding in terms of load capacity, efficiency, reliability and NVH performance, metrology is evolving from a final inspection function into an integral part of the manufacturing process.

In **GTI Vol. 4, Issue 6, 2026**, we explore this transformation through the lens of advanced gear inspection, measurement technologies and process optimisation. Our cover story with Mr Prasad Kizhakel, Chief Sales Officer & Executive Board Member, Klingelnberg Group, examines how modern metrology is enabling manufacturers to make informed process decisions, improve quality assurance and strengthen production performance.

This edition also looks at bevel gear measurement, intelligent machine monitoring, AI-driven manufacturing, grinding process optimisation and engineering software. Together, these developments reflect a shift towards data-driven manufacturing, where measurement results are increasingly used to understand process behaviour, identify deviations at an early stage and support continuous improvement.

For India's gear manufacturing ecosystem, the opportunity lies in integrating precision measurement with machining, heat treatment and finishing processes to achieve repeatability, traceability and global quality benchmarks.

At GTI, we remain committed to bringing these technical developments and industry perspectives to the forefront, supporting a more informed and competitive gear and mechanical power transmission sector.

Happy Reading!

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

PUBLISHER
Anitha Raghunath
anitha@virgo-comm.com

CONTENT CONTRIBUTOR
editorial@geartechnologyindia.com

ASSOCIATE EDITOR
Sushmita Das

TECHNICAL WRITERS
Nishant Kashyap
Neha Basudkar
Vishwajit Kothari
Sudhanshu Nayak
Vivek Singh

TECHNICAL EXPERTS
Soundararajan KP
Mahendran Muthu
Vishwajit Kothari

DESIGNER
Aneena AS

ADVERTISING, MARKETING & SALES
Raghunath G
raghu@virgo-comm.com | M: +91 98450 95803

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

ACCOUNTS
C Mahesh
accounts@virgo-comm.com

MANAGEMENT
Raghunath G
Matthew Croson



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

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Gear Metrology Moves Beyond Inspection to Drive Manufacturing Excellence:

An Exclusive Interview with Prasad Kizhakel, Chief Sales Officer & Executive Board Member, Klingelnberg Group



Prasad Kizhakel
Chief Sales Officer & Executive Board Member
Klingelnberg Group

Gear metrology is evolving from a final quality-checking process into a critical component of modern gear manufacturing, enabling manufacturers to improve precision, optimise production processes and maintain consistent quality. With the growing demands of electric mobility, automotive, aerospace and wind energy applications, advanced measurement technologies, automated inspection and data-driven quality management are becoming increasingly important to achieving higher productivity and tighter tolerances.

In this exclusive interview with Gear Technology India, Sushmita Das, Associate Editor, interacts with Mr Prasad Kizhakel, Chief Sales Officer and Executive Board Member, Klingelnberg Group, about the changing role of gear metrology, the impact of e-mobility on gear quality requirements, and the growing importance of closed-loop manufacturing and connected measurement systems. He also discusses Klingelnberg's technological innovations, the evolving capabilities of Indian gear manufacturers, and the growth opportunities emerging across India and Asia, including in robotics, humanoid systems and digital manufacturing solutions.



Klingelnberg Assembly Hall

1. How is gear metrology evolving from a final inspection process into an integral part of modern gear manufacturing?

Answer:

A fully finished gear is the result of good design, machine, workpiece, tool and process working together to produce desired quality. Contrary to the past where final inspection was primarily carried out to classify a part as OK or not OK, modern gear metrology drives optimisations in tools, machine settings, processes and, in some cases, the very design itself to ensure stable quality in production. I consider good metrology – the ability to measure with precision and consistency – central to stable quality in production and reliability in service.

Adoption of technology and the right inspection process thereof, to best accomplish these objectives, is increasingly decided by the end use of the component or the aggregate in consideration. Gear metrology evolved in lockstep with concomitant progress in design capabilities, invention of closed-loop manufacturing, transition from legacy ICE transmissions to E-mobility (NVH), ever-increasing service life on wind gearboxes and the eternal need to minimise cost of quality assurance. Emerging mega trends such as humanoids will drive further innovations and adaptations.

2. With its expertise in gear manufacturing and precision measurement, how is Klingelnberg Group helping manufacturers meet increasingly demanding quality and productivity requirements?

Answer:

This is a very good question, thank you. As I see it, Klingelnberg has dual responsibilities towards the market, firstly concerning productivity without compromising quality on the manufacturing side; secondly, precision in metrology without increasing the cost of quality assurance. I assure you, we take both responsibilities seriously. Conventional wisdom mandates that productivity and quality are inversely proportional. Every Klingelnberg product turns this conventional wisdom on its head.

Our bevel gear cutting and grinding machines have the best chip-to-chip time, thermal stability and ease of automation, all thanks to their vertical design. Our Speed Viper machines are capable of generating grinding at 100m/s and achieve the highest levels of quality for EV transmissions where form errors in the range of 2microns or lower are the norm. Our profile grinding machines are capable of up to 20,000mm/min stroke speed, without compromising on profile, lead or twist tolerances. All these manufacturing machines operate in full closed-loop with automated correction capabilities, so that production losses due to unjustifiable waiting times for expert intervention can be converted to useful productive times.

While enabling growth in productivity & quality on the production side, Klingelnberg also introduced a series of innovations on the metrology side for our customers. The core principle of our approach in metrology is summarised in three simple words – DONE IN ONE! We layer this core with intelligent hybrid technology for even faster inspection times and lower cost of quality assurance. For example, a Klingelnberg P-series Precision Measuring Machine can inspect an EV Final Drive Gear for geometric tolerances (GDT), all gear parameters, surface finish on tooth flank and general surfaces and even complete noise simulation based on flank topography, all this on a single shop floor-ready machine in one clamping!! Imagine the capital expenses you saved, and the handling times you eliminated with this approach? With an intelligent switch between optical and tactile technologies for time-consuming pitch measurements, even higher throughput can be achieved. From this year, we have launched fully automation-ready metrology machines targeted at high-volume industries such as e-mobility, humanoids and legacy automotive to bring down the human cost of inspection per component or machine.



P 40 Measuring Center_Done-in-One

3. What has been the single biggest transformation in gear metrology requirements you witnessed in the last 5 years? What has been your company's contribution in meeting these requirements?

Answer:

Without any doubt, the arrival of e-mobility caused the biggest transformation in gear quality requirements and the way we measure them. The dual requirements of lowest friction loss in transmission and tightest NVH signature took precedence over the legacy DIN/ISO/AGMA evaluations in passing or failing a gear. This led to narrower gear tolerances, limits on mesh/ghost frequencies, and significantly better surface finish through fine or polish grinding. The EV industry required metrology solutions that offered a single source of truth with reliable, precise and extremely cost-effective technology.

Klingelnberg's biggest contribution to the industry at this critical juncture was our GDA (Gear Deviation Analysis) Software that provided a reliable and precise forecast of potential noise behaviour of a component based on topography inspection. An absolute prerequisite for the success of this evaluation was the availability of sub-micron-level flank data collected from a highly precise and accurate inspection machine. Klingelnberg P-series machines fulfilled these requirements fully and uniquely. Evaluation results from GDA Software matched consistently with end-of-line (EOL) and field test results, leading to Klingelnberg metrology machines and GDA Software being adopted as an industry standard by major e-mobility players around the world. It is safe to say, as of today, we enjoy nearly 90% market share in this uniquely premium market.

4. What role do automated inspection, connected measuring systems and data-driven analysis play in building smarter, more consistent gear production lines?

Answer:

Right at the beginning of our conversation, I spoke about how machine, process, tool, workpiece and even the environment each has an influence on the final quality of the gear at the end of the cycle. Any inconsistency in any one of these variables by itself or in combination with others leads to traceable inconsistencies in the quality of the final product. Short-term fixes are taken care of by the production closed loop. For systemic issues such as vibration, ghost orders or inconsistency between identical machines, etc..much more nuanced approach is necessary to establish root causes and find solutions. Here, collection of relevant data related to machine, process, tool, context, environment and quality through connected measuring systems over an extended period is necessary. Our concept of DDQM (Data Driven Quality Management) is precisely bringing this value proposition to customers, irrespective of which equipment they use in gear production. DDQM leads the way in proactively identifying inconsistencies and guides users with useful solutions, be it maintenance, process adjustments, tooling changes or drive optimisation. The ultimate benefit for the customer is consistent quality without unwanted production stoppages. Good data and smart systems will define the shape of future manufacturing.

5. How do measurement requirements differ across automotive, electric mobility, aerospace, wind energy and industrial power transmission, and how is Klingelnberg Group addressing these needs?

Answer:

When it comes to precision and accuracy, our measuring machines are size- and application-agnostic. Between the smallest P26 model and the largest P400, we cover every size, application and inspection requirement of every industry. Automotive and EV sectors demand high precision with shortest inspection times and lowest cost of ownership. All models (P26-P40-P65) catering to these segments are shop-floor-ready and equipped with quick chucking and automated stylus changes to fully exploit our “done in one" capabilities. There is no need to cool down a component to 20degC unlike normal practice, as the P-machines can reliably compensate for component temperature. On the other hand, industrial applications have heavy and oversized components, including extra-long pinion dimensions. The requirement here is to enable easy handling, quick set-up assistance and, most importantly, a robust machine that doesn't twist or deform under component weight or length. With component weights up to 30T and measuring ranges of 2500mm and 4000mm diameter, Klingelnberg machines can completely meet the requirements of all industrial scales and applications.

In aerospace applications, the extra-long turbine shafts require extended measuring ranges, robust clamping and special stylus executions to meet all measuring requirements. One special feature of Klingelnberg execution for long pinions is the swing-away tailstock functionality that is extremely useful for safe handling and reliable clamping of parts on any of our large machines. For the wind energy market, we offer a specialised W-type (W for wind) measuring head to support our customers in critical inspection of internal rings with extra-long face width. As you can see, Klingelnberg is a one-stop technology hub for all your measuring needs.

6. As Indian gear manufacturers expand into global supply chains, what are the major gaps in measurement capabilities, quality assurance and process control that need to be addressed?

Answer:

Indian gear manufacturers are generally very technology-savvy and clever adopters. Especially, companies that are integrated into supply chains of leading global OEMs – irrespective of the sector – are mostly at par with their global peer group, in terms of know-how, equipment, processes and understanding. Some of these companies collaborate with us to develop new capabilities and features. These companies represent the crème de la crème of the industry and are already quite substantial in number. Refreshingly, they are very closely followed by the "early majority" and "late majority" players. Klingelnberg has been working successfully with an overwhelming majority of Indian customers to make this transition.

A specific area where I see further scope for progress is a better understanding of noise evaluation in spiral bevel and parallel axis gears, especially in sophisticated transmissions. Klingelnberg's GDA (Gear Deviation Analysis) suite is a global standard in e-mobility; R300 Noise Finder offers end-of-line correspondence at component level through reliable SFT/SBN/Torsional Acceleration tests. For more than three decades, we have been offering noise analysis capabilities for spiral bevel gears with our T60 Gear Testers. I am hopeful that with increasing adoption of sophisticated closed-loop finishing of gears, gaps in adoption of noise evaluations will also disappear in India.



R 300_The Gear Noise Finder

7. Apart from measurement precision, what factors should manufacturers consider when selecting a gear measuring machine, particularly in terms of repeatability, throughput, flexibility and total cost of ownership?

Answer:

For any serious gear manufacturer, precision and gauge repeatability are non-negotiable when selecting a gear measuring machine. The second is the cost of ownership, which is the sum of "cost of quality assurance and cost of operation". The cost of quality assurance is an important metric that is often not discussed enough. A gear inspection machine that can effectively replace multiple satellite inspection machines such as roundness, surface finish and GDT needs lower overall capital investment. When this can be coupled with intelligent characteristics of the machine that guarantee lower operational costs, you have the lowest cost of ownership. For instance, a Klingelnberg gear inspection machine, by virtue of its machine tool construction, doesn't require the user to spend on a temperature-controlled inspection room; the complete absence of air bearings saves the customer huge recurring expenses for preparing clean and dry compressed air. Customers are well advised to consider these important aspects while selecting the right asset for their application.

8. What challenges do manufacturers face in adopting advanced metrology solutions, and how can workforce training and technical support accelerate their adoption?

Answer:

Our guiding principle while developing metrology solutions is to "simplify with passion"; in other words, the complexities stay behind the screen and training requirements remain minimal due to intuitive guidance of the operator by our user-friendly software. For this reason, I don't see modern metrology systems causing challenges for manufacturers.

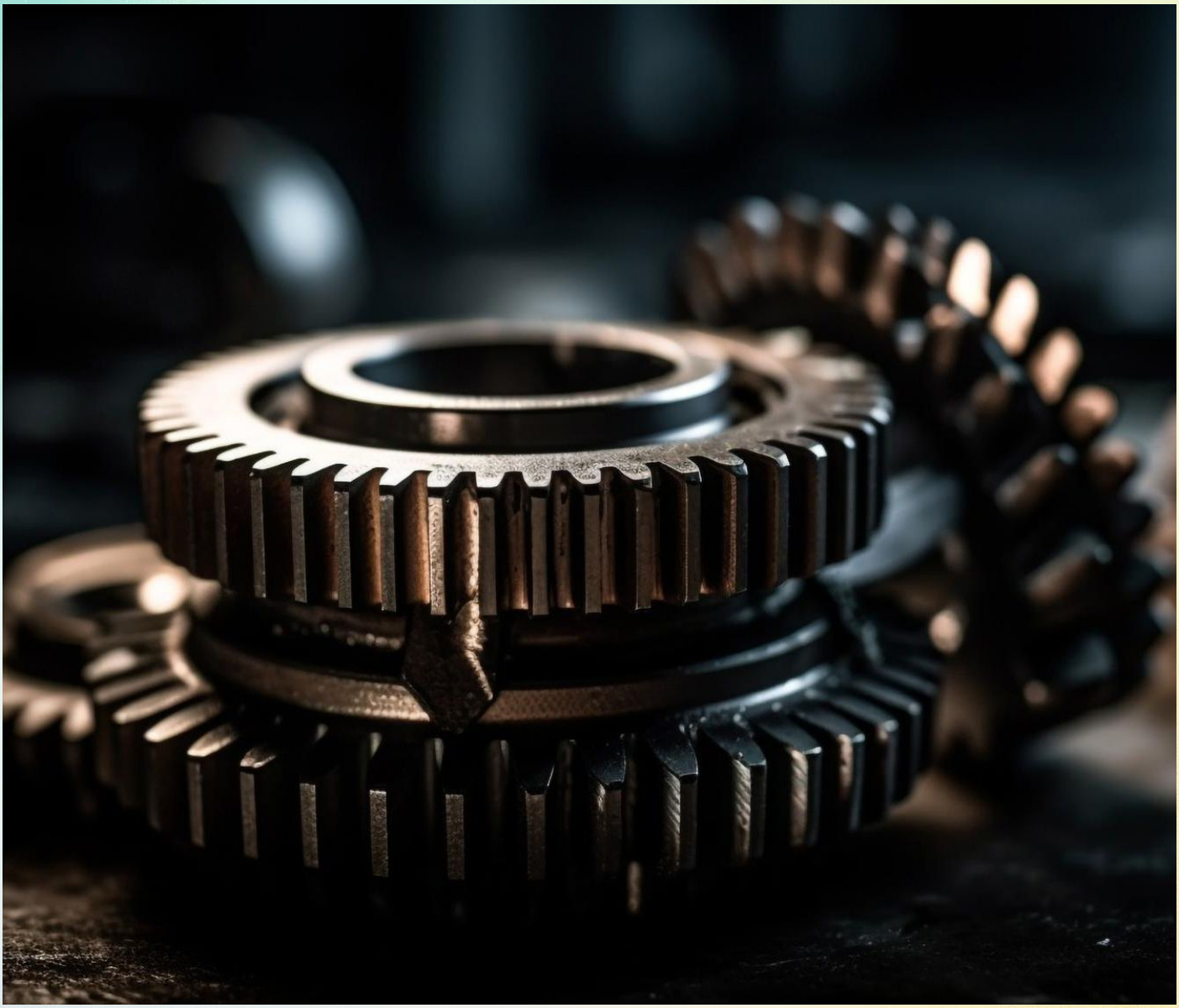
However, I do see challenges when a manufacturer tries to upgrade from general-purpose gear production to highly sophisticated transmission components for e-mobility or wind power or any comparable application. To pull this off efficiently, a great deal of hand-holding will be necessary to bring the workforce up to speed with requirements of the new industry, related manufacturing processes, definition and evaluation of quality, etc. The learning curve for the manufacturer can be significantly shortened by aligning with carefully chosen technology partners. For example, Klingelnberg invests heavily in last-mile competence in all our markets. We ensure availability of the latest metrology equipment in every regional Technology Centre and back this up with well-trained experts for ready support to our customers. Customers can experience the power of the technology, ease of operation and the strength of local support before deciding to go in for investment.

