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COVER STORY

The Rise of a Strategic Hub: Odisha's Aerospace and Defence Ambition

Shri Hemant Sharma, IAS,
Additional Chief Secretary, Home, Industries & I&PR Department,
Government of Odisha

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Burri Werkzeugmaschinen GmbH & Co. KG
Im Wasen 9
D-78667 Villingendorf, Germany.
India: Telefon: +91-9551358845 / +91-9822775128
E-Mail: arputharaj.kovilpillai@burri.de / kedar.katre@burri.de
Website: www.burri.de

Anitha Raghunath
Director / Publisher
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Dear Readers and Industry Partners,

Welcome to Gear Technology India – Volume 4, Issue 1 (2026), a Special Print Edition published in association with the American Gear Manufacturers Association (AGMA).

While Gear Technology India is a digital-first publication dedicated exclusively to the gear, grinding and power transmission industry, this special print edition has been released alongside our flagship IPTEX & GRINDEX 2026 expo-cum-conference to reach a wider industry audience and strengthen engagement across the manufacturing value chain. Today, the magazine stands as one of the most dedicated voices for the gear industry in India – bridging manufacturers, technology providers, and end users across sectors such as automotive, aerospace, defence, energy, railways, cement, marine, and industrial machinery.

As part of our continued effort to bring the perspectives of policymakers and government initiatives to the forefront, we are honoured to feature Shri Hemant Sharma, IAS, Additional Chief Secretary, Home, Industries & I&PR Department, Government of Odisha. In this issue, he shares his insights on how Odisha is emerging as a significant aerospace and defence manufacturing hub, reflecting the growing synergy between industry and government.

Through this platform, we strive to bring our readers the best of industry news, technical articles, expert insights, and global innovations. Our distinguished advisory board plays a vital role in ensuring that the content remains relevant, forward-looking, and aligned with the evolving needs of the sector.

In the coming years, we aim to further expand the editorial scope and readership of Gear Technology India, strengthening its role as a knowledge and networking bridge between producers and users, and as a trusted source of insight for the evolving power transmission ecosystem.

With its carefully curated mix of technical features, research insights, industry updates, leadership interviews, and integrated industry initiatives, this issue is designed to serve as a valuable knowledge resource for professionals across the gear manufacturing ecosystem.

We sincerely thank you for your continued trust and readership. We hope this edition supports your journey toward higher productivity, precision, and global excellence.

Warm regards,

Sushmita Das
Associate Editor
Gear Technology India

As we present Gear Technology India – Volume 4, Issue 1 (2026), the IPTEX GRINDEX 2026 Special Edition, published in association with the American Gear Manufacturers Association, we are proud to share an edition that reflects the growing technical maturity, strategic relevance, and global integration of India's gear and power transmission industry.

Over the past few years, our publication has undergone a significant editorial evolution. Since 2023, Gear Technology India has transitioned from a quarterly to a bi-monthly publication cycle. This shift was driven by the accelerating pace of technological advancement, policy developments, and market transformation within the manufacturing ecosystem. As innovation cycles shorten and global collaboration intensifies, we recognised the need to provide more frequent, timely, and technically robust content to keep pace with the industry's momentum.

This issue has been carefully structured to address the evolving challenges faced by design engineers, production heads, R&D specialists, and quality professionals. Our technical features explore critical areas such as hobbing optimisation, multi-axis CNC grinding for EV powertrains, fatigue behaviour influenced by surface integrity, gear shaping accuracy, and advanced tooling solutions using CBN. Collectively, these articles provide actionable insights for improving process capability, dimensional accuracy, productivity, and component reliability.

Our cover story, "The Rise of a Strategic Hub: Odisha's Aerospace and Defence Ambition," examines how Odisha is emerging as a vital contributor to high-precision, mission-critical manufacturing. The transformation of regional ecosystems into aerospace and defence hubs reflects a broader industry shift toward tighter tolerances, advanced materials engineering, supply-chain localisation, and digitally enabled production systems.

A key feature of this edition is the MPMA Update on the 2026 Annual Meeting organised by the Motion + Power Manufacturers Alliance. Such international platforms play a crucial role in knowledge transfer, standardisation dialogue, and leadership development, reinforcing the interconnected nature of today's manufacturing landscape.

We are also pleased to introduce our new Women in Tech section. This initiative is designed to spotlight the technical expertise, innovation leadership, and strategic contributions of women professionals across manufacturing engineering, quality systems, metrology, automation, and industrial marketing. By documenting these achievements, we aim to foster inclusivity while strengthening the industry's overall talent ecosystem.

Complementing our editorial content are the Gear Technology India Summit 2026 and the Gear Technology India Awards 2026, which continue to serve as platforms for technical exchange, recognition of industry excellence, and collaborative dialogue across the sector.

We would like to sincerely acknowledge the invaluable support of our Editorial Advisory Board, whose guidance has been instrumental in shaping the technical depth and strategic direction of every edition of Gear Technology India. In particular, Mr. Soundarajan KP, one of our Technical Advisors, has played a pivotal role in strengthening the analytical rigor and technical relevance of our content. His consistent inputs have helped ensure that each issue meets the expectations of industry professionals seeking precision-driven and application-oriented insights.

Our objective remains clear to deliver a technically robust, knowledge-driven publication that supports continuous improvement in gear design, manufacturing processes, inspection methodologies, and strategic growth. We remain committed to evolving alongside the industry we serve.

We thank our readers, contributors, advisory board members, and partners for their continued trust and engagement. Together, we will continue to advance precision engineering and global competitiveness.

gear TECHNOLOGY INDIA

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

PUBLISHER
Anitha Raghunath
anitha@virgo-comm.com

CONTENT CONTRIBUTOR
editorial@geartechnologyindia.com

ASSOCIATE EDITOR
Sushmita Das

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

TECHNICAL EXPERTS
Mahendran Muthu
Vishwajit Kothari

DESIGNER
Aneena AS

ADVERTISING, MARKETING & SALES
Sandiip Sudhir Shetye
sandiip@virgo-comm.com | M: 9833750284

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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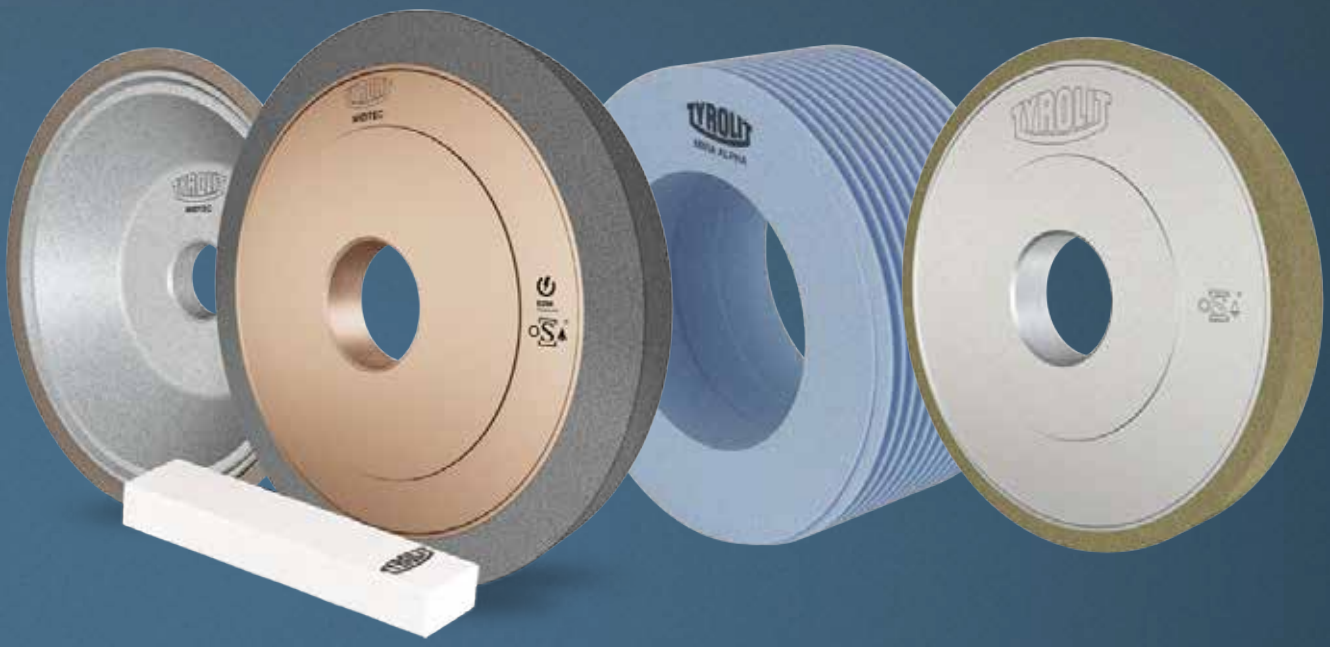

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The Rise of a Strategic Hub: Odisha's Aerospace and Defence Ambition

- By Shriyal Sethumadhavan

Shri Hemant Sharma, IAS,
Additional Chief Secretary,
Home, Industries & I&PR Department,
Government of Odisha

As India accelerates its push towards self-reliance in defence and advanced manufacturing, states are competing to position themselves as strategic industrial anchors. Odisha, long recognised for its mineral strength and metallurgical base, is now undertaking a decisive shift towards value-added precision manufacturing in aerospace, defence, EV and advanced component ecosystems. The state is laying the groundwork to emerge as the focal manufacturing hub for East-Central India.

Shri Hemant Sharma, IAS, Additional Chief Secretary, Home, Industries and I&PR Department, Government of Odisha, in this exclusive conversation with Shriyal Sethumadhavan, outlines the policy thinking, ecosystem strategy and long-term vision driving Odisha's transformation into a nationally significant aerospace and defence manufacturing destination.

Q: Odisha is known for minerals and heavy industry. What is driving its shift towards defence and advanced engineering manufacturing?

One big factor enabling this transition is the government's focus on value addition. Odisha has traditionally been known for mining and mineral-based industries, which means we have a strong presence in steel, stainless steel, aluminium, ferro-chrome and ferro-alloys. This has been our traditional strength, similar to what we share with Jharkhand, Chhattisgarh and parts of West Bengal.

In the last few years, the government is focusing more on encouraging further value addition. The starting point of much of the metallurgy used in aerospace, defence, auto components and other sectors lies in precision alloys, speciality steels and super alloys. So, the government's focus has shifted drastically from 2023-24 towards this segment. We continue to attract mineral-based industries because of the raw material advantage. But to draw this industry further, we need to make additional efforts.

That effort is towards value addition – encouraging companies for whom we already have the base raw materials, such as steel ingots, stainless steel, aluminium and ferro-alloys – and examining whether super alloys and other specialised alloys required for advanced applications can be promoted here. So, the focus on value addition is leading this shift.

Q: Modern defence and aerospace platforms rely heavily on high-precision gear systems, transmission assemblies, propulsion components and advanced metallurgy. How is Odisha building capabilities in this space?

High-precision gear systems, transmission assemblies and propulsion components depend on two critical enablers: advanced skills and a strong manufacturing ecosystem.

First, skilling. These industries require precision-trained professionals, not conventional ITI-level manpower. Odisha has invested heavily in advanced technical training, anchored by the World Skill Centre at Mancheswar. Developed with support from the Singapore government and ITE Education Services as the technology partner, the centre represents an investment of nearly Rs 1,500 crore. Diploma and engineering graduates undergo an additional year of specialised training on sophisticated precision equipment, making them industry-ready for defence, aerospace and auto-component manufacturing. The model is now being expanded with centres in Berhampur and Sambalpur, alongside structured industry placement tie-ups.

Second, ecosystem development. Odisha is systematically attracting precision engineering manufacturers. Companies such as Kalyani Steels, Bharat Forge, Jupiter Wagons and Amsted Industries are establishing operations in the state. The initial focus has been on railway components, a logical entry point given proximity to Kolkata, a major rail equipment hub. Firms such as Texmaco and Premium Transmission are also

progressing with investments, while global engineering players like Danieli Corus are in discussions. Aerolloy Technologies has recently received land for aerospace component manufacturing. The objective is to build integrated engineering clusters anchored by leading precision manufacturers.

In essence, the strategy is twofold: deepen value addition in precision metals and superalloys, and attract expansion-oriented manufacturers to create a sustainable high-precision defence and aerospace ecosystem.

Q: Several companies, including Kalyani Steels, Premier Explosives Ltd, Anadrone Systems, IG Drones and Inventgrid have received approvals in Odisha. What do these new investments mean for Odisha's defence manufacturing ambitions?

Defence and aerospace manufacturing in India is still emerging. For decades, the country relied heavily on imports. That is now changing, and we are positioning Odisha to participate meaningfully in this shift.

Our strategy has been to attract technology-driven domestic players who can scale with rising opportunities. Companies such as Bharat Forge and the Kalyani Group were initially encouraged to set up base material and superalloy facilities. After assessing our policy support, infrastructure and skilled workforce availability, they expanded into machining, forging and casting. Through these anchor investments, we have drawn companies like Amsted Industries and Aerolloy Technologies, gradually building a broader ecosystem.

Our objective is to develop the full value chain – from bulk materials to precision assemblies and sub-assemblies.

To enable cluster-based growth, we have earmarked 1,500 acres near Angul, with 560 acres allotted to Kalyani. The location is strategic: in the heart of the metal belt, within two hours of the state capital and Paradip Port, ensuring logistical advantages for exports and imports. Clusterisation is critical; dispersed units cannot create ecosystem efficiencies.

Unlike established hubs such as Chennai or Bengaluru, which evolved from automotive ecosystems into aerospace and defence, Odisha is building this sector from the ground up. Our approach is to anchor large investments first and allow ancillary growth to follow.
Policy support underpins this strategy. Aerospace and defence are classified as thrust sectors under our industrial policy, eligible for a 30 per cent capital investment subsidy without an upper cap, extendable up to 11 years, including phased investments.

We recognise that aerospace and defence manufacturing scales gradually. Companies expand component by component, facility by facility. Our policy framework is designed to support this phased growth and long-gestation investment cycle.

Q: Defence manufacturing depends on strong Tier-II and Tier-III supplier networks, particularly in precision components and transmission systems. What steps is Odisha taking to integrate MSMEs into these high-value supply chains?