9. As the Executive Board Member of Klingelnberg, what growth opportunities do you see for Klingelnberg Group in Asia and India in particular? Which technologies or customer segments will be key to its future strategy?

Answer:

Our top five markets mirror the biggest manufacturing economies of the world, and three of them fall in Asia. We continue to be bullish on Asia, especially with new mega trends such as robotics and the humanoid industry contributing to further growth in China, Japan and Korea. Currently, India is our second biggest market in terms of sales of new machines, just behind China. With strong GDP growth of 7.5%, good policy adjustments and the continued relevance of India as an attractive sourcing market, we see the current momentum continuing for the foreseeable future. The bulk of the growth we see in India is driven by Automotive (both passenger cars & commercial vehicles), e-mobility, defence and industrial sectors. We are investing heavily in India to support our customers with retrofits and refurbishments as well as to strengthen our in-house manufacturing of workholding.

On the technology front for the future, we see opportunities for further innovations in optical metrology, development of new processes and machines to support increasing sophistication in e-mobility and humanoid drive systems. What should not be underestimated is the key role digital solutions will play in driving efficiencies in smart manufacturing. To drive our focus and harness growth in this field, we have launched our newest brand, AIKTEC, dedicated to digital solutions. The adoption rate across the market has been extraordinarily positive. In addition to these future-oriented actions, the regular enhancements of our legacy products will continue.



The Quiet Metrology Revolution: How a Patented Innovation is Redefining Gear Quality Control Across Indian Shop Floors

- By Sudhanva Shevade, Director, CalibroMeasure Equipments Pvt. Ltd



In high-precision automotive, defence, and heavy machinery manufacturing, gear inspection has long represented a costly dilemma. While drive systems demand ever-tighter tolerances, shop floor quality assurance has remained burdened by legacy manual inspection systems. On September 1, 2026, the United States Patent and Trademark Office granted Patent

US 12,723,948 B2 to CalibroMeasure Equipments Pvt. Ltd., recognising a groundbreaking approach to gear inspection that bridges the gap between legacy machinery and Industry 4.0 digitisation.

The Industry Challenge: The Limitations of Analogue Measurement

For decades, the Parkinson-style manual roll tester has been a workhorse of gear manufacturing facilities. However, traditional shop floor testing relies heavily on dial gauges, making inspection results inherently subjective and dependent on operator technique.

While fully automated CNC Gear Roll Testers exist, their high capital cost makes them impractical to deploy at every stage of production. As a result, manufacturing lines face a trade-off: costly batch sampling in specialised measuring rooms or subjective manual checks on the shop floor that risk letting non-conforming parts slip through.

Innovating Through Shop Floor Collaboration

CalibroMeasure's engineers have spent years visiting manufacturing plants, collaborating directly with quality managers, metrology experts, and machine operators.

These discussions revealed three core requirements:

1.Eliminating Operator Variance: Quality departments needed consistent, quantifiable numerical data instead of operator-dependent analogue dial readings.

2.Protecting Capital Investment: Existing manual roll testers were mechanically sound and robust; replacing them entirely was economically unnecessary.

3.Achieving Cost-Effective Digitisation: Manufacturers required a flexible, affordable solution that could be deployed across multiple production cells.

To address these needs, CalibroMeasure developed the CNCtized Manual Gear Roll Tester—a solution that modernises existing manual inspection hardware without requiring major structural changes.

Intelligent Metrology: The Power Behind CNCtize

At the core of this patented technology is CalibroMeasure's Continuous Monitoring and Guide Module (CMGM), paired with an intelligent software suite. The system transforms basic mechanical fixtures into intelligent inspection stations that actively guide the operator through each measurement step. What's more, it can also capture traceable data that can be shared to the central server for further use.

Critical-to-Quality (CTQ) Parameters Measured

- **Total Composite Error (TCE /DFCE):** Automated tracking of radial composite deviations.

- **PCD Runout (Fr):** Precise evaluation of Pitch Circle Diameter runout.
- **Dimension Over Balls (DoB / DuB):** Automated, high-repeatability size checks.
- **Nick & Flicker Detection:** Real-time identification of local tooth imperfections and surface irregularities.

Backed by Industry Leaders: Proven Results on Big Production Lines

This innovation did not happen in isolation—it gained early support and backing from major global gear manufacturers who recognised its game-changing potential. Leading industrial players collaborated closely during shop floor testing, benefiting directly from massive savings in both capital cost and floor space:

- **Drastic Cost Reductions:** Upgrading robust existing iron instead of investing in full-sized standalone measuring systems lowered equipment costs significantly.
- **Optimised Floor Space:** Compact retrofits allowed manufacturers to maintain efficient cell layouts without sacrificing valuable floor real estate to bulky new machines.
- **Industry Validation:** The enthusiasm and field success with these manufacturing partners helped validate the CNCtized approach, establishing it as a trusted benchmark for modernising plant metrology.

Operational & Economic Impact

The implementation of CNCtized roll testing delivers measurable operational improvements for component suppliers and Tier-1 manufacturers as well as OEMs:

- **Zero Rejection Skipping:** Quantified pass/fail thresholds prevent non-conforming parts from moving to downstream assembly steps.
- **Operator Deskilling:** Automated guidance reduces reliance on specialised manual techniques, enabling consistent results regardless of operator experience level.
- **Complete Data Traceability:** Integrated QR/barcode scanners link measurement records directly to individual part serial numbers for audit compliance.
- **Capital & Space Savings:** Retrofitting existing fixtures delivers automated digital inspection at a fraction of the cost and floor space required by new standalone machinery.

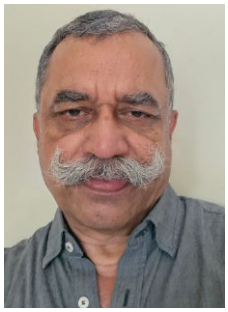
Watch a CNCtized Manual Roll Tester in action - https://youtu.be/zgpgmY9ts7o?si=hacyPvugaGYf2YDj

Expanding the CNCtize Ecosystem

Beyond gear roll testing, CalibroMeasure applies this patented digitisation approach across a full range of shop floor inspection platforms:

- **DobSmart:** Automated in-process inspection for Dimension Over Balls (DoB) and Dimension Under Balls (DuB) parameters.
- **RollSmart:** Dedicated high-speed automated gear rolling inspection stations.
- **GearMate:** Multi-parameter workstation capable of measuring both gear and non-gear features in a single setup.
- **MeasureMate:** Multi-gauging system engineered specifically for precision transmission shafts.

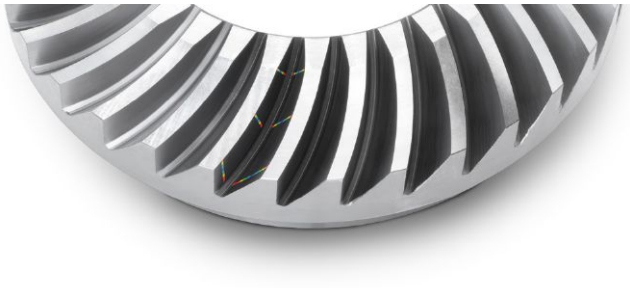
With the granting of US Patent 12,723,948 B2, American gear manufacturers have access to a proven, cost-effective path toward fully digitised quality assurance – Reach out to our application team at connect@calibromeasure.com or call +91 98220 32062, explore our complete metrology lineup - calibromeasure. com or watch product demos on our YouTube Channel - https://www.youtube.com/ channel/UCdsDetyuP1WqScZpXxWifEQ



Sudhanva Shevade
Director
CalibroMeasure Equipments Pvt. Ltd

Next-Generation Bevel Gear Metrology: Unified Surface and Geometry Analysis in a Single Inspection Cycle

- By Mark E Cowan, Gleason Metrology Systems Corporation



Abstract

Increasing torque density, stricter acoustic requirements, and higher durability expectations are driving the need for more advanced bevel gear quality control. Traditional flank form inspection alone is no longer sufficient to fully characterise surface-related deviations such as waviness and roughness, both of which play a critical role in noise generation, efficiency, and fatigue performance.

This paper presents recent advancements in bevel gear measurement technologies, including dedicated waviness analysis, enhanced surface roughness evaluation, and comprehensive form and surface charting techniques. These innovations provide deeper insight into gear quality, enabling faster diagnostics, improved process control, and reduced cycle times.

1. Introduction

Modern bevel gear manufacturing increasingly requires inspection systems that go beyond traditional flank form evaluation. Surface-related characteristics—particularly waviness and roughness—play a critical role in defining gear performance under load, directly influencing noise behaviour, efficiency, and fatigue life.

Conventional measurement of these parameters typically relies on specialised surface roughness instruments when high-resolution roughness evaluation is required. However, this approach often introduces additional complexity, longer inspection times, and the need for separate measurement setups.

This article presents new measurement capabilities that enable accurate and efficient assessment of waviness and form using industry-standard spherical probe tips. By eliminating the need for dedicated surface roughness hardware, these advancements streamline the inspection process while maintaining high measurement fidelity, ultimately supporting faster diagnostics and improved manufacturing efficiency.

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2. Separation of Form Error, Waviness, and Surface Roughness

A fundamental requirement of surface characterisation is the clear separation of form error, waviness, and surface roughness. International standards define a cutoff wavelength—typically 0.8 mm (λc)—to distinguish between these components. Deviations with wavelengths exceeding this cutoff are classified as waviness, while shorter wavelength deviations are attributed to surface roughness. Accurate surface roughness evaluation therefore requires the systematic removal of both form and waviness components through appropriate filtering techniques.

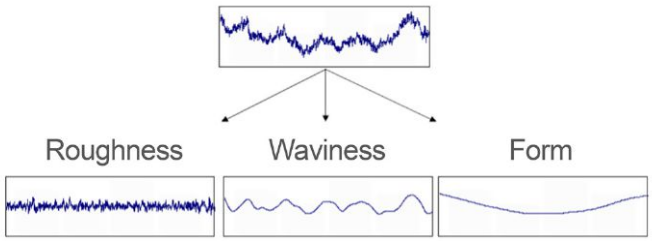


Figure 1 conceptually illustrates the separation using filtered surface profiles

3. Limitations of Roughness-Derived Waviness

Surface roughness measurement requires a significantly higher sampling density, which directly impacts scanning speed due to limitations in data acquisition rates (samples per second). While surface roughness analysis typically involves the collection of many thousands of data points, waviness evaluation can be performed with substantially fewer samples. As a result, the increased data density required for roughness measurements can limit the achievable scan length and reduce overall inspection efficiency.

In addition to throughput limitations, conventional surface roughness measurement systems involve higher hardware costs. The extremely fine stylus tips required for high-resolution roughness evaluation are considerably more expensive and inherently fragile. These probes are highly susceptible to damage if not handled carefully (see Figure 2), leading to increased maintenance requirements and potential downtime. Furthermore, such systems rely on dedicated electronics optimised for high-frequency

signal acquisition, adding complexity to the measurement setup.

In contrast, waviness evaluation does not require the same level of resolution or specialised hardware. By leveraging industry-standard spherical probe tips—commonly used for form measurement—it is possible to accurately capture waviness characteristics without the need for dedicated surface roughness instrumentation. This approach significantly reduces system cost and complexity while enabling longer scan lengths and faster measurement cycles. As a result, waviness analysis using spherical probes provides a practical and efficient solution for identifying surface-related deviations that influence noise, efficiency, and durability in bevel gears.



Figure 2 Skidless surface finish probe

4. Surface Roughness Measurement

Surface roughness measurements are typically performed using skidless probes to preserve long-wavelength surface information (see Figure 3). Automatic stylus orientation is employed to maintain perpendicular contact with the tooth flank throughout the scan, ensuring accurate data acquisition across the profile. In contrast, skidded probes are not suitable for waviness extraction, as the skid mechanically filters out longer-wavelength deviations. However, skidded probes do offer certain practical advantages—such as robustness and ease of implementation—and are therefore utilised in some large-scale gear inspection systems, including those developed by Gleason.

Given these limitations, dedicated waviness evaluation methods provide a more reliable and consistent solution. By avoiding the constraints of skidded probe designs and eliminating the need for high-resolution roughness instrumentation, waviness-focused measurement approaches—particularly those based on spherical probe tips—enable efficient, repeatable characterisation of surface deviations that are critical to gear performance.

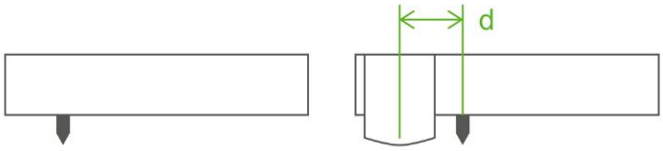


Figure 3 Skidless verses skidded probe

5. Bevel Gear Waviness Analysis

Recent developments by Gleason Metrology Systems enable waviness testing using a standard spherical ruby stylus without the need for dedicated surface roughness hardware (typically 1–2 mm tip diameter). For cutoff wavelengths above 0.8 mm, a reduced sampling density is sufficient, allowing for significantly faster scans and reduced measurement cycle times.

Measurements are performed along the pressure angle direction, which is particularly well suited for detecting the predominant waviness patterns on the tooth flank. This orientation aligns with the typical surface lay produced by common bevel gear manufacturing processes, improving the sensitivity and relevance of the measurement results.

Advanced mathematical spline fitting algorithms are employed to effectively increase the nominal XYZ point density of the measured surface. This enables high-resolution waviness characterisation while utilising the standard 9×5 flank form measurement grid typically generated by bevel gear design software.

The required increase in data density for waviness evaluation is achieved dynamically during the measurement cycle, while preserving the original flank form results that are transmitted to machine correction software. This approach eliminates the need to create separate part programs with finer flank form grids solely for waviness analysis. Furthermore, it allows waviness evaluation to be seamlessly integrated into the standard inspection process without impacting existing correction workflows or requiring additional measurement passes.

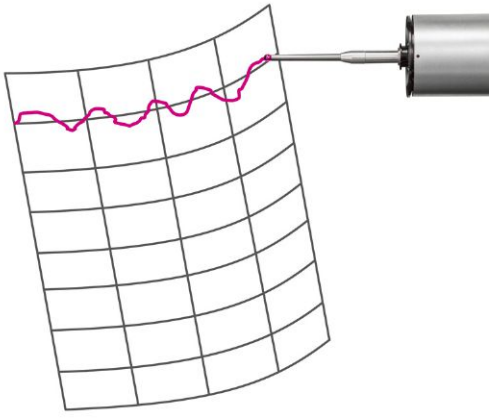


Figure 4 illustrates waviness along the tooth depth

6. Software Implementation and Programming

Waviness analysis is fully integrated into the GAMA software environment, providing a flexible and user-friendly interface for evaluation. Operators can select individual or multiple grid columns, apply averaging functions, define independent tolerance limits for drive and coast flanks, and choose from multiple filtering strategies, including Gaussian and form-following methods, to tailor the analysis to specific application requirements.