In the cluster we are developing, we have earmarked 300 acres exclusively for MSME vendors. For instance, some of these MSMEs may already have business relationships with Kalyani, Bharat Forge or Bharat Dynamics. We have also reached out to CPSUs in neighbouring states like Andhra Pradesh and Telangana and examined their vendor base. Hindustan Aeronautics Ltd, which has a major facility in southern Odisha, also has a large vendor base. We have assessed where they source their components from and whether those MSMEs would like to relocate closer to this emerging ecosystem.
Our strategy is twofold: first, attract anchor tenants such as Kalyani; and second, develop smaller land parcels and plug-and-play facilities around them for their vendors.

Our direct outreach to MSMEs may be limited, but the outreach of companies like Kalyani or Sharpex can be far more impactful, because they can provide business. The government can provide facilities and incentives, but anchor companies can provide sustained orders. That is our strategy.

A similar approach has worked well in the metallurgy space. Today, in the steel ancillary ecosystem, around 35 companies have either migrated or set up operations in Odisha. Earlier, they were based in Jamshedpur, Pune or Hyderabad. They were brought in by Tata Steel, as they were its vendors.

We are replicating this model in the aerospace and defence cluster as well. We have created a dedicated facility for MSMEs that is highly subsidised and incentivised – even more than what is offered to large industries – so that this vendor base can gradually develop and strengthen.

Q: With India's push towards Aatmanirbhar Bharat, how can states like Odisha reduce import dependence in critical areas such as gears, driveline systems and specialised mechanical assemblies?

This can only be done by encouraging and incentivising domestic manufacturing.

To reduce import dependence, we must be cost-competitive. If we are not cost-competitive, nobody will buy from us. Import substitution essentially requires both cost competitiveness and quality. While state governments cannot directly influence quality, as that depends on the vendors and the technology they adopt, we can certainly influence the cost component.

We can make industries cost-competitive by offering land at lower prices, providing power at subsidised rates, incentivising skill development, and reducing or reimbursing taxes wherever possible. This enables them to compete effectively and participate in the Government of India's import substitution efforts. We believe that our focus on MSMEs, combined with incentive support, will certainly help in this regard.

Q: How is Odisha enabling startups and academia to drive next-generation motion technologies?

Without technical support, startups cannot grow. Our strategy is to encourage incubators housed within specialised technical institutions. For instance, at IIT Bhubaneswar, we have set up an AI–ML research lab. The state government has funded this initiative with Rs 25 crore, and its services are available free of cost to registered startups. IG Drones and BonV Aero, which are into drone manufacturing, have benefited significantly from this support.

Similarly, in private sector institutions like KIIT, we have supported the establishment of a technology-based incubator. KIIT TBI is now one of the most renowned science and technology incubators and provides strong technical support to emerging startups. BonV Aero, for example, was initially incubated there.

We are also leveraging government institutions, including CTTC Bhubaneswar. A dedicated centre has been created where technical support is available free of cost to aerospace and defence startups. If a startup wants to participate in a Ministry of Defence tender and requires technical assistance, CTTC provides that support.

Additionally, support for design certification and related requirements is available free of cost to startups registered in Odisha – not only through CTTC, but also through CIPET and our NABL-accredited standard testing laboratories.

By encouraging private sector incubators like KIIT TBI and partnering with institutions such as IIT Bhubaneswar, CTTC and CIPET, we are building strong linkages between startups, academia and industry.

Aerospace and defence production requires highly skilled engineers and technicians trained in precision engineering and advanced manufacturing processes. How is the state aligning its skilling ecosystem to meet these demands?
This was in fact the first step we took. Without specialised skills, no company can survive, whether in Pune or in Odisha. Since setting up new institutions from scratch would have taken much longer, we identified some of our stronger existing institutions. For instance, IIT Bhubaneswar has now been converted into a university called Odisha University of Technology and Research (OUTR); and another well-rated engineering college at Burla.

At these three institutions, we have established Centres of Excellence in precision engineering. In Bhubaneswar, this has been done with the support of Larsen & Toubro. At another location, it has been set up with support from the Tata Group. In this way, we are creating centres that function like finishing schools. Students who complete a three-year diploma can undergo an additional six months to one year of training focused entirely on sophisticated machines. The equipment has been selected based on consultations with industry, so that it reflects what is currently used in manufacturing, rather than standard teaching lab equipment.

In addition, we have established an exclusive Centre for Precision Engineering at the World Skill Centre in Bhubaneswar. This is a 4-acre facility with a capacity of 500 seats on a rolling two-year basis, dedicated entirely to precision engineering. It has been set up with the assistance of the Government of Singapore and in collaboration with the Asian Development Bank.

Q: Looking ahead to Viksit Bharat 2047, what is Odisha's long-term vision for defence and aerospace manufacturing?

We are positioning ourselves as the hub for East-Central India. As per the Government of India's strategy, this industry should not be concentrated in one geography for strategic reasons. These are strategic clusters that are exposed to geopolitical and other risks. Therefore, the Government of India wants this industry to be geographically distributed. Our opportunity lies in Eastern and East-Central India, covering Bihar, Jharkhand, Chhattisgarh, West Bengal and the Northeast. We aim to become the focal point.

Just as Pune serves as a focal point in Western India, we would like Odisha, particularly the Angul-Dhenkanal belt, where we are developing our aerospace and defence cluster, to emerge as the focal point in Eastern India. From there, we want to grow as a solution provider for aerospace and defence manufacturing.

If we can establish ourselves as the focal point in Eastern India, we will naturally become an integral part of the Government of India's Viksit Bharat 2047 vision. In fact, we are receiving guidance from the Government of India to emerge as this focal point in the East.

We have the advantages of ports, strong connectivity, a robust metallurgical base, and now a focused policy and skilling ecosystem. These factors together will help us emerge as a leader in Eastern India.

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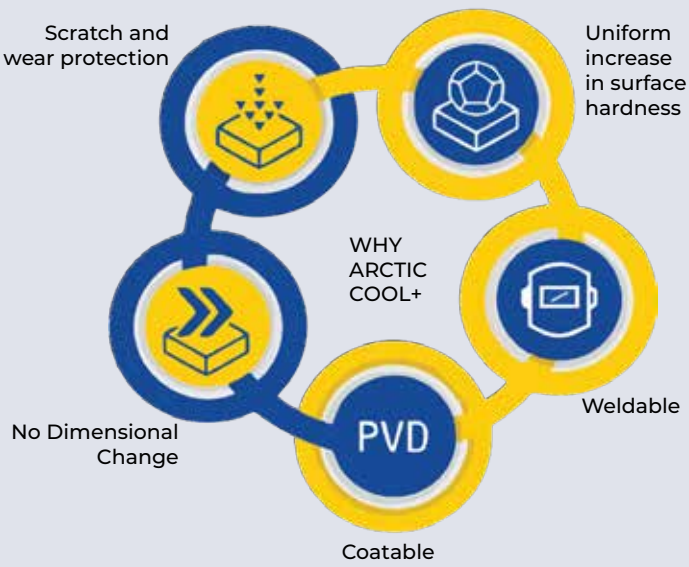

Engineering Longevity: Burri on Precision Gear Grinding, Digital Upgrades, and Global Growth

- By Sushmita Das

Dieter Burri
Director
Burri Werkzeugmaschinen GmbH & Co.KG

As gear manufacturing moves toward finer tolerances, faster delivery cycles, and stronger emphasis on energy efficiency, Burri Werkzeugmaschinen continues to differentiate itself with a clearly defined engineering mindset and a long-term commitment to precision. From introducing hydraulic-free gear grinding to creating compact, automation-ready machine platforms, the German company has consistently ensured that innovation is closely tied to real-world shopfloor demands.

In this interview, Dieter Burri, Director, Burri Werkzeugmaschinen GmbH & Co. KG, offers insights into the company's evolution from a strong retrofit foundation to a new-generation machine architecture. He explains the technical rationale behind key platforms such as the BZ 70 H, BZ 130, and BZ 300, and outlines why dialogue-based operation, integrated loading systems, and advanced grinding wheel dressing remain at the core of Burri's design philosophy. The discussion also touches on the rising importance of micro gears, increasing automation-led requirements, and the shift of energy efficiency from a differentiator to a fundamental design criterion.

Conducted by Sushmita Das, Associate Editor, Gear Technology India, this conversation highlights how Burri is engineering longevity through precision, digital innovation, and a focused global vision for advanced gear grinding.

1.What motivated Burri as the global market leader in Reishauer retrofits to also build new machines?

We can incorporate our creative and innovative ideas much better in new machines, which is why we decided to do so.

2. How does Burri's new generation platform differ technically from conventional gear grinding machine concepts in the market?

Unique Features:

- BZ70H world's first hydraulic-free gear grinding machine.
- BZ130 patented double-spindle concept with short chip-to-chip time.
- BZ300 flexible gear grinding centre with gear profile and worm grinding.

3. Machines such as the BZ 130 and BZ 300 emphasise compact design and automation. How do these features translate into real gains on the shopfloor?

Easy operation of the machine and automation via the machine's touch panel. The automation does not require a separate control system or a larger footprint; only a Conveyor belt is required.

Integration of profile and worm grinding - more flexibility- no separate machines needed for profile or worm grinding - gives flexibility and makes sure machine capacity can be increased (especially job shoppers).

Based on customer requirements and production volume, we can decide on machine configuration by manual, semi-automatic and fully automatic loading systems without modifications to the main machine construction.

4. The BZ 70 H addresses very small modules and energy-efficient grinding. How do you see demand evolving in this segment?

Automation and robot applications will continue to increase in the coming years, so we anticipate growing demand. Especially for upcoming markets, micro gears will more and more be a topic (smaller module gears).

5. How important is a dialogue-based operating concept in reducing dependency on highly skilled CNC operators?

This is very important to us and has always been our approach. If an operator is familiar with one Burri machine type, they can operate all the others without extensive training.

6. Integrated loading and parallel operations are key highlights of Burri machines. How do these influence cycle time and overall equipment effectiveness?

Integrated loading systems offer significant added value in terms of cost efficiency and productivity because they can communicate more easily with the machine.

7. Grinding wheel dressing remains a core competence at Burri. How does tight integration between grinding and profiling improve accuracy and consistency?

The high-precision pre-profiling on our PM machines can save a lot of setup time when changing discs in the production machine, and also protects the dressing discs. The PM machine gives flexibility because customers can buy only the blanks.

8. Energy efficiency and sustainability are gaining importance in capital equipment decisions. How are Burri's machines responding to these expectations?

Burri machines are leaders in energy efficiency. We have always placed great importance on this, and all systems run at less than 12 kVA with integrated loading.

9. Looking ahead, which technological developments will most strongly shape Burri's next generation of gear grinding machines?

We are working on continuous developments and new ideologies on gear grinding machines.

GTI Award 2024 - Life Time Achievement Award Presented to Mr. Sulaiman Jamal

Leading Through Legacy: John J. Perrotti Reflects on 160 Years of Gleason's Excellence in Gear Manufacturing

- By Sushmita Das

John Perrotti, Chairman and Chief Executive Officer of Gleason Corporation, drives a Design – Manufacture – Measure strategy to build a Smart Loop Ecosystem.

For more than a century and a half, Gleason has stood at the forefront of gear manufacturing, shaping not just machines and processes, but the very evolution of the global gear industry. Founded on engineering excellence and a deep understanding of customer needs, the company has continuously reinvented itself, embracing new technologies, markets, and manufacturing philosophies while staying true to its core values.

In this exclusive interview, John J. Perrotti, Chairman and Chief Executive Officer of Gleason Corporation, reflects on the company's remarkable 160-year legacy and its journey into the future. From the development of the Design–Manufacture–Measure strategy and the Smart Loop Ecosystem, to addressing the demands of electrification, sustainability, and Industry 4.0, Perrotti offers insights into how Gleason balances tradition with transformation. He also shares his perspectives on leadership, global collaboration, and the opportunities that lie ahead for the next generation of engineers entering the gear and power transmission industry.

1. Gleason has been shaping the gear industry for over 160 years. How do you ensure that the company continues to innovate and stay ahead in a rapidly changing manufacturing landscape?

We will remain focused on people and process. The foundation of our company culture emphasises continuous learning and customer focus, accompanied by an unwavering passion for problem-solving and continuous improvement. We will continue to adapt to develop skill sets around digital manufacturing, automation and a systems approach across the entire value chain of Design – Manufacture – Measure.

2. Gleason's concept of "Total Gear Solutions" and the Smart Loop Ecosystem connect design, manufacturing, and inspection digitally. How has this approach transformed the way your customers produce gears today?

We are in the early phases, but customers realise this connected value chain is the only means to meet the challenges for high productivity and high precision in a repeatable manner. The infrastructure we have built is robust and can be customised for our customers' varying environments.

3. The shift toward electrification and e-mobility is redefining transmission design. How is Gleason adapting its technology portfolio to meet the demands of EVs and future powertrains?

We have invested significantly across design, manufacturing and measurement processes to address the needs of these markets. This investment strategy includes Gleason's KISSsoft gear design software with its advanced analysis tools and the KISSsoft System Module as well as every relevant gear manufacturing process including hobbing, chamfering, power skiving, grinding and honing and measurement solutions, analytical measuring machines with Advanced Waviness, GRSL, INTRA SFT and DFT single and double flank inspection systems providing stand-alone or up to 100% in-process quality assurance

with smart tools to identify ghost orders and root causes, and finally a wealth of functional gage products, tailored to our customers' requirements.

4. With facilities and customers across multiple continents, how do you maintain a balance between global integration and local responsiveness, especially in key regions like India and Asia?

Gleason's KISSsoft Gear Design Software and KISSsoft System Module offer the design and optimisation of single gears as well as complete transmission systems with many integrated and optional plugins for further analysis. KISSsoft is a central element of Gleason's Smart Loop Ecosystem approach.

Gleason has been serving international markets since the late 1800's, so we have had a great deal of experience working with many different cultures but maintaining alignment with our core principles and mission. One of the things I am most proud of is how our team spread across 19 different countries cooperates and collaborates on a daily basis. Common philosophical and moral values are an important foundation for consistent messaging and global leadership.

5. Sustainability is now a central pillar of industrial strategy. How is Gleason embedding energy efficiency, waste reduction, and circular practices into its machines and processes?

Gleason has installed a global team of experts in relevant fields focussing on measuring and reducing our carbon footprint. As we develop new products and features, sustainability is one of the key areas we address. At the same time, we serve customers in important markets including electrification, wind power and other sustainable technologies, becoming a driver in carbon footprint reduction.

6. As gear manufacturers embrace Industry 4.0 technologies, from AI-based inspection to digital twins, how do you see automation and data analytics shaping the "factory of the future"?