All bevel gear measurements—including index, flank form, tip and root depth, and waviness—are completed within a single automated measurement cycle without the need for operator intervention. This integrated approach ensures consistent results, reduces inspection time, and minimises the potential for user-induced variability, while supporting efficient and comprehensive gear quality assessment.

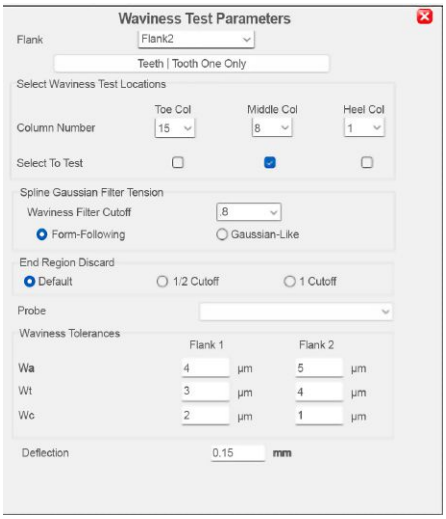


Figure 5 shows an example of waviness programming within the GAMA interface

7. Advanced Waviness Charting

New charting functionality enables the visualisation of multiple waviness traces for each tooth and flank, supporting rapid identification of systematic and localised deviations. Key waviness parameters—Wa (arithmetic mean waviness), Wc (maximum peak-to-valley height), and Wt (total waviness height)—are calculated for each trace and automatically compared against user-defined tolerance limits.

This enhanced visualisation and evaluation capability allows operators and engineers to quickly interpret surface behaviour, identify recurring patterns, and take targeted corrective actions, further improving process control and gear quality.

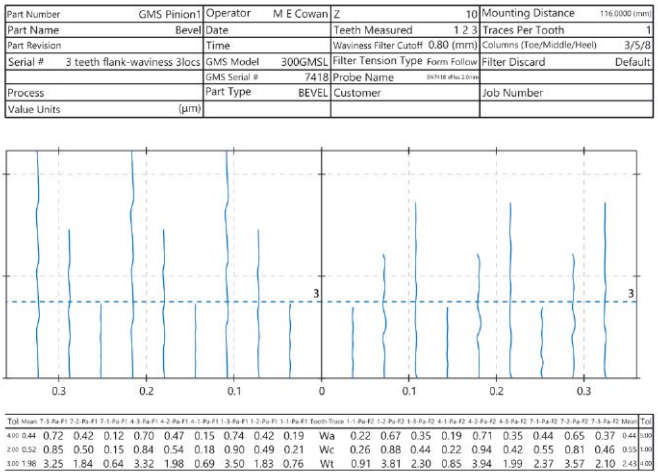


Figure 6 presents an example waviness chart

9. Enhanced Bevel Gear Charting

A new portrait-style gear chart consolidates deviation data, surface quality metrics, and key geometric characteristics into a single comprehensive report, enabling more efficient analysis and interpretation (see Figure 8).

In addition, a new bevel flank "Form" analysis has been developed to evaluate form deviations on a per-column basis along the flank form grid. This analysis incorporates the removal of longer-wavelength form elements—such as crowning (see Figure 7)—through second-order polynomial fitting. By filtering out these intentional macro-geometry features, the resulting form deviation data more accurately represent localised surface variations critical to gear performance.

GAMA further enhances this functionality by allowing independent tolerance definitions for form deviations at each measurement column, organised across five distinct regions from heel to toe. This capability supports the application of region-specific tolerances along the spiral angle, accommodating intentional surface modifications—such as ENDREM—while maintaining precise control over critical areas of the tooth flank.

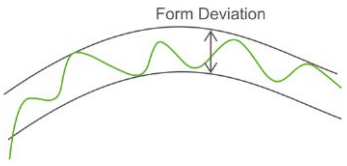


Figure 7 Form deviation analysis at each column of flank form measurements

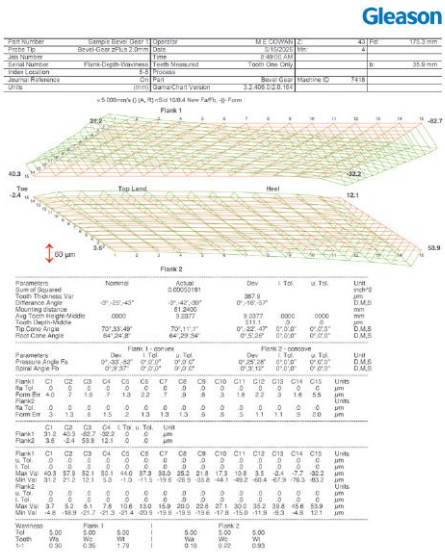


Figure 8 Bevel Portrait Chart

10. Bevel Gear Root Scanning

Root scanning capability enables the measurement of multiple critical features—including flank geometry, tooth spacing, top land, root depth and angles, as well as detailed root geometry—within a single automated inspection cycle. Root measurements are evaluated relative to theoretical design coordinates, ensuring accurate comparison to nominal values.

Nominal root data is stored in dedicated root definition files, allowing both standard flank form measurements and root scan evaluations to be performed within the same measurement cycle. This integrated approach improves measurement efficiency, maintains consistency between datasets, and supports comprehensive analysis without the need for separate setups or additional inspection steps.

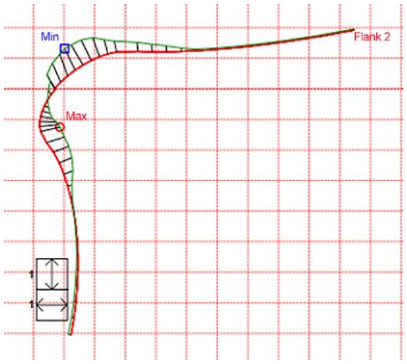


Figure 9 Flank and root fillet scan using nominal points from design software

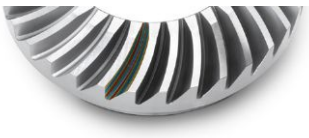


Figure 10 Root fillet scanning selectable locations along the face width

11. Conclusion

Increasing performance demands in bevel gear applications—driven by higher torque density, stricter acoustic requirements, and extended durability expectations—necessitate more advanced and comprehensive inspection methodologies. Traditional flank form evaluation alone is no longer sufficient to fully characterise the surface-related deviations that directly influence gear performance.

The advancements presented in this work demonstrate a significant evolution in bevel gear measurement capabilities. By enabling accurate waviness analysis using standard spherical probe tips, the need for specialised surface roughness hardware is eliminated, reducing system cost, complexity, and sensitivity to probe damage. At the same time, dynamic data density enhancement and advanced spline-based processing allow high-resolution surface characterisation without compromising measurement speed or requiring modified inspection programs.

Integration within the GAMA software environment further enhances usability and efficiency, allowing flexible parameter selection, advanced filtering strategies, and fully automated multi-parameter inspection within a single measurement cycle. New visualisation tools—including multi-trace waviness charting and portrait-style gear reports—provide improved diagnostic capability, enabling rapid identification of systematic deviations and facilitating targeted process corrections.

Additional innovations such as per-column flank form analysis, region-specific tolerance control, and integrated root scanning expand the scope of measurement beyond traditional limits, delivering a more complete representation of gear geometry and surface condition. The ability to evaluate these characteristics relative to theoretical design data within a unified workflow ensures consistency and traceability across all measurement results.

Together, these technologies provide a powerful and efficient solution for modern bevel gear quality control. By combining faster measurement cycles, reduced hardware requirements, and enhanced analytical capability, they enable manufacturers to achieve higher product quality, improved noise and efficiency performance, and more robust process control in increasingly demanding applications.



Mark Cowan
Senior Systems Engineer
Gear Laboratory Technical Manager
Gleason Metrology Systems

Revolutionising Gear Manufacturing: Achieving Efficiency & Precision - Strategies for Modern Gear Production

- By Vishwajit Kothari



Today we are looking at how the gear manufacturing landscape is shifting. It's no longer just about cutting metal; it's about a holistic approach—from digital twin simulations to the final surface treatment - to meet the extreme demands of modern aerospace and electric vehicle drivetrains. We will cover the four pillars of efficiency that can reduce your cycle times by up to 30% while maintaining micron-level precision.

The Importance of Efficient Gear Manufacturing

We often hear that gears are a 'mature' technology. But the truth is, the gear industry is undergoing a second industrial revolution. Why? Because the electric vehicle (EV) market and high-tech aerospace don't just want gears; they want silent, lightweight, and indestructible power transmission.

Standard hobbing is no longer enough. When you are dealing with EV motors spinning at 20,000 RPM, the margin for error disappears. Efficiency today isn't just about speed; it's about getting it right the first time to avoid the 'hidden factory' of rework and scrap.

If we can improve our efficiency by even 15%, we aren't just saving money on the shop floor—we are increasing the energy density of the final product, which is the number one competitive metric in the world right now.

Pillars of Efficiency in Gear Manufacturing

To achieve efficiency, we can't look at the machine in isolation. We have to treat gear manufacturing as an ecosystem supported by four distinct pillars.

First, we have our hardware. We are moving away from 'form cutting'—where you cut one tooth at a time—toward 'generation' methods like hobbing. If you're doing internal gears, skiving is the new gold standard for speed."

Second is the science. If the material isn't right, or if the heat treatment causes too much warping, we spend our entire profit margin fixing the gear in the grinding stage. Precision starts in the furnace, not just on the lathe."

The third pillar is our 'Digital Thread.' We now use simulations to predict exactly how a gear will behave under load. This 'measure twice, cut once' philosophy—digitally—is what separates the leaders from the laggards in 2026."

Finally, the fourth pillar is Lean logic. Efficiency is lost in the 'white space' between machines—the waiting, the setup, and the transport. Lean ensures that the gear is always moving toward the customer."

Advanced Machining Technologies

The Hardware Evolution: When we talk about machining efficiency, the conversation starts with speed and ends with integration. We are no longer just 'cutting'—we are 'generating' geometries with extreme velocity.

On Hobbing: Modern CNC hobbing isn't just faster; it's smarter. By moving to dry machining with carbide tools, we aren't just saving on oil—we're eliminating the thermal expansion issues that coolant can sometimes mask, leading to more stable dimensions.

The Power Skiving Breakthrough: If you are still shaping internal gears, you are losing money. Power Skiving has revolutionised the production of internal ring gears and splines. What used to take 20 minutes can now be done in 3. This is the single biggest leap in gear productivity in the last decade.

The Finish Line: Finally, efficiency isn't just about the rough cut. Generating grinding allows us to correct heat-treat distortions and apply specific surface textures that reduce gear whine—a critical requirement for the silent operation of electric vehicles.

Material Science & Heat Treatment

The Material Foundation: We often say that a gear is only as good as the steel it's born from. As we move toward higher power density—especially in robotics—we are using high-purity alloys that can withstand incredible stress without pitting.

On Distortion Control: The biggest 'efficiency killer' in a gear shop is heat-treat distortion. If a gear warps significantly in the furnace, your grinding machine has to work twice as hard to fix it. By switching to vacuum carburising, we control the cooling so precisely that the gear stays nearly 'true,' dramatically cutting our finishing costs.

On Targeted Hardening: With induction hardening, we aren't heating the whole part; we're laser-focusing energy exactly where the teeth meet. It's faster, cleaner, and uses a fraction of the electricity of a traditional batch furnace.

The Final Touch: Finally, look at shot peening. By 'hammering' the surface at a microscopic level, we create a shield of compressive stress. This allows us to use a smaller gear to do a bigger job, saving weight and material costs across the entire vehicle.

Digitalisation & Industry 4.0 in Gear Production

The Shift to Intelligence: We are entering the era of 'Agentic IoT.' Our machines are no longer just tools; they are data generators that communicate with each other. Slide 6 is about the Digital Thread that ties every stage of the gear's life together.

On Digital Twins: Imagine having a 'Ghost Gear' in your computer that reacts exactly like the one on your machine. We can run a thousand stress tests on that digital twin in seconds. This allows us to fail fast and fail cheap in the virtual world so we can succeed perfectly on the shop floor.

Real-time Response (Edge Computing): In 2026, we don't wait for a cloud server to tell us something is wrong. With 'Edge Computing,' the machine itself analyses vibration patterns. If a cutter starts to dull, the machine senses the micro-chatter and adjusts its own feed rate instantly to save the part.

From Reactive to Proactive: Predictive maintenance is the end of 'Unplanned Downtime.' We no longer fix things because they broke; we fix them because the data told us they were about to break. This shift alone can improve your overall equipment effectiveness (OEE) by double digits.

Process Optimisation & Lean Manufacturing

The Concept of Flow: We've talked about how to cut a gear faster, but Pillar 4 is about how to get it out the door faster. If your machine cuts a gear in 5 minutes, but the gear sits in a bucket for 3 days waiting for the next process, your 'machine efficiency' is a lie.

On Cellular Layouts: By moving to 'Cellular Manufacturing,' we create a 'One-Piece Flow.' The gear goes from the hob to the deburring station to the wash in seconds, not hours. This eliminates the 'Work-in-Progress' (WIP) mountain that ties up your cash flow.

The Agility Edge (SMED): In 2026, the era of million-part runs is shrinking. Our customers want 50 of this gear today and 50 of a different one tomorrow. SMED allows us to change our setup with the speed of a Formula 1 pit crew. If you can change over faster than your competitor, you own the market.

Eliminating Waste: Lean isn't about working harder; it's about removing the 'White Space'—the walking, the waiting, and the double-handling. When we synchronise our Takt time with customer demand, we stop building 'Inventory' and start building 'Profit'.

Quality Control & Metrology

The Intelligence Loop: Quality control is no longer a 'police officer' at the end of the line. In a modern factory, it's a feedback loop. When our measuring machine detects the slightest drift in pitch or profile, it doesn't just send an alert—it tells the cutting machine exactly how to correct itself. This is 'Closed-Loop' manufacturing.

The EV Challenge (NVH): In the world of electric vehicles, the engine noise is gone, which means gear noise is suddenly very loud. We are now measuring things we never cared about 10 years ago—like surface 'waviness' and acoustic signatures. If it isn't silent, it's a failure.

Speeding Up Metrology: We are moving metrology out of the climate-controlled lab and onto the shop floor. By using optical scanners and ruggedised CMMs, we get our data in seconds, not hours. This drastically reduces the 'Dead Time' between making a part and knowing it's perfect.

From Data to Insight: A measurement report is just paper; a trend analysis is power. By tracking our SPC data in real-time, we can predict exactly when a tool will start producing out-of-spec parts, allowing us to change it at the perfect moment—not too early (wasted money) and not too late (wasted parts).

Case Study – High-Performance Automotive Tier 1 Supplier

Setting the Scene: Let's look at how this works in the real world. We worked with a Tier 1 supplier producing planetary gears. They were hitting a wall: their cycle times were too high, and their scrap rate was eating their profit.

The Strategy: Instead of just buying a faster machine, they overhauled their process using the pillars we've discussed. They moved to Power Skiving—which was the 'speed' win—but more importantly, they fixed their distortion issues by moving to Low-Pressure Carburising.

The Power of Simulation: By using a Digital Twin, they identified a mesh interference issue in the design phase that had been causing 'whine' in the transmission. They corrected it digitally before ever cutting metal for the new batch.

The Bottom Line: The results were transformative. They didn't just get faster; they got better. A 75% reduction in cycle time meant they could take on more volume with the same floor space. This is what true manufacturing efficiency looks like.

Future Trends in Gear Manufacturing

The AI Frontier: As we look toward 2030, the 'Efficiency' conversation shifts from hardware to intelligence. We are moving toward 'Self-Healing' systems—where the machine's AI detects a quality drift and fixes it before the operator even knows there was a problem.

The Sustainability Mandate: Efficiency and Sustainability are now the same thing. In the future, every kilowatt of energy and every drop of oil will be tracked. Technologies like MQL—Minimum Quantity Lubrication—allow us to cut gears with almost zero environmental footprint while actually extending tool life through better thermal control.

The Hybrid Revolution: Why waste a block of expensive alloy when you can print the gear to 98% of its final shape? Hybrid manufacturing—combining 3D printing with precision grinding—allows us to create gears with 'graded' materials. We can have a gear that is flexible in the middle and diamond-hard on the teeth.

The Human Element: The future isn't about replacing people; it's about empowering them. Cobots and AI tools will handle the repetitive, dangerous, and microscopic tasks, leaving our engineers to focus on the highest level of process optimisation and innovation.



Vishwajit Kothari
Director
Cyber Gears

Optimised Grinding Processes for Double Helical Gears

- By Holger Staub



Introduction

Double helical gears are characterised by a symmetrical arrangement of two identical gear sets with exactly opposite helix angles. Due to this symmetry, the axial forces within the gearbox cancel each other out. For many years, such double helical gears – serving as examples of components with geometric discontinuities – have represented a particular challenge in the hard finishing of gears.

Whereas in the past, military applications with small batch sizes were the primary focus, demand for double-helical gears in planetary gear systems for engines in civil aviation is now increasing. Growing requirements for weight reduction and fuel savings are leading to smaller overall design size.



Typical sun or planet gears in such gearboxes have approximately the following main parameters (values are exemplary and do not correspond to any specific customer component):

- Number of teeth: 44
- Module: 3.5 mm
- Outer diameter: 175 mm
- Overall width: 130 mm
- Gap between the two gears: 30 mm
- Weight: 13 kg

Assuming that the gap between the two gears could be reduced by 10 mm from the overall width, the weight of the workpiece would decrease by approximately 7.7 per cent. This significant reduction- particularly in the aerospace industry – would directly impact aircraft fuel efficiency. KAPP NILES has already demonstrated that customers can achieve, or even exceed, such a design target through the optimal combination of machine, grinding spindle,
and tool.

Hard gear finishing of the tooth flanks can typically only be carried out using the profile grinding process. Due to the nature of this process, a gap is required between the gear teeth for tool runout. Double helical gears can traditionally be machined using both dressable and non-dressable CBN profile grinding wheels, which are mounted with screws on one or two grinding spindles. The tool diameter is often limited to approximately 80-100 mm due to spindle size and interference from the grinding spindle contour. When using dressable tools, the diameter range required for dressing presents an additional limitation.

The Limitations Of Traditional Solutions

The conventional grinding solutions described above are increasingly reaching their limits. They no longer meet the growing demands for narrower gap widths (and thus reduced weight), higher quality, and improved surface finish. Moreover, they fall short of achieving the production targets required for cost-efficient manufacturing in the highly competitive global civil aerospace market.

The balance between cost and productivity is essential - without compromising precision.

When grinding double helical gears, CBN tools from KAPP NILES offer a decisive advantage: their diameter can

be optimally adapted to the available complex geometries is only possible through an ideal interaction between machine and tool. As in any industry, maintaining the right balance between cost and productivity is essential – without compromising precision.

To meet a wide range of customer requirements, KAPP NILES has developed unique 3D simulation tools for optimising gear design – often in close collaboration with its customers. Among other things, the following parameters can be specifically optimised:

Tool diameter: Directly related to the advanced grinding spindle from KAPP NILES (described below) as well as the CBN tool manufacturing line between tool and workpiece. However, it can lead to imbalanced grinding forces, requiring greater spindle rigidity

Position of the DHC point: An off-centre position can provide additional clearance for the grinding wheels, potentially enabling reduced gaps

Other features: Chamfers and edge rounding can also offer improvement potential, depending on the specific application.
As part of the optimisation process,
the DHC point can be shifted off-centre.



As part of the optimisation process, the DHC point can be shifted off-centre.

Case Study: Optimising Gap Width

Together with a renowned European manufacturer of civil and military aerospace engines, optimisation processes were conducted, as outlined below:

1. The initial customer design featured a 30 mm gap and a conventional wheel and grinding spindle size, as available on an existing KAPP NILES machine (manufactured in 1993 and still in continuous aerospace production use).

2. In the first reduction step, the tool diameter specialised spindle with a counter-bearing. The CBN grinding wheels and spindle arbour remained separate.

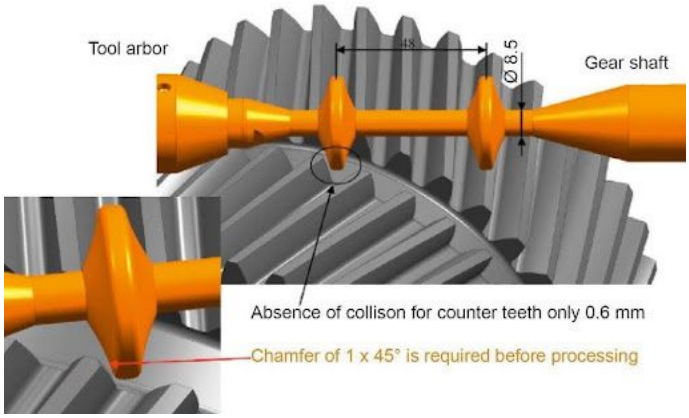
3. The second step involved rotating both gears against each other (i.e., shifting the DHC point off-centre), allowing the grinding wheel to use the opposing gap as additional clearance. At this stage, a gap of 18 mm was achieved with a grinding wheel diameter of 50 mm.

4. The final challenge was the customer's request for a 15 mm gap – less than half of the original design – intended to reduce the weight by approximately 10 per cent.

KAPP NILES addressed this challenge as follows:

- An integrated design of the CBN grinding wheel and wheel arbour with dual CBN grit for roughing and finishing
- A CBN grinding wheel diameter of 30 mm
- An optimised tool swivel angle
- The recommendation of a small chamfer to achieve the required geometric clearance

5. In the final design, the customer opted for a slightly larger gap. This allowed secure separation of the CBN grinding wheels from the arbour, improving tool cost-efficiency while maintaining compatibility with the gearbox and bearing design.



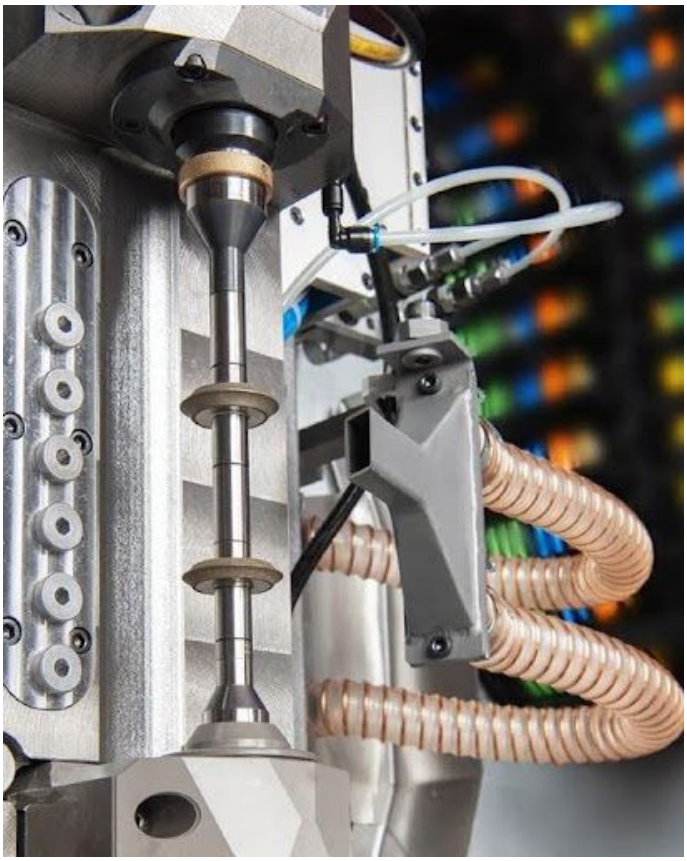
In step four, the gap was reduced to 15 mm.

A particular challenge in this project was the design of the grinding spindle. Achieving the highest material removal rates and surface quality typically requires a two-stage process using CBN roughing and finishing tools. To address this, KAPP NILES developed an optimised grinding spindle with a counter-bearing, enabling high precision and productivity even with very small wheel diameters.
This offers several advantages:

- An integrated HSK interface minimises tool
- set-up times
- The spindle contour is designed to prevent collisions at high swivel angles

- The spindle speed is optimised for small tool diameters. The counter-bearing significantly increases rigidity, ensuring maximum precision even with large modules and uneven grinding forces.

Throughout all optimisation stages, prototypes were ground at KAPP NILES and validated using in-house gear measurement machines. The customer recognised the advanced capabilities of the process. On a modular standard machine, KAPP NILES achieved what several competitors could not: a solution precisely tailored to increased customer requirements. Following this successful collaboration, the customer proceeded with the purchase of a new grinding machine and CBN tools to prepare for the future production of this advanced aircraft engine.



Thanks to its counter-bearing, the optimised grinding spindle has increased rigidity, enabling unique precision and productivity.

Selecting the most suitable gear grinding machine required a comprehensive process. KAPP NILES offers a wide range of machine concepts for grinding double helical gears across various sizes – both with a horizontal workpiece axis, as in the VX series, and with a vertical workpiece axis, as in the KNG master or ZE series. All machines can be equipped with hardware and software solutions specifically optimised for double helical gear grinding. Without the appropriate tooling concept and software, even

Conclusion

This case study demonstrates that optimising the grinding process – particularly the grinding spindle – can significantly reduce both gap width and workpiece weight. Through the targeted interaction of machine, software, tooling, and extensive technological expertise, KAPP NILES successfully met these demanding requirements.

The key success factors were:

- Systematic optimisation of tool diameter, swivel angle, and DHC point
- Use of a highly rigid grinding spindle with counter-bearing for small wheel diameters
- Use of non-dressable CBN tools from KAPP NI-LES
- Validation of all optimisation steps under real
- production conditions
- Close and constructive collaboration with the customer

Even ambitious targets are technically and economically achievable.

The results show that even the aerospace industry's most ambitious targets are technically and economically achievable. At the same time, this project marked the beginning of further collaborations with aerospace customers now also successfully using KAPP NILES' optimised system.

About Kapp Niles

KAPP NILES is a globally operating group of companies with high-quality and economical solutions for finishing gears and profiles and is a partner for companies from numerous industrial sectors in the mobility, automation and energy segments. The perfect interaction between machine, tool, technology and metrology enables extremely precise machining to a thousandth millimetre.



Holger Staub is Head of Sales Asia, CIS and Australia at the grinding machine manufacturer KAPP NILES. He has been providing advice to customers worldwide for over 25 years. Among other roles, he spent four years as Head of Product Management with exclusive responsibility for the aerospace sector, working with numerous leading companies in the aerospace industry across the globe.

Holger Staub's passion for gear grinding and aviation dates back to his studies in technical mathematics at Karlsruhe University of Technology (now KIT). He started his career in the traditional "gear region" of Karlsruhe/ Ettlingen before joining the

dSPACE Showcases New Validation Technologies at User Conference India 2026

- By Gear Technology India



More than 500 participants explore integrated workflows for AI deployment, ECU cybersecurity, radar testing and scalable HIL validation

Bengaluru, India: More than 500 delegates from automotive and non-automotive OEMs, suppliers, and global engineering companies gathered at the dSPACE User Conference India 2026, held on 25 September 2026 at the Marriott Whitefield, Bengaluru, under the theme "Software-defined". Test-verified, the conference examined how simulation and virtual validation are transforming product development, particularly as engineering teams increasingly need to validate software before physical hardware is available.

The conference highlighted the growing importance of simulation-based testing, Hardware-in-the-Loop (HIL) systems and software validation in developing increasingly complex and software-defined products. Discussions covered automotive, aerospace, defence, railway and other industrial applications, with particular emphasis on artificial intelligence (AI), cybersecurity, radar testing and scalable validation workflows.

Ahead of the conference, dSPACE India Solutions Pvt. Ltd. organised a press conference and media interaction led by Andreas Gau, CEO, dSPACE India Solutions Pvt. Ltd. The briefing provided insights into the company's India strategy, technology roadmap and its expanding portfolio of simulation and validation solutions.

Integrated Workflows for Software Validation

A key focus of the conference was the shift towards validating software early in the product development cycle, reducing dependence on physical prototypes and enabling engineering teams to identify potential defects



Media briefing by the Leadership team of dSPACE (in picture: Andreas Gau, CEO, dSPACE India Solutions Pvt. Ltd.)



Sushmita Das, the Associate Editor representing Gear Technology India at the Press Meet along with the dSPACE team and others from the media

before products reach the testing or deployment stage.

The importance of early validation was highlighted by Murali Manohar of Ashok Leyland, who observed, "The best defects are not the ones we solve quickly. The best defects are the ones we don't allow to reach the vehicle." Partner demonstrations formed a major part of the technology showcase, focusing on integrated and deployable engineering workflows rather than standalone product demonstrations. These included the generation of DO-178C certification artefacts using TargetLink and partner products, Vehicle-to-Everything (V2X) simulation for testing future autonomous and assisted-driving functions, cybersecurity penetration testing combined with simulation of real-world vehicle effects, and the generation of virtual ECUs incorporating complete production software with minimal downtime.

The demonstrations highlighted how dSPACE and its partners are combining complementary technologies to deliver turnkey solutions for customer engineering programmes.



India Focuses on Locally Developed Test Solutions

The conference also highlighted the growing demand for simulation and validation technologies designed around Indian engineering requirements. India's expanding automotive market, diverse vehicle platforms and increasing engineering R&D capabilities are creating new requirements for scalable testing solutions.

According to the industry figures cited during the conference, domestic vehicle sales in India reached 28.3 million units in FY26, registering 10.4% growth, while exports increased 24% to 6.6 million units. India's engineering R&D services revenue was estimated at $63 billion in FY26, with projections indicating that it could



exceed $100 billion by 2030.

These developments are driving demand for locally designed and engineered test solutions that can address the requirements of Indian OEMs and suppliers while supporting global engineering programmes.

Customer presentations demonstrated how dSPACE technologies are being used to manage large numbers of vehicle variants in virtual environments and accelerate testing. Discussions also covered the application of simulation in aerospace, particularly for testing flight-control laws safely and accurately before actual flight trials.

Another important topic was the validation of software-defined vehicles (SDVs). With software updates and increasingly interconnected vehicle systems becoming more common, engineering teams face the challenge of continuous regression testing and reproducible, scalable end-to-end validation.

Four Technologies Introduced for the Indian Market

To address these emerging requirements, dSPACE



showcased four technologies for the Indian market, covering AI-based embedded systems, ECU cybersecurity, radar testing and component-level HIL validation.

Neural Net Coder: The solution converts trained neural networks into deterministic, standards-compliant C code for safety-critical and resource-constrained embedded systems. It incorporates post-training optimisation, built-in verification and early estimates of runtime and memory requirements. The technology addresses the growing need to deploy AI models in embedded mobility applications while ensuring predictable performance and compliance with engineering requirements.



dissecto HydraProbe: Designed for ECU security testing, dissecto HydraProbe introduces controlled penetration testing capabilities to existing HIL systems. It aims to accelerate cybersecurity testing and provide reliable evidence throughout the validation lifecycle, supporting the assessment of vehicle electronic systems against potential security vulnerabilities.