Automation and data analytics transform the factory of the future into a highly connected, self-optimising environment. AI-driven inspection and digital twins will continuously monitor processes, predict deviations, and automatically adjust

Gleason's interdisciplinary and international teams work closely together to exceed customers' expectations on a local and global scale. Sharing a common mission and moral values is an important foundation for collaboration and success.

production parameters to ensure consistent quality. Real-time data sharing across machines and departments will enable faster decision-making, reduced downtime, less scrap, and more flexible, customised manufacturing. Ultimately, factories will become smarter, more efficient, and capable of delivering higher performance with fewer manual interventions.

Our design–manufacture–measure strategy drives in exactly this direction, leveraging digital twins to accurately simulate gear performance before anything is physically produced. By collecting and analysing deviations with smart metrology systems and integrating real production data into these virtual models, we can predict behaviour, identify potential issues early, and optimise key parameters. This approach shortens development cycles, enhances quality, and ensures that the final product aligns closely with customer expectations.

7. Gleason's modernisation and retrofit programs help extend the life of legacy machines. How important is this for customers aiming to upgrade capabilities without full replacement investments?

Remanufacturing and machine upgrades remain an important part of our product portfolio and also part of our sustainability initiative, from mechanical rebuild to recontrols and software upgrades. In today's world, whether it be for productivity, safety or IT security, keeping customers' machines

Gleason Intra SFTX Single Flank Roll Tester with Twin Spindle and Gleason GRSL Double Flank Roll Tester with Laser Technology, ideally suited for state-of-the-art EV gear inspection with integrated NVH analysis.

and equipment in general up to modern standards is a requirement. We offer these rebuild programs through all of our global machine plants.

8. Having been with Gleason for more than three decades, how has your leadership philosophy evolved in guiding a legacy company through waves of technological disruption?

I have tried to remain consistent in my core values, but done so with an awareness of our changing markets. Remaining disciplined regarding global alignment of our mission, being data-driven in decision making and valuing our employees and customers are timeless, no matter what technological trends may exist.

9. With such a diverse customer base, spanning automotive, aerospace, wind, mining, and more, how does Gleason decide where to focus its R&D and product development efforts?

For the most part we try to make our products as universal as possible to serve a variety of end-markets. We will create special features which may be pointed to certain industries. Our ability to nimbly serve different markets is part of what has aided the Gleason's longevity.

10. Finally, what message would you like to share with young engineers and entrepreneurs entering the gear and power transmission industry today?

The power transmission industry is a multifaceted industry that can expose you to many, very diverse fields, as gears are used across a wide spectrum of applications. Besides the interesting customers you may interact with, there is a range of career opportunities from mechanical design, software, manufacturing engineering, application engineering, technical sales, and more. Gears are still one of the more challenging fields, trying to balance precision and productivity, offering great opportunities for learning and professional growth.

Gleason provides a complete gear technology ecosystem to its customers, including design software with digital twin technology and feasibility checks, manufacturing machines, metrology systems, tools and workholding, as well as Smart Loop software to feed back inspection results to manufacturing machines for potential corrective actions.

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Digitalisation in Action: How Tyrolit Is Shaping Smart Manufacturing

- By Sushmita Das

1. Tyrolit has over a century of heritage. How does this legacy shape your strategic vision for the company today?

Our legacy of more than 100 years provides the foundation for our credibility and long-term strategic thinking. It shapes our vision by combining traditional craftsmanship and deep material expertise with pioneering technologies, ensuring stability and reliability in a volatile global market.

2. What are the key strategic priorities for Tyrolit over the next three to five years in a rapidly evolving global manufacturing landscape?

Our priorities for 2026–2030 include the digitalisation of grinding processes through the integration of AI technologies, expanding our local footprint in emerging markets such as India, and transitioning from a product supplier to a holistic system provider for process optimisation.

This strategy is strongly supported by Team Tyrolit in India, whose regional presence, application expertise, and close customer proximity enable us to translate global innovation into market-specific solutions.

3. Innovation is central to Tyrolit's identity. How do you ensure continuous technological leadership across such a broad product portfolio?

We maintain leadership through significant R&D investment and a matrix organisation that facilitates technology transfer across industries, such as from aerospace to automotive. Collaboration with elite universities and research institutes helps us anticipate and drive future trends.

4. How is digitalisation influencing Tyrolit's approach to product development, process optimization and customer engagement?

Digitalisation is manifested in "Smart Grinding." We use digital prototyping for development, offer digital assistance systems like Tool Scope to help customers maximise tool life and minimize waste, and provide 24/7 support through e-commerce and digital application consulting.

5. With a wide range of standard and customised solutions, how does Tyrolit balance scalability with application-specific precision?

We utilise a modular manufacturing strategy. While high-volume standard products are made on automated lines, specialised "Customisation Cells" handle high-precision niche solutions, allowing us to scale bespoke specifications to industrial volumes rapidly.

6. Which end-use industries do you see driving the next phase of growth for Tyrolit, and what is enabling this momentum?

Growth is driven by E-mobility, medical technology (implants), and the semiconductor industry. This momentum is enabled by the increasing demand for harder materials and tighter tolerances, where our high-performance abrasives excel.

7. Managing a global manufacturing and distribution footprint comes with complexity. What are the key challenges and learnings in building a resilient supply chain?

A key learning is the "Local for Local" approach. By strengthening regional hubs, we reduce dependency on global logistics and improve responsiveness.
In markets like India, Team Tyrolit's strong regional presence and market expertise play a critical role in ensuring supply reliability, faster decision-making, and consistent customer support. A digitally monitored supply chain allows us to anticipate and mitigate bottlenecks before they impact our customers.

8. How is Tyrolit enhancing manufacturing efficiency while maintaining high standards of quality, safety and cost competitiveness?

We implement Lean Manufacturing and Industry 4.0 principles, using real-time automated quality controls. Our adherence to the strictest global safety standards ensures maximum reliability while maintaining cost-efficiency through optimised production.

9. Sustainability is increasingly critical for industrial companies. How is Tyrolit embedding sustainability into products, processes and corporate strategy?

Sustainability is a core pillar: we develop naphthalene-free specification systems, reduce the CO2 footprint of our plants using renewable energy, and implement circular economy programs to recover valuable raw materials from used tools.
10.From a leadership perspective, what kind of organisational culture is essential to sustain innovation and long-term growth at Tyrolit?

A culture of entrepreneurship and personal responsibility is essential. We foster an environment where flat hierarchies and the courage to challenge the status quo allow us to maintain the innovative spirit that has defined Tyrolit for over a century.

Enabling High-Performance Bearings and Gears with Rose Plastic Packaging Solutions

- By Rose Plastic Group

Precision bearings and gears operate at the heart of high-performance systems, where even minor contamination or surface damage can affect reliability. Protecting these components during storage and transport is therefore essential. This article outlines their specific protection requirements and highlights how rose plastic, a manufacturer of high-quality plastic packaging, provides purpose-designed solutions to ensure components reach assembly in optimal condition.

Engineering Efficiency in Limited Space

Needle roller bearings and miniature bearings are designed for applications where space constraints coexist with high-performance demands.

Needle roller bearings feature long, slender cylindrical rollers that provide a large contact area relative to their size. This enables them to handle high radial loads while maintaining a compact footprint. They are widely used in transmissions, pumps, compressors, aerospace mechanisms, and industrial machinery.

Miniature bearings, characterized by their very small dimensions, play a vital role in applications requiring high precision and smooth rotational motion. These include micro-motors, robotics, medical devices, optical equipment, and measuring instruments.