DARTS ARROW: The compact radar target simulator supports functional, end-of-line and periodic inspection testing across the 76–81 GHz frequency



range. It offers simulation ranges of up to 500 metres and speeds of up to ±700 km/h, addressing radar validation requirements for advanced driver-assistance systems (ADAS) and other automotive applications.

SCALEXIO Essential: An entry-level, component-level HIL platform, SCALEXIO Essential is designed for the rapid validation of edge ECUs. It supports automotive Ethernet, CAN and LIN communication protocols, alongside analogue, digital and resistance inputs and outputs.

Together, these technologies address several critical areas in modern engineering, including the deployment of AI in embedded systems, cybersecurity verification, radar-based sensing and scalable electronic control unit testing.

Addressing AI and Software-Defined Mobility

AI integration in mobility systems is creating new validation requirements for automotive engineers. While developing an AI model is an important step, ensuring its predictable behaviour when deployed on an ECU within a larger physical system presents a more complex engineering challenge.

Neural Net Coder addresses the transition from a trained neural network to verified embedded C code. The



broader dSPACE simulation and validation environment, spanning Software-in-the-Loop (SiL) and HIL testing, enables engineers to evaluate system behaviour before deployment.

Commenting on the growing requirements of the Indian engineering ecosystem, Andreas Gau, CEO, dSPACE India Solutions Pvt. Ltd., said, "India's engineers are building for domestic and global markets at a scale few countries match, and they are being asked to prove software works before there is a vehicle to prove it on. This conference showed Indian teams combining partner technologies into turnkey workflows, and it showed the demand for test solutions designed for Indian programmes. The four technologies we introduced, including Neural Net Coder for AI in the ECU, are our answer to that demand."

Extending Simulation Beyond Automotive

Although automotive applications remained a central focus, the conference also explored the relevance of digital engineering across aerospace, defence and railway sectors. Simulation and HIL testing are increasingly important in these industries for evaluating complex systems, verifying software behaviour and assessing operational performance before deployment.



The sessions reflected a broader shift towards virtual development, where engineering teams can test multiple operating conditions and system configurations without relying exclusively on physical prototypes. This approach is particularly relevant for applications involving safety-critical systems and complex interactions between hardware and software.

Representing Gear Technology India, Sushmita Das, Associate Editor, participated in the pre-conference media interaction and attended the conference, engaging with the dSPACE leadership team and industry experts. The interactions provided insights into the company's technology direction and the expanding applications of simulation and validation across different industrial sectors.

The dSPACE User Conference India 2026 highlighted how the convergence of AI, virtual engineering, cybersecurity and advanced testing technologies is changing product development. As software assumes a greater role in modern engineering systems, the emphasis



is shifting towards validating performance earlier, more comprehensively and repeatedly before products reach the road, factory floor or flight line.

About dSPACE

dSPACE is a provider of simulation and validation solutions for the development of networked, autonomous and electrically powered vehicles. Automotive manufacturers and suppliers use its technologies to test software and hardware before new vehicle models reach the road. Its solutions also support engineering applications in aerospace, agriculture and industrial automation.

With more than 2,900 employees worldwide, dSPACE is headquartered in Paderborn, Germany, and operates four additional project centres in Germany. The company serves customers through regional offices in the USA, UK, France, Japan, China, Croatia, South Korea, India, Sweden and Italy.

GWJ Technology: Innovative Software Solutions for the Gear and Transmission Industry

- By Gunther Weser & Joerg Weser

The requirements placed on modern gear and transmission systems are constantly increasing. Higher power densities, more compact designs, improved efficiency, lower noise emissions and an ever-growing variety of product configurations present designers and development engineers with increasingly complex challenges. At the same time, development cycles must be shortened, and the cost-effectiveness of design and manufacturing processes improved. Powerful calculation and design tools are therefore a key factor in maintaining competitiveness in the power transmission industry.

GWJ Technology GmbH, based in Braunschweig, Germany, has been developing specialised software solutions for mechanical and gearbox engineering for many years. The company combines in-depth engineering expertise with modern software development, offering a comprehensive portfolio that covers everything from the calculation of classical machine elements and the design of complex transmission systems to the generation of actual three-dimensional gear geometries for manufacturing.

A Comprehensive Software Portfolio for Mechanical Engineering

At the heart of the product portfolio are the calculation software solutions eAssistant and TBK, the SystemManager system solution, the specialised gear design software GearEngineer, as well as powerful 3D CAD integrations and solutions for rolling bearing calculations. eAssistant (Figure 1) is a web-based calculation software solution for the design, verification and optimisation of machine elements. These include, among others, cylindrical gears, bevel gears, worm gears, shafts, rolling bearings, springs, bolted joints, and various shaft-hub connections. The calculations are based on recognised technical standards and guidelines, such as DIN, ISO, and AGMA standards, as well as relevant technical literature. As a web-based solution, eAssistant requires no local installation and provides flexible access to its calculation capabilities.

For more than 20 years, eAssistant has played a leading role not only as a web-based solution for the professional calculation of machine elements, but also in terms of user-friendliness. All calculation modules feature a Redo/Undo function, allowing users to move several steps forward and backwards through their input history. In addition, calculations are automatically updated whenever an input parameter is changed, enabling users to immediately see how each parameter affects the results.

Different licensing and usage models make the software an attractive solution for both occasional calculations and regular professional use.

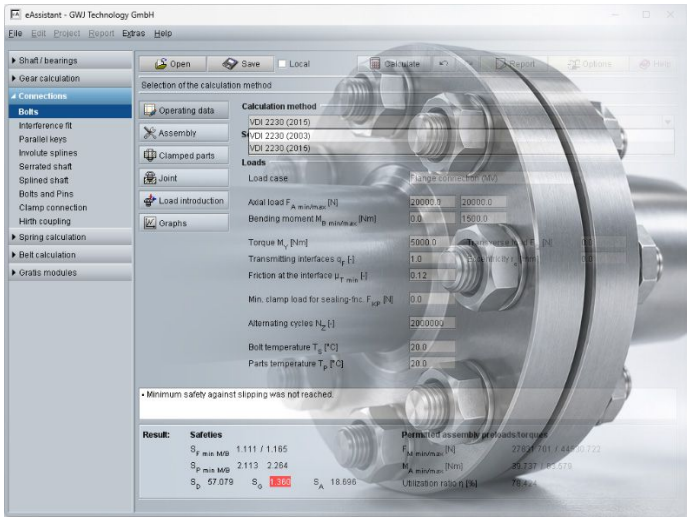


Figure 1: eAssistant Software with Calculation Module for Bolted Joints

With TBK (Figure 2), GWJ offers an established desktop-based calculation software solution that is widely used, particularly in the small and medium-sized gearbox manufacturing sector. The software offers the same calculation modules as eAssistant, as both software products are based on the same development

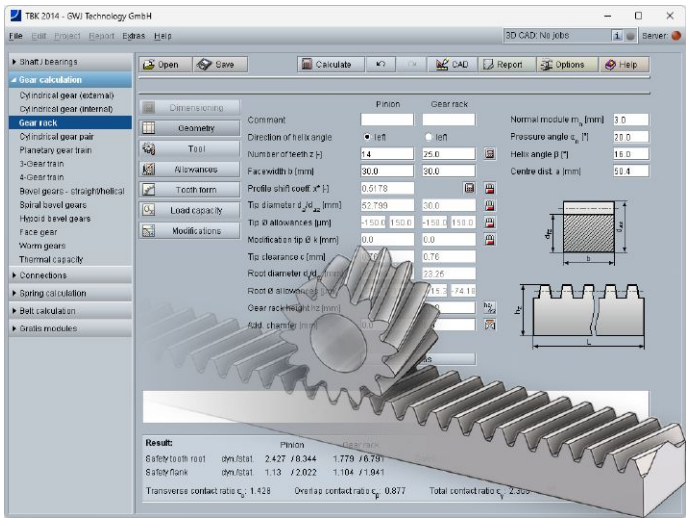


Figure 2: TBK Software with Calculation Module for Gear Racks

platform. TBK also features Redo/Undo functionality and automatic recalculation whenever input values are changed. Its practice-oriented program structure supports users in systematically addressing and solving engineering challenges.

The SystemManager (Figure 3) represents an important extension of these capabilities. While the calculation modules focus on the detailed analysis of specific machine elements, the SystemManager enables the analysis of the entire gearbox system. Multiple shafts, gears, bearings and other components can be represented within a single integrated model. This makes it possible to account for interactions between components and systematically investigate the effects of different operating and loading conditions. By integrating FE components, deformations of planet carriers and gear bodies, as well as housing stiffness, can also be taken into account with relative ease.

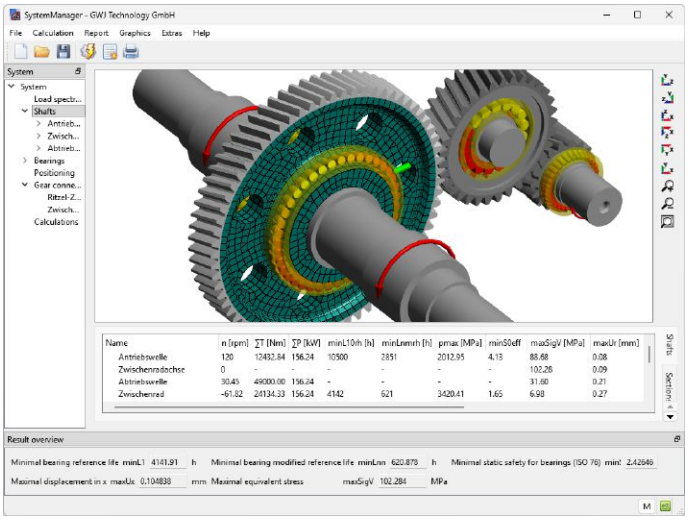


Figure 3: SystemManager Extension of eAssistant/TBK

GearEngineer: Precise Gear Geometries for Modern Manufacturing Processes

One of GWJ's key technological strengths lies in the development of its specialised gear design software, GearEngineer (Figure 4). The software goes beyond conventional gear geometry calculations, enabling the generation of accurate, true-to-life three-dimensional gear tooth geometries.

A key element of this capability is the use of mathematical manufacturing simulations. Rather than considering only an idealised theoretical tooth form, the software takes into account the actual geometry resulting from the specific manufacturing process and the tools used. Profile and flank modifications, as well as microgeometry, can also be incorporated into the calculations.

GearEngineer supports the design of external and internal cylindrical gears, as well as straight and helical bevel gears, including spiral bevel gears. For microgeometry design, particularly in the case of bevel gears, GearEngineer features a tooth contact analysis (TCA) to simulate the contact pattern. Collision detection is performed simultaneously.

The calculated geometries can be exported at high resolution in common CAD exchange formats such as STEP and IGES. This creates a seamless link between gear design, engineering and manufacturing.

This technology is particularly valuable for flexible gear manufacturing using 5-axis milling. The precise 3D tooth geometries can serve as the basis for direct manufacturing. This opens up new possibilities for producing complex gear geometries, prototypes, special-purpose gearboxes and small production batches.

A recent example of ongoing development is the calculation of face couplings based on bevel gear tooth geometries. The software also supports contact pattern design and the definition of the required microgeometry modifications. The resulting high-resolution 3D models can subsequently be used for manufacturing by means of 5-axis milling.

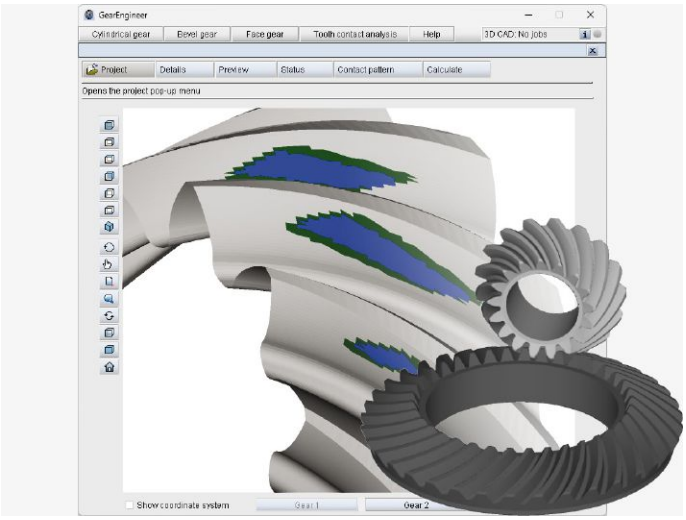


Figure 4: GearEngineer Software with Tooth Contact Pattern Module

Seamless Integration of Calculation and CAD Design

Another key focus of GWJ Technology is the integration of engineering calculations and design processes. With its 3D CAD plugins (Figure 5), calculation functions can be integrated directly into the respective CAD environment. This helps reduce discontinuities in the workflow between calculation software and CAD systems.

The results of engineering calculations can be

directly incorporated into the design process. Changes to geometry or design parameters can be efficiently transferred into the development workflow. This facilitates iterative optimisation and ensures a consistent data basis from the initial design concept through detailed engineering and the creation of manufacturing drawings.

In combination with the SystemManager and GearEngineer, this creates a powerful digital development workflow: individual components are dimensioned, interactions within the complete gearbox system are analysed, and the resulting gear geometries can be made available for further CAD processing and manufacturing.

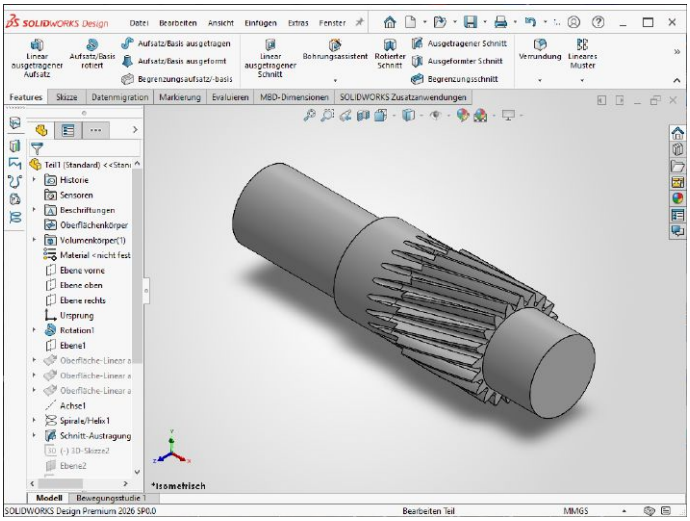


Figure 5: eAssistant/TBK 3D CAD Plugin for SOLIDWORKS

A Wide Range of Applications in Gear and Drive Technology

GWJ's software solutions are used in numerous areas of mechanical and plant engineering. A particular focus is on conventional gearbox engineering. Applications include industrial gearboxes, automotive transmissions, planetary gearboxes, as well as drive systems for locomotives, rail vehicles, construction machinery and agricultural equipment.

Other important fields of application include wind turbines, extruders, pumps, compressors, water turbines and marine propulsion systems. The calculation software is also used in the aerospace industry, motorsports and test bench applications.

Particularly in demanding gear applications, the combination of standards-compliant load capacity calculations, detailed gear geometry design and realistic system-level analysis provides significant added value. Engineers can evaluate loads, gear parameters and system interactions at an early stage of development, enabling potential design weaknesses to be identified at an early stage.

The international reach of GWJ's software solutions is reflected in their global user base: customers in more than 45 countries across six continents rely on the programs for engineering and design tasks. The range of applications extends from precision engineering to heavy mechanical engineering, covering both low-speed drives and highly dynamic turbomachinery, with rotational speeds of up to 500,000 rpm, for example.

Engineering Expertise as the Foundation for Innovation

In addition to its standard software products, GWJ Technology offers custom software development, customer-specific calculation and configuration tools, as well as engineering services. These include calculation services for drive technology, reverse engineering projects, technical analyses, expert assessments and consulting services.

Close collaboration with users from industry and mechanical engineering provides an important foundation for the continuous development of the software. Technological requirements arising from real-world engineering and manufacturing processes are directly incorporated into new features and ongoing improvements.

Conclusion: Digitalisation Across the Entire Process Chain

With its comprehensive portfolio, GWJ Technology supports companies in the gear and transmission industry throughout the key stages of product development. From standards-compliant design and calculation of classical machine elements and the integrated analysis of complex gearbox systems to the generation of actual 3D gear geometries for modern manufacturing processes, GWJ provides end-to-end digital engineering tools from a single source.

The combination of engineering expertise, precise calculation methods, CAD integration and manufacturing-oriented geometry calculations provides the foundation for more efficient development processes, reliable designs and innovative manufacturing concepts. In this way, GWJ Technology makes an important contribution to the advancement of modern gear and drive systems.

When a millisecond makes all the difference: intelligent collision protection

- By Luca Bruni



A single collision can halt a machine for days with enormous loss of money, especially in automated, unmanned production environments; this is a risk nobody can take. A collision can be caused by several factors and cannot be avoided in advance, but the GEMCMS system from Artis Marposs intervenes in under one millisecond, avoiding its consequences, such as damaging the machine, machining stops, loss of machine precision, breakage of the tool, damage to the piece and high and long repairing costs

The invisible risk of unattended shifts

Lights-out manufacturing, night shifts and weekends running without personnel are a growing reality across the industry. But without an operator present, even a simple error such as a previous process missing or an incorrect zero-point offset can trigger a collision during a rapid traverse move. The result: destroyed spindle bearings, broken tools, damaged workpieces, and machine downtime that can stretch into days.

“A single undetected collision can wipe out weeks of planned production and destroy components worth tens of thousands of euros."

The GEMCMS system from Marposs was also developed for this scenario: to protect machine tools, robots, and handling systems when no human eye is watching.

A hardware response, not a software alert

Speed is everything. When a collision occurs, kinetic energy transfers to mechanical structures within fractions of a millisecond. A system that detects the event after 10 or 20 ms is already too late. GEMCMS continuously evaluates signals from sensors with an internal cycle time of less than 1 ms. When a defined collision threshold is exceeded, the system triggers a direct hardware interrupt; drives are actively counter-controlled or de-energised before the energy can irreparably damage the spindle.

A self-contained, dedicated protection system

GEMCMS responds in under 1 ms via a direct hardware interrupt to the drive controller, without communication latency. Our sensor can detect mechanical deformation induced by dynamic or quasistatic impacts. Thresholds are fully configurable to meet each application's requirements.

Where GEMCMS is used

The system is designed for any environment where unplanned downtime carries a high cost. Typical applications include:

- High-value machining centres running continuous production
- Automated milling and turning lines
- Robotic cells for component handling
- Any machine operating in unmanned shifts, nights, weekends, ghost shifts

The cost of not having it

Protecting a single motor spindle, whose replacement cost typically ranges from $30,000 to $50,000, not counting lost production, is already sufficient to recover the entire investment in the monitoring system. On top of that, GEMCMS provides the confidence to extend production into unmanned night and weekend shifts, knowing that in the event of an anomaly, the machine will stop itself before the damage propagates.

“Preventing a single collision event is enough to pay back the full cost of the monitoring system."

When integrated with the other modules of the GENIOR MODULAR process monitoring line, GEMCMS becomes part of a complete sensory infrastructure, combining real-time collision protection, tool breakage and wear detection, and predictive maintenance into a single, unified system for fully autonomous production.



Luca Bruni
Machine Tool Monitoring
Sales & Marketing Manager, Marposs

Seco introduces MS3501 milling grade for high-heat and adhesive materials

- Gear Technology India



MS3501 milling grade

Seco® has launched MS3501, a new high-productivity milling grade developed for demanding applications involving heat-resistant and adhesive materials across ISO P, M, and S.

Stable cutting at high speeds in difficult materials

Built on the latest micro-alloyed, coarse-grained cemented carbide platform, MS3501 combines a heat-resistant substrate with a tough Ti(C, N)–Al O CVD coating to deliver stable cutting and improved wear resistance at higher cutting speeds. The grade is designed for materials with low thermal conductivity, including superalloys, precipitation-hardened steels, high alloy steels, and stainless steels.

Predictable and stable performance in variable conditions

Advanced pre- and post-treatment processes reduce friction and help suppress built-up edge, chip welding, and chatter in adhesive materials, enabling more predictable tool life and controlled cutting conditions.

"MS3501 targets applications where heat and adhesion typically limit productivity," says Markus Kilpinen, Global Product Manager for Milling at Seco. "It delivers stable performance even in less rigid setups or variable machining conditions."

Suitable for aggressive operations due to high heat resistance

The grade features a strengthened binder phase for improved resistance to chipping, cracking, and thermal shock, making it suitable for medium to rough milling operations. Integrated edge detection technology supports full edge utilisation and reduced tooling waste.

MS3501 complements the PVD-coated MP2051 grade, offering higher heat resistance and cutting speed capability for aggressive milling operations.

From Automation to Intelligence: How AI is Reshaping the Modern Manufacturing Shop Floor

- By Srinivas Choudhary, Founder & CEO of Alligator Automations

Manufacturing has spent decades making machines faster, more precise and more capable. Yet, as production environments become increasingly complex, the challenge is no longer limited to automating individual tasks. A production line can operate efficiently, even while delays in packaging, material movement, or palletising create bottlenecks further down the process. Similarly, an equipment failure at one point can disrupt several connected operations. For manufacturers, the real challenge is ensuring that the entire shop floor operates as one coordinated system.



This is where the next phase of industrial automation is emerging. The future of industrial automation lies in making the manufacturing process smarter through artificial intelligence. This would allow machines to understand the data being collected by them and to be able to adapt to changing scenarios. The shift is therefore from simple automation of tasks to intelligent systems supporting the overall process.

Automating Beyond Individual Tasks

Manufacturing is one area that has already been revolutionised by automation. Tasks such as filling, bagging, packaging, conveying and palletising can now be accomplished with considerably reduced human involvement. This has enhanced efficiency and workplace safety in addition to allowing greater volume production for manufacturers.

However, conventional forms of automation are usually designed in relation to preset commands. They work exceptionally well when the surrounding environment is stable. The current environment of manufacturing is, however, becoming increasingly dynamic. Manufacturers are processing many different product forms, smaller production batches, customer demands and delivery schedules. The next frontier for automation is therefore not just making more tasks automated but making the automated system adaptable and interconnected.

From Machines Working Separately to Systems Working Together

The most promising feature of AI in automation would be to link those processes that have been previously considered as separate tasks. In the final stages of production, there might be several operations performed, including filling, packing, conveyance, palletising, wrapping, and dispatch. Every process impacts the others. The inefficiency in these operations might not become evident when performed individually.

With the use of AI technology, there would be an analysis of the information available about all those processes that are interlinked. Rather than just focusing on each machine separately, there would be a broad view regarding the movement of materials and products.

Making Packaging More Responsive

However, the challenge for packaging is to become more adaptable, being able to handle increased product variety without reducing the speed and consistency of packaging operations. Bagging, filling and secondary packaging have become automated; however, flexibility will become equally significant. AI can make these packaging systems more adaptable by drawing on information about sensors, machines and manufacturing process changes. Such changes can be more easily detected, which enables automation systems to adapt their actions in accordance with changing conditions.

This allows for the creation of a more flexible packaging approach that is adaptable to the production process environment.

Bringing Intelligence to Material Movement

The efficiency of the production process is determined by the processes that occur between

the production steps. Materials and products should move constantly throughout the factory floor, but any disruptions may have an adverse effect on productivity. An automatic conveyor and handling system makes sure that the materials are conveyed from place to place. The AI will optimise the efficiency of the conveyor and handling process by analysing the data on the production demands, movement and limitations.

Making Palletising More Flexible

Another field that has evolved in accordance with the demands of modern manufacturing is palletising. Modern manufacturers have to cope with a wide range of products, packaging, and pallets. Hence, apart from fast and precise functioning, robotic palletising systems should be highly flexible.

When robotic palletising systems are provided with machine vision, sensors and AI systems, their flexibility becomes even higher. Thus, manufacturers can control a larger variety of products and production processes in the last stage of production.



Predicting Disruptions Before They Happen

As manufacturing systems grow more interconnected, equipment reliability becomes even more critical. Any failure in any part of the system has the potential to cause a chain reaction throughout packaging, material handling, palletising, and dispatch.

AI technology can assist in solving this problem through analysis of equipment data and detection of anomalies in their operation. Maintenance specialists will no longer be bound by regular cycles and will be able to perform maintenance according to the actual condition of equipment. Of course, the benefits of such maintenance do not end with fault prevention. More intelligent equipment means better asset management and production planning.

Creating an Integrated Manufacturing Ecosystem

This transformation begins only when automation, data, and intelligence converge across the shop floor. Packaging machinery, robots, conveyors, sensors, and dispatch systems individually produce useful data about production operations, from material movement to the disposition of products. Using this data, manufacturers can have a much better understanding of their production operations. This is because AI technology can analyse this data to find out repeating patterns, operational challenges, and areas for improvement.

With time, this will bring the manufacturing operations to a state where decisions will be increasingly based on the real-time operation of the production process rather than on past or manually observed data.

The Shift from Automation to Intelligence

The manufacturing shop floor is moving into an era where automation cannot be seen as the only ultimate goal anymore. Rather, there is a need to develop systems that are capable of connecting processes, understanding information and adapting to changes.

In this regard, AI creates a chance to introduce intelligence into all phases of the production flow, from packaging and material handling to palletising and dispatch. When these processes are carried out in connection with each other within a single ecosystem, manufacturers will be able to get closer to not only automated but also intelligent and adaptive manufacturing processes.

The future of manufacturing is, thus, not determined by the number of automated processes but by their intelligent interaction. The evolution from automation to intelligence is all about constructing shop floors that can understand what is going on and constantly improve the process of products' movement from production to dispatch.



Srinivas Choudhary
Director
Alligator Automations

From Components to Capabilities: Can Indian Gear Manufacturers Enter the Global Tunnel Boring Machine (TBM) Supply Chain? Part 2

- By Sushmita Das



In Part 1, we examined how India's expanding underground infrastructure sector is creating opportunities for heavy-duty gear manufacturers, particularly in the development of planetary gearboxes, ring gears and high-torque transmission systems used in Tunnel Boring Machines (TBMs).

The next question concerns the industry's ability to convert this emerging demand into a manufacturing opportunity. Can Indian gear manufacturers move beyond conventional industrial gearing and become qualified suppliers to global TBM manufacturers?

The answer will depend on three critical factors: manufacturing capability, technology partnerships and the ability to meet demanding application-specific performance requirements.

India's Localisation Drive: A Turning Point for the Supply Chain

India's dependence on imported TBMs and specialised components has brought the issue of domestic manufacturing into sharper focus. Supply chain disruptions and export restrictions have highlighted the strategic importance of developing indigenous capabilities in critical infrastructure equipment.

Recent developments indicate a shift towards domestic TBM manufacturing. According to industry reports, India is progressing towards manufacturing TBMs with diameters of 8 metres and 15 metres, with plans to develop machines exceeding 16 metres. Tamil Nadu is emerging as an important manufacturing base for this transition.

This development has implications for the gear industry. As TBM manufacturing expands domestically, opportunities could emerge for Indian suppliers of planetary gearboxes, large ring gears, pinions, bearings, shafts and other precision transmission components.

The localisation opportunity is not limited to supplying components to Indian projects. Developing a qualified domestic supply chain could eventually position Indian manufacturers as suppliers to international TBM manufacturers.

Global Technology Providers and the Competitive Landscape

The specialised nature of TBM drive systems has created a market dominated by established international manufacturers. Their expertise extends beyond individual gears to complete power transmission solutions.

Some notable technology providers include:

ZOLLERN, Germany

ZOLLERN manufactures specialised planetary gearboxes and integrated drive systems for hard rock, Earth Pressure Balance (EPB) and microtunnelling applications. Its TBM gearbox range includes solutions with standard drive torques of up to 3 million Nm. The company also offers liquid-cooled systems, integrated brakes and overload protection.

SEW EURODRIVE, Germany

The company offers industrial drive technology and gearbox solutions for tunnelling and heavy construction applications. Its expertise in planetary and industrial gear units makes it a relevant technology provider for high torque transmission requirements.

Flender, Germany

Flender has an established presence in heavy industrial power transmission, including planetary gear technology. Its experience in mining and other high load applications is relevant to the technical requirements of underground construction machinery.

David Brown Santasalo

The company specialises in heavy-duty industrial gear systems and engineered transmission solutions for demanding industries, including mining and minerals processing.

Bonfiglioli, Italy

Bonfiglioli offers planetary gearboxes and drive solutions for construction, mining and other heavy machinery applications.

For Indian manufacturers, these companies represent potential technology partners, competitors and benchmarks for developing application-specific gear solutions.

It is important to distinguish between companies supplying complete TBM drive systems and manufacturers with adjacent industrial gearing capabilities. Not every supplier in the latter category is a confirmed TBM gearbox supplier.

Indian Manufacturers: Where Does the Opportunity Lie?

India has an established industrial gear manufacturing base serving sectors such as cement, steel, mining, power generation, wind energy and material handling.

Several companies have capabilities that could be relevant to the development of TBM transmission components.

Elecon Engineering Company

With experience in industrial gearboxes and material handling equipment, Elecon operates in applications involving high torque and demanding operating conditions. Its industrial gearbox expertise provides a potential foundation for exploring specialised tunnelling applications.

Premium Transmission

The company manufactures industrial gearboxes and power transmission solutions for sectors including steel, cement, mining and infrastructure. Its experience in heavy-duty drive systems could be relevant to auxiliary TBM applications and specialised gearbox development.

Bharat Gears

The company's expertise in gear manufacturing, automotive transmission components and precision gear production represents a possible starting point for exploring specialised gear applications.

David Brown Santasalo India

With access to the group's international engineering and manufacturing expertise, its Indian operations could play a role in serving the country's growing demand for heavy industrial transmission solutions.

These companies should be viewed as potential participants in the wider TBM supply chain rather than confirmed suppliers of main cutterhead gear systems.

The Manufacturing Capabilities That Will Matter

Entering the TBM supply chain requires more than conventional gear manufacturing infrastructure. The components must withstand continuous operation, heavy shock loads, variable torque and challenging underground conditions.

Some of the critical manufacturing capabilities include:

1. Large Gear Manufacturing

The production of large diameter internal and external ring gears requires specialised gear cutting, machining and inspection facilities. Maintaining dimensional accuracy across large components is particularly challenging.

2. Advanced Heat Treatment

Case carburising, quenching and controlled tempering are essential for achieving the required surface hardness, core strength and fatigue resistance.

3. Precision Gear Grinding

Profile and lead accuracy, tooth contact patterns and surface finish directly influence transmission efficiency, vibration and operational reliability.

4. Metallurgical Validation

Material selection, cleanliness, hardenability and microstructural consistency play an important role in determining the service life of heavily loaded gears.