Both bearing types demand extremely tight tolerances, high-quality surface finishes, and consistent material quality. Any exposure to contamination, corrosion, or mechanical stress during handling and transport can negatively affect their performance.

Protecting Precision During Handling and Logistics

To maintain functional integrity, bearings require specialised packaging solutions that protect them from external influences such as impact, dust, moisture, and corrosion. Engineered plastic packaging systems offer:

- Secure protection against mechanical damage
- Effective shielding from contamination and environmental exposure
- Ergonomic handling for easy opening, closing, and reuse

For metal components, VCI-based packaging options provide additional corrosion protection by releasing vapour-phase inhibitors that form a protective molecular layer on metal surfaces – without leaving residues. This ensures bearings remain clean, intact, and ready for immediate assembly upon delivery.

Gears: The Core of Power Transmission Systems

Precision at Every Tooth

Gears are essential mechanical elements responsible for transmitting torque, modifying speed, and controlling the direction of motion. Their efficiency, noise behavior, and durability depend heavily on accurate tooth geometry and flawless surface integrity.

Common gear types include:

- Spur gears for straightforward power transmission
- Bevel and worm gears for angular drives
- Crown, elliptical, and special-profile gears for customised motion requirements

Even minor surface damage or contamination can lead to increased noise, vibration, premature wear, or failure in service – making careful handling and protection a necessity.

Packaging Solutions for Gear Protection

Precision-machined gears are particularly vulnerable during transport and storage. Dedicated plastic packaging solutions help maintain gear quality by:

- Preventing contact damage to gear teeth and flanks
- Protecting against dirt, dust, and moisture
- Ensuring stable positioning through custom inserts

Reusable packaging designs allow goods to be safely stored, transported, and handled multiple times within the production and supply chain. Foam or form-fitted inserts ensure minimal movement inside the packaging, reducing abrasion and maintaining surface integrity. These solutions also support sustainability initiatives by reducing single-use packaging waste.

The Role of Packaging in the Precision Manufacturing Value Chain

While design and manufacturing excellence define component quality, effective packaging ensures that quality reaches the end user intact. For needle roller bearings, miniature bearings, and gears, tailored packaging solutions play a strategic role in:

- Reducing logistics-related damage and rejection rates
- Improving efficiency in assembly and warehousing operations
- Preserving surface finish, dimensional accuracy, and corrosion resistance

For OEMs and component manufacturers, investing in intelligent, reusable packaging is not merely a logistics decision – it is a value-protection strategy that enhances reliability, customer satisfaction, and brand confidence.

Safeguarding Precision, Delivering Long-Term Value

As industries continue to push the boundaries of performance, compactness, and efficiency, needle roller bearings, miniature bearings, and gears remain indispensable to modern machinery. These components operate at the heart of motion systems, where precision is non-negotiable.

Protecting this precision through every stage of the supply chain is equally critical. Purpose-designed packaging solutions ensure that components retain their engineered quality from production to final assembly – supporting long service life, operational reliability, and sustainable manufacturing practices.

In today's competitive industrial landscape, the synergy between advanced component engineering and intelligent packaging is a decisive factor in delivering consistent performance and long-term value.

With decades of expertise in developing engineered plastic packaging for precision industrial components, Rose Plastic supports manufacturers of needle roller bearings, miniature bearings, and gears in safeguarding quality across the entire supply chain. The company's focus on component-specific design, reusability, and corrosion protection enables OEMs and suppliers to reduce damage, improve handling efficiency, and ensure components reach assembly lines in perfect condition.

For manufacturers seeking reliable, sustainable, and application-oriented packaging solutions for high-precision mechanical components, Rose Plastic offers a proven partnership approach – where protection, performance, and practicality come together.

LMT Tools India Unveils the Nation's Largest Gear Cutting Tool Plant in Chakan

- By Gear Technology India

Ramakant Reddy
Managing Director
LMT Tools India Pvt. Ltd.

LMT Tools India, a subsidiary of the Germany-based LMT Group and a global leader in precision tool manufacturing, has officially inaugurated the expansion of its state-of-the-art manufacturing facility in Chakan, Pune, on February 2, 2026. This expansion marks a significant milestone for the organisation, establishing it as India's largest gear-cutting tool manufacturing plant. The move represents a major leap forward in the company's regional footprint.

The newly expanded facility increases LMT Tools India's production capacity by 60%, reflecting a strong commitment to high-precision engineering. By integrating advanced manufacturing technologies and future-ready infrastructure, the plant is poised to meet the growing demand for high-performance cutting tools. This expansion strengthens the Chakan facility into a strategic global manufacturing hub; LMT Tools India is catering to the Indian domestic market needs, also exporting to international markets, supporting global supply chains. The facility will serve automotive, aerospace, railways, wind energy, die & mould as well as general machining sectors.

The inauguration was attended by the senior global and regional leadership of the LMT Group. Key dignitaries present at the event included Oliver Thomas, Managing Director of LMT Group and CEO of LMT Tools, along with Ramakant Reddy, Managing Director of LMT Tools India. They were joined by Carsten Storm, CFO of LMT Tools, and Raphael Lienau, Managing Director of LMT Fette. The ceremony also saw a significant gathering of customers, industry associates, vendors, and service partners, reflecting the company's deep-rooted collaborative ecosystem in India.

LMT Tools remains one of the global leaders of the cutting tool industry, known for its expertise in precision solutions for complex machining tasks. Through this expansion in Chakan, the company further solidifies its position as a global technology leader, ensuring that it remains at the forefront of providing high-performance cutting tools and engineering excellence for the most demanding industrial applications across the globe.

In an exclusive interaction, Sushmita Das, Associate Editor of Gear Technology India, spoke with Ramakant Reddy, Managing Director of LMT Tools India Pvt. Ltd., about the company's expanded Pune manufacturing facility. He shares insights on how this strategic investment is strengthening production capacity, enhancing global competitiveness, integrating advanced technologies, and improving delivery, customisation, and customer value across key industries.

Explore the interaction below:

1. How does this expanded facility strengthen LMT Tools India Private Limited's long-term manufacturing and growth strategy in India?

The expansion of our Pune facility marks a defining milestone in LMT Tools India's long-term growth journey. With this investment, we have increased our production capacity by 60%, positioning the plant as India's largest gear cutting tool manufacturing facility. This is a strategic step toward building a future-ready manufacturing ecosystem aligned with India's industrial growth ambitions.

India continues to emerge as a global manufacturing hub; our expanded infrastructure ensures that we are well-equipped to support this momentum with high-precision, high-performance gear cutting solutions.
As a subsidiary of the globally renowned LMT Group, we are deeply aligned with the group's global manufacturing and technology roadmap. The Pune plant now functions not only as

a strong pillar for domestic supply but also as a strategic global manufacturing hub supporting international markets. This dual focus, serving India while strengthening global supply chains, forms the core of our long-term strategy.

2. As one of India's largest gear cutting tool manufacturers, how do you see this expansion enhancing your competitive position in the global market?

With this expansion, LMT Tools India significantly strengthens its position within the global manufacturing network of LMT Tools. Our Pune facility now stands as a high-capability production center that meets global quality benchmarks and technological standards.

In today's competitive environment, customers worldwide expect precision, consistency, and reliability. By integrating advanced manufacturing technologies and strengthening our infrastructure, we have enhanced our ability to deliver complex gear cutting tools that meet the demanding requirements of global OEMs and Tier-1 suppliers.

This expansion also improves agility. With increased capacity and localised expertise, we can respond faster to global demands while maintaining uncompromising quality. It enhances our export capability and reinforces India's role as a key contributor within the LMT global ecosystem.

Ultimately, this positions LMT Tools India not just as a large manufacturer, but as a technology-driven, globally integrated partner capable of supporting complex machining applications across continents.

3. What new technological capabilities does this facility bring to gear cutting tool production and quality consistency?

The expanded facility incorporates advanced manufacturing technologies and future-ready infrastructure designed for precision, repeatability, and scalability. Gear cutting tools require micron-level accuracy, and maintaining that consistency across higher volumes demands both process automation and robust quality systems.

At Pune, we have strengthened our capabilities across multiple critical processes such as precision grinding, advanced profiling, and high-accuracy finishing operations supported by enhanced quality assurance systems. The integration of modern machinery and process controls ensures improved dimensional accuracy, surface finish consistency, and longer tool life.

The optimised production workflows further enhance process reliability. This increases productivity, ensuring every tool meets global standards.

Being part of the LMT global technology network, we leverage cross-border knowledge exchange, standardised best practices, and engineering expertise developed across multiple international facilities. This synergy enables us to deliver consistent quality, whether the product is supplied to a customer in India, Europe, or any other international market.

4. How will this expansion help improve delivery timelines, customisation, and customer satisfaction across key industries?

One of the most tangible benefits of this expansion is improved responsiveness. With 60% higher capacity and optimised production flows, we can significantly reduce lead times.

The automotive, aerospace, railway, wind energy, and general machining industries operate under strict production timelines. Our enhanced infrastructure allows us to align closely with customers' project cycles and ramp-up requirements.

Customisation is another critical factor. Gear manufacturing demands application-specific tool geometries and coatings respective to component geometries and materials. With strengthened engineering and manufacturing capabilities, we are now better positioned to offer customised solutions.

Furthermore, by serving both domestic and export markets from Pune, we minimise logistical complexities and improve supply chain reliability. Customers benefit from shorter transit times, faster technical support, and localised collaboration backed by global expertise.

Ultimately, this expansion is about delivering greater value through precision, reliability, faster delivery, and application-focused engineering. Our goal is not only to manufacture tools but to become a long-term technology partner for our customers' growth and competitiveness.

The Role of APAR's High-Performance Lubricants in Modern Industrial Systems

- By Sushmita Das

As industrial and automotive systems undergo rapid transformation driven by electrification, sustainability imperatives, and advanced manufacturing technologies, lubricants are increasingly becoming strategic performance enablers rather than mere consumables. In this exclusive interview, Sushmita Das, the Associate Editor of Gear Technology India, speaks with Mr Satyendra Debdas, Director, APAR Industries, to understand how high-performance lubricants are supporting modern industrial systems across the globe. He shares APAR's long-term vision for its lubricants business, insights into emerging technology and regulatory trends, and the company's approach to sustainability, OEM collaboration, digitalisation, and global market expansion, offering a comprehensive perspective on how lubrication solutions are evolving to meet the demands of a future-ready industry.

Satyendra Debda
Vice Presiden
APAR Industries Limited

Satyendra Debdas is a highly accomplished professional with more than three decades of experience in the oil and lubricants industry. A B.Tech graduate with an MBA, he brings together strong engineering fundamentals and strategic management expertise.
He is currently associated with APAR Industries Limited as Vice President – Industrial Oil Division, where he oversees the domestic lubricants business. In this leadership role, he focuses on business development, market expansion, and operational excellence.
Known for his deep industry knowledge and result-oriented approach, Mr. Debdas has consistently contributed to strengthening organizational performance and building sustainable growth in the industrial oils sector.

1. How do you define the long-term vision for APAR's lubricants business in a rapidly evolving global market?

APAR Industries defines its long-term vision for the lubricants business as becoming a global leader in sustainable, innovative, and high-performance lubricants that support the energy transition, enhance environmental sustainability, and drive value for stakeholders in a rapidly evolving market characterised by electrification, digitalisation, and stricter ESG standards.

This vision emphasises pioneering eco-friendly solutions, such as bio-based and environmentally acceptable lubricants (EALs) that are biodegradable, low-toxicity, and designed for applications like transformer oils, metalworking fluids, and engine oils, while maintaining superior performance to extend equipment life and reduce operational costs.

Key pillars of this vision include:

- Sustainability and Innovation: Prioritising R&D for next-generation products aligned with circular economy principles, UN SDG 12 (responsible consumption and production), and global standards like OECD 301 B for biodegradability. This involves developing 99% biodegradable, natural ester-based fluids, fuel-saving formulations (e.g., up to 2.5% efficiency gains), and synthetic oils that meet API/SP and ILSAC GF-6 specifications to

minimise environmental impact from spills and emissions.

- Market Expansion and Premiumization: Aiming to solidify its position as one of India's top 10 lubricant manufacturers (ninth by volume) by expanding premium portfolios across automotive (17.6% YoY volume growth in FY25) and industrial segments, while growing exports to the Middle East, Africa, and beyond. This includes leveraging partnerships like the ENI Italy licensing for auto lubes and targeting high-growth areas like EV production with specialised metalworking fluids for advanced alloys.

- Digital and Operational Agility: Integrating digital transformation for distribution networks, OEM collaborations for logistics, and real-time marketing to adapt to trends like India's automotive boom (the largest two-wheeler producer globally) and industrial growth at a 4% CAGR, amid rising electrification (e.g., 40% electric three-wheeler penetration).

- Global Brand Positioning: Evolving from an Indian-origin company to a respected global brand that contributes to net-zero goals (e.g., India's 2070 target), with a focus on being "greener, cleaner, better, and cheaper" through capacity expansions (e.g., over 750,000 KL in India and 175,000 KL in UAE) and participation in international exhibitions to build B2B/B2C relationships.

2. What key technology trends are currently influencing your lubricant formulation and R&D priorities?

APAR's lubricant formulation and R&D priorities are shaped by several key technology trends in the rapidly evolving global lubricants industry, focusing on sustainability, performance optimisation, and adaptation to emerging applications like electric vehicles (EVs). With the adoption of Electric Vehicles in India, the gear and transmission industry is definitely going to be revolutionised by the OEM offering various transmission options to the buyer. With the industry growing at a rapid pace by introducing Industry 4 standards with automation at work place, it becomes more stringent for the Lubricant suppliers to remain in the competition. APAR has been working progressively with the Industries and machine OEMs to develop more environmentally friendly products for the gear and transmission industry.

Key influencing trends include:

- Sustainability and Bio-Based Formulations: A major shift toward environmentally acceptable lubricants (EALs) that are biodegradable, low-toxicity, and derived from renewable sources like natural and synthetic esters. This trend addresses stricter environmental regulations and spill-risk mitigation, with R&D emphasising 99%+ biodegradability while enhancing properties like oxidation stability and thermal performance. For instance, we have developed smoke-free gear hobbing oil and high-flash-point gear grinding oil, which provides better productivity for the machines while keeping in mind operator health & safety.