5. Testing and Quality Assurance

Manufacturers must demonstrate dimensional accuracy, load-carrying capacity, vibration performance

TBM subsystem	Gear application
Screw conveyor	Planetary and helical gearboxes
Belt conveyor	Helical and bevel helical gearboxes
Segment erector	Planetary and slewing drives

Gripper system	Hydraulic and mechanical drive systems
Muck handling equipment	Industrial gearboxes
Cutterhead positioning	Slewing and reduction drives
Service and handling systems	Spur and helical gearboxes

and reliability through appropriate inspection and testing procedures.

Investment in these capabilities will be essential for Indian manufacturers seeking qualification from international TBM OEMs.

Beyond Main Drives: Opportunities in Auxiliary Gear Systems

While the cutterhead drive represents the most demanding gearing application in a TBM, several auxiliary systems also depend on reliable power transmission.

These include:

These applications could provide Indian manufacturers with an entry point into the TBM supply chain.

Rather than immediately competing in the highly specialised main cutterhead drive segment, domestic suppliers could initially target auxiliary transmission systems, replacement gears and maintenance requirements.

This would also allow manufacturers to build application experience and establish relationships with TBM OEMs and infrastructure contractors.

Aftermarket and Maintenance: A Recurring Business Opportunity

TBMs operate in demanding environments where maintenance planning directly affects project economics. Unlike conventional industrial installations, accessing and replacing major drivetrain components inside a tunnel can be extremely complicated. Equipment downtime can disrupt excavation schedules and increase project costs. This creates opportunities in replacement gears, gearbox refurbishment, condition monitoring, lubrication management and predictive maintenance.

For Indian manufacturers, the aftermarket could become an important business segment, particularly as the installed base of TBMs expands across metro, road, railway, hydropower and water infrastructure projects.

Developing local repair and refurbishment capabilities could also reduce dependence on overseas service providers and improve component availability.

The Road Ahead: Building a Competitive Indian Supply Chain

The next phase of India's TBM manufacturing journey will require collaboration between machine manufacturers, gear companies, component suppliers, research institutions and infrastructure developers.
Technology transfer agreements, joint development programmes and supplier qualification initiatives could accelerate the process.

Indian gear manufacturers will also need to invest in specialised machinery, advanced inspection systems, metallurgical capabilities and application engineering teams.
The opportunity is not necessarily to replace established international suppliers overnight. It is to gradually develop the capabilities required to participate in a technically demanding global supply chain.

GTI Outlook: From Infrastructure Demand to Manufacturing Opportunity

India's growing underground infrastructure network is creating a new avenue for the gear and power transmission industry. The expansion of domestic TBM manufacturing could further strengthen this opportunity by encouraging the localisation of critical components and drive systems.

For gear manufacturers, the potential extends from large diameter ring gears and planetary gearboxes to auxiliary drives, replacement components and specialised maintenance services.

However, entering this segment will require long-term investment, stringent quality standards and close collaboration with TBM manufacturers.

The next growth opportunity may not lie only in manufacturing gears for conventional industrial applications. It could also come from supplying the precision transmission systems that make some of the world's most complex infrastructure projects possible.

For India's gear industry, the underground infrastructure boom presents an opportunity to move up the technology value chain, strengthen domestic manufacturing and establish a presence in a specialised global market.



Sushmita Das
Associate Editor
Gear Technology India

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- By Gear Technology India

New India-based organisation brings software protection and licensing expertise closer to India's growing ecosystem of software vendors and intelligent device manufacturers.



Karlsruhe, Germany / Bengaluru, India: Wibu-Systems, a global provider of software protection, licensing and cybersecurity solutions, marked a new stage in its long-term commitment to India with the official inauguration of WIBU-SYSTEMS India Pvt. Ltd. on October 15, 2026, in Bengaluru. Organised in collaboration with VDMA India, the launch brought together Wibu-Systems' CEO and co-founder Oliver Winzenried, senior specialists from the company's German headquarters, the leadership of its Indian organisation, and representatives from India's industrial and technology community. Discussions focused on software protection, licensing and the development of sustainable digital business models.

India and Germany: A Growing Technology Partnership

India and Germany share a substantial and increasingly technology-driven economic relationship. Bilateral merchandise trade reached approximately USD 35.4 billion in 2025, while total bilateral foreign direct investment stood at around USD 30.4 billion in 2024. More than 2,000 German companies are active in India, with investments extending beyond manufacturing into R&D, engineering, digital capabilities and technology-intensive operations.

The next phase of this relationship is expected to move beyond conventional buyer-seller arrangements. Technology partnerships, local manufacturing, supplier integration, licensing, R&D collaboration and joint innovation are set to play a growing role as India strengthens its position as a manufacturing, engineering and digital technology base. By 2030 and beyond, the strength of Indo-German industrial collaboration will increasingly depend on how closely companies, technologies, talent and industrial ecosystems become interconnected.

Against this backdrop, Wibu-Systems' permanent presence in India is intended to connect its German technology base more closely with the country's expanding software and industrial ecosystem. Based in Hyderabad, WIBU-SYSTEMS India Pvt. Ltd. provides software vendors, intelligent device manufacturers, industrial enterprises and technology partners with more direct access to the company's expertise in software IP protection and licensing.

"Our investment in India is about much more than establishing another location on the map. We see a market with extraordinary engineering competence and a growing ability to create its own digital intellectual property and software-driven products," said Oliver Winzenried, co-founder and CEO of WIBU-SYSTEMS AG. "With WIBU-SYSTEMS India, we are creating the local foundation for long-term cooperation while keeping our customers closely connected with the technology, research and expertise developed at our headquarters in Germany. We want to help Indian innovators protect what they create and build scalable business models around it."

From Protecting Software to Running the Software Business

At the centre of Wibu-Systems' offering in India is CodeMeter, a technology platform that combines software protection with flexible licensing and entitlement management. Its capabilities extend across the software business lifecycle. Developers can protect software and firmware against unauthorised copying, manipulation and reverse engineering, while manufacturers can control access to paid functionalities. Commercial teams can also implement perpetual, subscription-based, feature-based, usage-based and other licensing models tailored to different products and markets.

Companies beginning their licensing journey can use CodeMeter Licensing-as-a-Service (CmLaaS)

to accelerate implementation through ready-to-use infrastructure and predefined workflows, without having to build an entire licensing backend independently. This provides a starting point that can evolve alongside products, customer numbers, distribution models and commercial requirements.

The CodeMeter ecosystem also supports more advanced licensing operations. CodeMeter License Portal enables customers and partners to access and manage their assigned licences through self-service processes, while delegation capabilities extend licensing workflows into reseller and distribution networks. CodeMeter License Reporting provides visibility into licence usage, helping software vendors understand how licensed products and functionalities are being used and identify opportunities to develop future commercial offerings.

Together, these capabilities provide a framework for managing the relationship between software vendors, device manufacturers, distribution partners and end users beyond the initial sale. This broader approach was also reflected in the launch event's agenda, which covered software IP protection, access control, subscription models, usage-based licensing and software-enabled services.

Local Engagement Backed by Headquarters Expertise

WIBU-SYSTEMS India Pvt. Ltd. is led by Dr Ashok-Kumar Chandra-Sekaran, who spearheads the company's business development in India. Combining his role at Wibu-Systems' headquarters in Karlsruhe with frequent engagement in the country, he is responsible for connecting the Indian organisation with the company's development, product and specialist teams in Germany while building relationships and addressing the priorities of the local market.

"Our task is to connect the depth of Wibu-Systems' technology with the realities of doing business in India," said Dr Ashok-Kumar Chandra-Sekaran, Managing Director of WIBU-SYSTEMS India Pvt. Ltd. "That means being close to customers and partners, understanding how their products are evolving, and identifying where software protection and licensing can create genuine commercial value. Indian companies are developing increasingly sophisticated software-enabled offerings, and our local presence allows us to work with them from the first licensing concept through to scalable deployment and ongoing business operations."

The Board of Directors of WIBU-SYSTEMS India Pvt. Ltd. comprises Dr Ashok-Kumar Chandra-Sekaran, Elke Winzenried and Ravi Ladia.

The official launch took place on October 15, 2026, at The Park, MG Road, Bengaluru. Organised by VDMA India, the invitation-only event featured discussions with Wibu-Systems' leadership and specialists, insights into software protection and licensing, and a live demonstration of CodeMeter technology.

The establishment of a permanent organisation in India represents a transition from Wibu-Systems' initial market-building activities to a sustained local presence. The move is intended to support businesses as software becomes an increasingly important source of intellectual property, product differentiation and revenue.

Gear Technology India at the Wibu-Systems India Launch 2026

The official launch of WIBU-SYSTEMS India Pvt. Ltd. marked a new chapter in the company's engagement with the Indian market, with discussions focusing on software protection, licensing and monetisation across industrial automation, automotive, medical technology and other software-driven sectors.

As software becomes an increasingly integral component of industrial products and connected devices, secure licensing is gaining importance in safeguarding intellectual property, preventing unauthorised use and enabling flexible commercial models, including subscription-based and usage-based services.
Sushmita Das, Associate Editor, Gear Technology India, represented the publication at the press meet and official launch. The press briefing brought together industry leaders and technology experts from India and Germany to discuss software security, technological developments and emerging business opportunities.



The event featured Mr Rajesh Nath, Managing Director, VDMA India; Dr Christoph Dorschfeldt, Consul General-Designate, German Consulate; Mr Oliver Winzenried, Co-founder and CEO, WIBU-SYSTEMS AG; Mr Rüdiger Kügler, Vice President, Professional Services and Security Expert, WIBU-SYSTEMS AG; and Dr Ashok Chandra-Sekaran, Managing Director, WIBU-SYSTEMS

India Pvt. Ltd.

The programme included leadership addresses, customer experiences, industry perspectives on Indo-German collaboration and a live demonstration of CodeMeter's software protection and licensing solutions. Discussions highlighted how secure software licensing



can help manufacturers safeguard software assets, manage access to product functionalities, develop differentiated offerings and explore additional revenue streams through software-enabled services.

The establishment of the Indian subsidiary is expected to strengthen Wibu-Systems' engagement with local businesses and provide closer access to its software protection and licensing expertise as India's industrial and technology ecosystem continues to evolve.

About Wibu-Systems

Wibu-Systems is a global provider of cybersecurity and software licence lifecycle management solutions. The company develops security technologies designed to protect intellectual property embedded in digital assets and support the monetisation of technical know-how. Its CodeMeter suite comprises interoperable hardware and software modules that protect software publishers and intelligent device manufacturers against piracy, reverse engineering, tampering, sabotage and cyberattacks across multiple platforms and industries.



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IMTS 2026 Brings Global Manufacturing Community Together to Accelerate Industrial Innovation

- By Sushmita Das

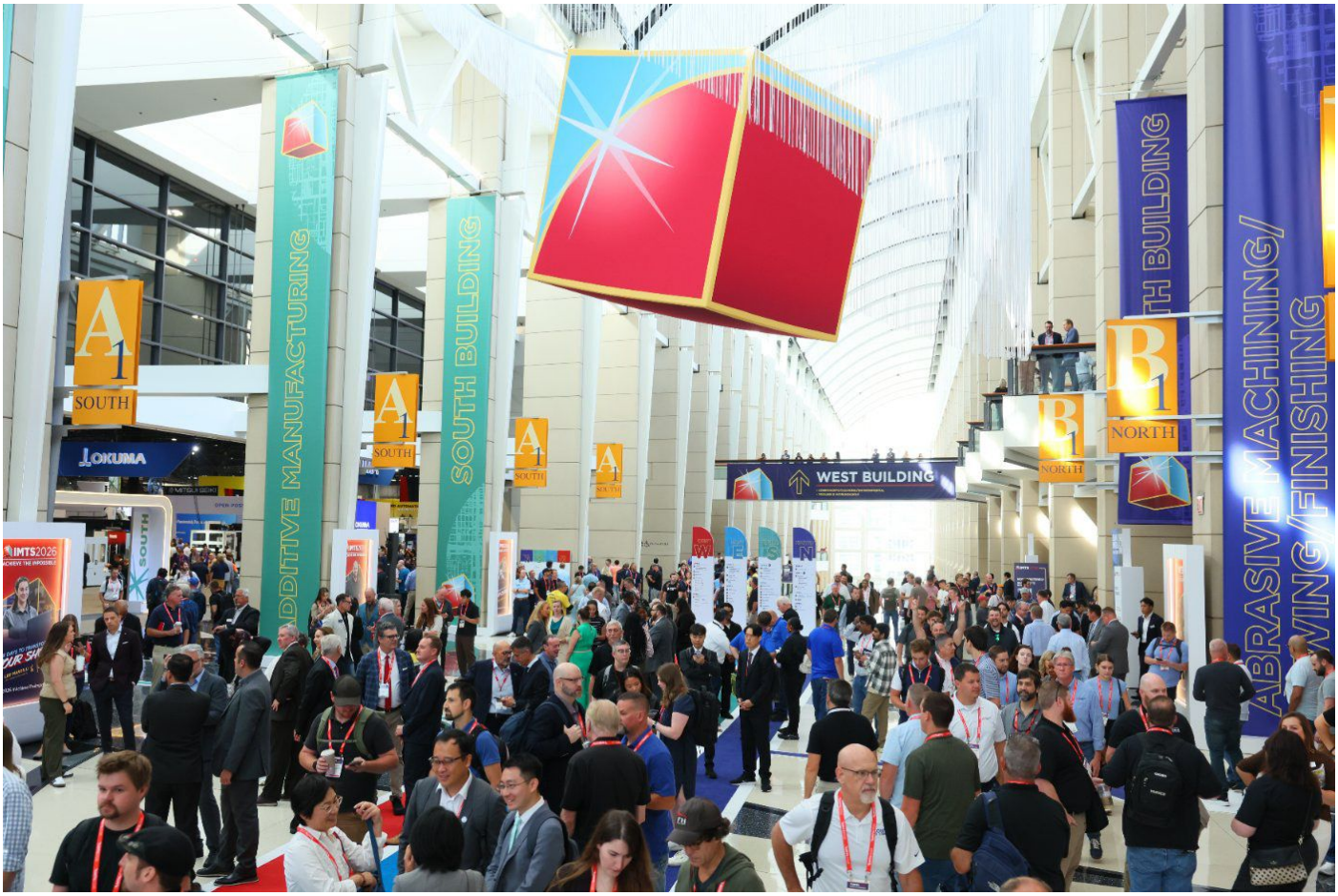


Image from IMTS 2026. Photo courtesy of IMTS.

The six-day International Manufacturing Technology Show in Chicago brought together 1,788 exhibitors and manufacturing professionals from 114 countries, showcasing the growing role of artificial intelligence, automation, robotics, additive manufacturing and digital technologies in strengthening industrial capabilities.

Chicago, USA: The 2026 edition of IMTS – The International Manufacturing Technology Show, held from September 14 to 19 at McCormick Place, Chicago, concluded with 91,295 registrants, reinforcing its position as one of the world's leading platforms for manufacturing technology and industrial innovation. Organised by AMT – The Association For Manufacturing Technology, the event brought together manufacturers, technology providers, machine builders, industry leaders, investors, academic institutions and government representatives to explore emerging technologies and their applications in modern production environments.

IMTS 2026 featured 1,788 exhibiting companies, including 400 first-time exhibitors, across 1.17 million square feet of exhibition space. The event attracted participants from all 50 US states, Washington, D.C., Puerto Rico and 114 countries, reflecting its international reach and the growing importance of manufacturing technology in global industrial development. The Smartforce Student Summit also recorded significant participation, attracting 14,447 students and highlighting the industry's efforts to engage the next generation of manufacturing professionals.

A major theme throughout this year's exhibition was the role of advanced manufacturing technologies in strengthening the US industrial base, improving production capabilities and supporting the country's



reindustrialisation initiatives. Discussions and technology demonstrations focused on the convergence of artificial intelligence (AI), automation, robotics, connected manufacturing systems, advanced machining, metrology, additive manufacturing and industrial software.

Douglas K. Woods, President of AMT – The Association For Manufacturing Technology, which owns and produces IMTS, said the exhibition reflected a renewed focus on domestic manufacturing and investment in industrial capabilities. He highlighted how manufacturers are rethinking and regionalising supply chains while investing in technologies that can improve productivity, flexibility and production scale.

Manufacturing Investment Gains Momentum

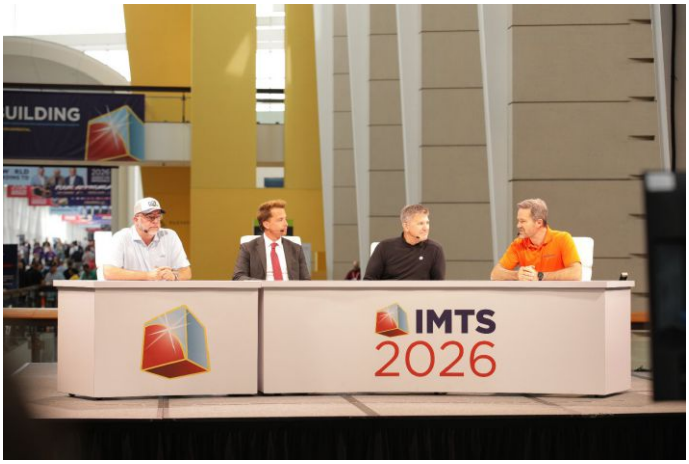
The strong participation at IMTS 2026 coincided with increased investment activity in the US manufacturing sector. According to the US Manufacturing Technology Orders Report issued by AMT, new orders for metalworking machinery reached $605.8 million in July 2026. Cumulative orders through July stood at $4.03 billion, representing a 37.1% increase compared with the corresponding period in 2025.

The report also indicated that manufacturing technology orders had exceeded $500 million for five consecutive months, marking only the second time since data collection began in 1998 that such a trend had been recorded.



The broader economic significance of manufacturing was another focus of the event. US manufacturing generates approximately $3 trillion in annual output, while the sector continues to face workforce constraints. Durable goods manufacturers are estimated to be short of 435,000 workers, strengthening the case for investments in automation, digitalisation and technologies that can increase output without proportionately increasing workforce requirements.

The Reshoring Initiative projected that approximately 400,000 jobs would have been reshored by the end of 2026. Meanwhile, US and foreign companies had announced investment commitments worth $11.2 trillion in the country.



These developments provided an important context for the technologies showcased at IMTS, particularly solutions that enable manufacturers to improve operational efficiency, reduce dependence on manual processes and respond more effectively to changing production requirements.

Strengthening the Defence and Aerospace Manufacturing Base

The importance of advanced manufacturing in supporting national defence and strategic industries featured prominently at IMTS 2026. Presentations included contributions from Vice Admiral Robert Gaucher, Director, Submarine Programs, US Department of War, and representatives of the US Navy.

The discussions highlighted the manufacturing requirements associated with expanding the country's submarine fleet and strengthening the defence industrial base. General Dynamics Electric Boat and Huntington

Ingalls Industries had received a joint contract worth $76.6 billion to build 14 nuclear-powered submarines. Meeting the production requirements of such programmes will require significant manufacturing capacity, skilled labour and improved supply-chain coordination.

Advanced manufacturing technologies, including robotic assembly, automated tooling and additive manufacturing, were identified as important enablers of higher production volumes.

The exhibition also attracted aerospace and defence manufacturers looking for solutions to improve precision, productivity and manufacturing flexibility. These requirements are particularly relevant to gear manufacturers and suppliers of precision mechanical components, where dimensional accuracy, material performance, process reliability and inspection capabilities are critical.



Artificial Intelligence Moves Closer to the Shop Floor

Industrial AI emerged as one of the defining technology themes of IMTS 2026. The exhibition demonstrated how AI is moving beyond experimental applications towards practical deployment in machining, programming, inspection, robotics and production management.

The inaugural IMTS Industrial AI Conference reflected growing industry interest in the subject and sold out twice following an expansion of its capacity. Manufacturers, software developers and technology providers discussed how AI could help address programming complexities, workforce shortages and the need for greater productivity.

One of the key developments was the application of AI in robotic machine tending. Intrinsic Innovation, an AI robotics group at Google, demonstrated how camera-based AI systems can reduce the need for dedicated fixturing and repeated robot reprogramming when introducing new components. Such applications could be particularly valuable for small and medium-sized machine shops handling high-mix, low-volume production.

CloudNC showcased CAM Assist, an AI-powered plug-in compatible with established computer-aided manufacturing platforms, including Autodesk, Mastercam and Siemens. The solution uses physics-based AI to assist with toolpath generation and determine cutting parameters such as depth, width, feeds and speeds. It also identifies potential programming issues while allowing machinists and programmers to retain control over the final output.

According to Dan French, Head of Sales at CloudNC, the technology can significantly reduce programming time, allowing manufacturers to move from programming to machining more quickly.

The growing application of AI in manufacturing was also highlighted by Amazon Web Services (AWS). Steve Blackwell, Leader of AWS' Product Engineering & Services Center of Excellence, observed that manufacturers had moved beyond exploring the potential of agentic AI and were already deploying AI across operations to improve efficiency, quality and agility.

Ryan Kelly, Vice President of Technology at AMT, emphasised the importance of digital technologies in improving productivity from existing capital equipment, particularly as manufacturers face a shortage of skilled workers.

Digital Manufacturing and Interoperability

The AMT Emerging Technology Center (ETC) demonstrated how the integration of digital technologies, automation and additive manufacturing can accelerate product development and improve production flexibility. A key demonstration involved a convergent manufacturing platform for drone production, led by the Manufacturing Demonstration Facility at Oak Ridge National Laboratory. The platform integrated machine tools, industrial robots, collaborative robots, pallet-changing systems and metal and polymer additive manufacturing technologies.

The demonstration highlighted how manufacturers could increase production capacity using interconnected equipment while retaining the flexibility to manufacture different product configurations. The platform produced three different sizes of drone bodies, illustrating the potential of integrated manufacturing systems for responding to changing production requirements.



Another example came from Sandia National Laboratories and its partners, which used AI, advanced computing and metal additive manufacturing to accelerate the development of the Aires Tide flight-test vehicle. The approach reportedly reduced development time by approximately seven times and costs by 15 times compared with conventional manufacturing methods.

Interoperability was another important area of discussion. The demonstrations highlighted the role of MTConnect, a manufacturing communication protocol designed to enable data exchange between machine controls, equipment and software applications.

By making machine data accessible in a standardised format, MTConnect can support connected manufacturing environments and provide the structured information required for AI-based applications and advanced production analytics.

Automation and Robotics Focus on Practical Applications

Automation solutions at IMTS 2026 reflected a shift towards systems that are easier to deploy, operate and adapt to changing manufacturing requirements.

Collaborative robots, or cobots, featured integrated vision systems, advanced end effectors and improved connectivity, enabling manufacturers to automate repetitive operations while maintaining flexibility on the production floor.

Safety technologies, including scanners and proximity detection systems, demonstrated how robots can automatically slow down or stop when people or objects enter designated working zones.





These developments are particularly important for manufacturers looking to introduce automation into existing production environments without extensive changes to factory layouts.

AI-enabled robotics also demonstrated the potential to translate natural-language instructions and handwritten inputs into manufacturing tasks and robot programmes. This could reduce programming complexity and make automation more accessible to smaller manufacturers.

The emphasis was on improving the usability of automation systems while enabling operators to concentrate on higher-value activities.

CNC Machining: More Productivity from Every Machine

CNC machining remained a major focus, with exhibitors presenting technologies designed to increase productivity, reduce setup times and improve machine utilisation.

Multi-tasking machine tools capable of performing several operations in a single setup were among the key highlights. Such systems can reduce component handling, minimise repositioning errors and improve process consistency, particularly in the production of complex precision components.

Manufacturers also demonstrated solutions for increasing unattended machining, automating repetitive tasks and improving machine operation through intuitive controls and graphical programming interfaces.

AI-based assistance and natural-language instructions were increasingly incorporated into control systems to reduce programming effort and make advanced machining technologies easier to operate.

The emphasis on producing more components

per machine and improving output per employee reflects the industry's response to rising production demands and persistent skilled-labour constraints.

Tooling, Workholding and Metrology Support Precision Manufacturing

Developments in tooling and workholding highlighted the importance of integrated solutions for improving machining performance, tool life and process reliability.

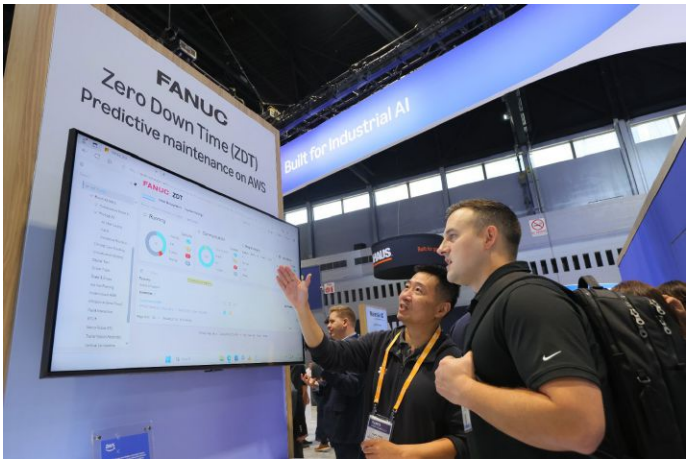
Exhibitors presented advanced cutting-tool geometries, sensor-based technologies and software solutions designed to provide better visibility into toolroom operations. Faster changeover systems and simplified tooling arrangements were also highlighted, particularly for high-mix, low-volume manufacturing environments.

These developments are relevant to the gear manufacturing industry, where cutting-tool performance, workholding stability and process consistency directly influence productivity, surface quality and dimensional accuracy.

Metrology and inspection technologies also featured prominently. Manufacturers demonstrated advanced measurement systems designed to improve inspection speed and provide more comprehensive quality information.

Examples included Renishaw's Equator-X, which combines touch-probe and comparator capabilities, and Hexagon's Optiv S, which incorporates AI-based measurement capabilities. Hexagon also presented MAESTRO, integrating scanning probe and laser scanner technologies to capture component data in a single setup.

The growing integration of measurement technologies with manufacturing processes reflects the industry's move towards data-driven quality assurance and improved process control.





Additive Manufacturing Complements Conventional Machining

Additive manufacturing was positioned alongside metal removal technologies at IMTS 2026, highlighting the increasing integration of both processes in modern manufacturing.

The arrangement reflected how manufacturers are combining additive manufacturing with conventional machining to produce complex components, optimise material utilisation and improve design flexibility.

Metal additive manufacturing also featured in discussions on defence and aerospace production. EOS North America introduced its M4 ONYX metal 3D printer, reflecting the continued development of industrial metal printing technologies.

Glynn Fletcher, President of EOS North America, noted the significant progress made in metal additive manufacturing since the company's first IMTS participation in 2010. He highlighted the growing installed base of metal additive manufacturing systems and their expanding role in the US industrial ecosystem.

For manufacturers of complex mechanical components, the integration of additive manufacturing with conventional machining offers opportunities to explore new component geometries, reduce manufacturing constraints and develop specialised production processes.

Industry Engagement and Knowledge-Sharing Expand

Beyond the exhibition floor, IMTS 2026



strengthened its position as a platform for industry networking, technical discussions and professional development.

The event brought together industry associations, manufacturing organisations, universities, investors and technology communities through conferences, workshops, presentations and networking programmes.

Several specialised conferences recorded increased participation:

- The inaugural IMTS Industrial AI Conference sold out twice following an expansion of capacity.
- IMTS Investor Summit attendance increased by 118%.
- IMTS ELEVATE Conference participation grew by 34%.
- IMTS Job Shops Workshop participation increased by 34%.
- IMTS LATAM technical conference participation grew by 200%.
- EBITDA Growth Systems' conference on manufacturing opportunities in defence, space and aerospace recorded 227% growth.

The participation of organisations such as SME, Women in Manufacturing, the Illinois Manufacturers Association and the Defense Industrial Base Institute at Northeastern University further expanded opportunities for collaboration.

The exhibition also hosted live podcasts and industry discussions, extending conversations beyond the traditional exhibition environment.

Encouraging the Next Generation of Manufacturing Professionals

Workforce development remained another important priority at IMTS 2026. The Smartforce Student Summit attracted 14,447 students, providing opportunities to explore manufacturing technologies, interact with industry professionals and understand emerging career pathways.

Wendy Lawrence, retired US Navy Captain and former NASA astronaut, addressed students and highlighted the importance of manufacturing professionals in supporting technological progress and space exploration.

Industry participation also extended to initiatives supporting student attendance. Reader Precision Solutions, through its Operation Exploration initiative, sponsored 153 students and educators, enabling them to experience advanced manufacturing technologies and interact with professionals from the industry.

The emphasis on student participation reflects the growing need to attract new talent into manufacturing, particularly in areas such as CNC machining, robotics, automation, engineering, software and industrial AI.

Strong Commercial Activity Across the Exhibition

IMTS 2026 also recorded substantial purchasing activity, reflecting manufacturers' willingness to invest in technologies that can address production bottlenecks and improve capacity.

Several exhibitors reported strong interest in machinery and software solutions. Okuma reported that its sales gong had been struck more than 100 times by Friday morning, including a 24-machine order. Tsugami America reportedly sold every machine displayed at the exhibition, while an exhibitor offering an AI-powered software solution reported six-figure sales.

Precision job shop ProCam Services purchased two additional DN Solutions DVF 5000 five-axis CNC machining centres after experiencing increased demand for five-axis machining capabilities following its earlier investment in the same model.

These developments underline the importance of technology exhibitions as platforms not only for product demonstrations but also for business development, investment decisions and direct engagement between manufacturers and solution providers.

IMTS Continues to Strengthen the Global Manufacturing Ecosystem

With 91,295 registrants, 1,788 exhibiting companies and participation from 114 countries, IMTS 2026 demonstrated the growing convergence of manufacturing technologies and the industry's increasing focus on productivity, automation and digital





transformation.

For the global manufacturing community, the exhibition offered insights into how machine tools, cutting technologies, robotics, AI, additive manufacturing, metrology and connected systems are evolving together to address production challenges.

The developments showcased at IMTS also have relevance for India's manufacturing ecosystem, particularly in sectors such as automotive, aerospace, defence, heavy engineering, industrial machinery and precision component manufacturing. As Indian manufacturers continue to strengthen domestic production capabilities and expand their participation in global supply chains, the adoption of advanced machining, automation, inspection and digital manufacturing solutions will remain important. The next edition of IMTS is scheduled for September 11–16, 2028, at McCormick Place in Chicago.

About IMTS

IMTS – The International Manufacturing Technology Show is owned and produced by AMT – The Association For Manufacturing Technology. Recognised as the largest manufacturing technology exhibition in the Western Hemisphere, the event brings together manufacturers, technology providers and industry professionals to explore developments in CNC machining, automation, robotics, additive manufacturing, software, AI and digital manufacturing. IMTS 2026 featured 1,788 exhibiting companies across 1.17 million square feet of exhibition space and attracted 91,295 registrants from 114 countries.

About AMT

AMT – The Association For Manufacturing Technology represents US-based providers of manufacturing technology, including advanced machinery, equipment, devices and digital solutions supporting industrial productivity and competitiveness. Based in McLean, Virginia, AMT works to accelerate manufacturing innovation, strengthen global competitiveness and support the development of the industry's future workforce. The association also owns and produces IMTS – The International Manufacturing Technology Show.

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