- Electrification and EV-Specific Lubricants: The rise of EVs (e.g., India's 40% electric three-wheeler penetration and global EV market growth) is influencing specialised formulations for e-fluids, coolants, and greases that improve battery thermal management, reduce friction in drivetrains, and extend component life. Low-viscosity synthetics with enhanced conductivity and anti-wear additives are prioritised to boost range efficiency by up to 5-10% while ensuring compatibility with advanced materials like copper windings and composites.

3. How is APAR addressing sustainability and environmental responsibility within its lubricant portfolio?

APAR Industries is deeply committed to sustainability and environmental responsibility in its lubricants portfolio, integrating eco-friendly practices across product development, operations, and supply chains. This approach aligns with global standards such as ESG frameworks, UN Sustainable Development Goals (particularly SDG 12 on Responsible Consumption and Production), GRI reporting, and India's net-zero emissions target by 2070. As India's 9th largest lubricants manufacturer by volume, contributing about 25.74% to our total turnover, we focus on biodegradable, low-toxicity formulations that minimise ecological impact while delivering high performance.

Our efforts include expanding bio-based and environmentally acceptable lubricants (EALs), conducting life cycle assessments (LCAs), and achieving certifications like ISO 14001:2015 for environmental management. In FY 2024-25, we invested Rs 20.65 crore in R&D (0.12% of turnover) to innovate sustainable products, with 100% of our lubricants portfolio incorporating environmental and social parameters for safe usage, recycling, and disposal.

4. In what ways do OEM partnerships shape your product development and market strategy?

APAR Industries leverages OEM partnerships as a cornerstone of our lubricants business strategy, enabling co-innovation, market penetration, and alignment with global standards in a competitive landscape where the Indian lubricants market is projected to grow at a 3-4% CAGR through 2030.

These collaborations, including licensing agreements and direct supplier relationships, directly influence our R&D by providing insights into emerging needs (e.g., EV-compatible fluids and low-emission formulations), while shaping market strategies through enhanced branding, distribution networks, and premiumization. In FY25, OEMs accounted for 11.3% of our total sales mix, underscoring their strategic importance in driving revenue growth (e.g., 21.1% 5-year CAGR in our Speciality Oils & Lubricants segment to INR 5,087 crore). OEM collaborations enhance our competitive positioning as one of India's top 10 lubricant players (9th by volume), with a focus on exports (44% of oil division revenue, serving 140+ countries) and premium segments. They provide market access, credibility, and logistical efficiencies:

5. Which international markets are most critical for APAR's lubricant growth, and why?

APAR Industries identifies several key international markets as critical for the growth of our lubricants business, which contributes significantly to our Speciality Oils & Lubricants segment (21.1% 5-year revenue CAGR to INR 5,087 crore in FY25). These markets are selected based on factors like high industrial and automotive demand, proximity to our Sharjah (UAE) blending plant for cost-efficient delivery, alignment with global trends in electrification and sustainability, and established OEM approvals (e.g., GE, Siemens).

Exports account for 44% of our oil division revenue, serving 140+ countries, with a focus on premium, eco-friendly lubricants like biodegradable esters and fuel-efficient formulations. This strategy supports our goal of 5-8% annual growth in the oils segment amid a global lubricants market projected at 2.6% CAGR to USD 196.9 billion by 2031.

Critical International Markets and Rationale

The most pivotal markets include the Middle East (GCC), Africa and South East Asia, driven by infrastructure booms, renewable energy transitions, and automotive expansion.

- Middle East (GCC, including UAE, Saudi Arabia, Oman, Kuwait): This region is paramount due to our strategic Sharjah plant (175,000 KL capacity), enabling low-cost, rapid delivery and bulk exports. With the boom in the Industrial and Automotive sectors in this market, it becomes a strategic segment to offer our premium range of Industrial and Automotive lubricants in this market.

- Africa (South Africa, Ethiopia, North Africa, like Algeria, Tunisia): With a push from the Infrastructure segment in these countries, APAR has realised the potential through channel partners in various countries in the African region. We are also coming out with a plan to do local blending for automotive and industrial lubricants in Uganda in order to cater to the entire North African belt.

6. How is digital transformation impacting your manufacturing, distribution, or customer engagement processes?

APAR Industries is embracing digital transformation as a core driver of efficiency, innovation, and sustainability across our operations, particularly in the lubricants segment, which benefits from integrated advancements in our broader ecosystem. This transformation leverages technologies like IoT, AI, real-time data analytics, and predictive maintenance to optimise processes amid global trends such as Industry 4.0 and the energy transition. In FY25, these initiatives contributed to our overall revenue growth (30.6% 5-year CAGR to INR 18,581 crore), enhancing resilience in a market projected to grow at 3-4% CAGR for lubricants. Key impacts span manufacturing (e.g., smart factories reducing downtime), distribution (e.g., agile supply chains for 140+ countries), and customer engagement (e.g., data-driven personalisation), while aligning with ESG goals like reduced emissions and workforce empowerment.

Impacts on Manufacturing Processes

Digital tools are revolutionising our 11 state-of-the-art facilities, including the Sharjah plant for lubricants, by integrating smart manufacturing to boost productivity and quality:

- IoT and Predictive Analytics: Real-time monitoring via IoT sensors enables predictive maintenance, reducing unplanned downtime by up to 20-30% and enhancing equipment longevity for lubricant blending and packing. This supports our capacity expansions (e.g., doubling industrial/auto lube output) and innovations like biodegradable esters tested in our Rabale R&D center.

- AI and Automation: AI-driven optimisation in production lines improves formulation precision for over 500 lubricant grades, aligning with standards like API SP/ILSAC GF-6. Workforce reskilling programs (over 1,015 sessions in FY25) balance automation with human expertise, fostering safety and efficiency in high-tech environments like e-beam facilities.

- Lean Manufacturing and Sustainability: Digitisation streamlines procurement and lean processes, minimising waste (e.g., 98% recycling rate) and supporting eco-friendly products like natural ester-based fluids, while cybersecurity measures protect intellectual property in R&D.

Impacts on Distribution Processes

Our global supply chain, handling exports to 140+ countries (44% of oil division revenue), is transformed for agility and cost-effectiveness:

- Supply Chain Digitisation: IoT-enabled tracking at the OEM tankage level is helping us to determine the usage pattern, real-time volume level and on-time delivery of the products at the site.

7. What role do technical support and after-sales service play in building long-term customer relationships?

APAR Industries recognises technical support and after-sales service as foundational elements in fostering enduring customer relationships within our lubricants business, which spans over 500 grades for automotive, industrial, and speciality applications.

These services go beyond transactional interactions, building trust, loyalty, and repeat business in a competitive market where customer retention drives long-term growth. By providing expert guidance, rapid issue resolution, and value-added insights, we ensure optimal product performance, minimise downtime, and align with customer needs in sectors like renewables, automotive, and infrastructure. This customer-

centric approach has contributed to our position as India's 9th largest lubricant manufacturer by volume, with exports to 140+ countries and no product recalls in recent years.

8. How does APAR ensure supply chain resilience while maintaining consistent product quality?

APAR Industries ensures supply chain resilience and consistent product quality in our lubricants business through a multifaceted strategy that integrates advanced digital technologies, rigorous quality management systems, ethical sourcing, and proactive risk mitigation. As a global leader exporting to 140+ countries with a 21.1% 5-year revenue CAGR in our Speciality Oils & Lubricants segment (reaching INR 5,087 crore in FY25), we prioritise these elements to navigate challenges like geopolitical disruptions, raw material volatility, and environmental regulations while maintaining high-performance standards for over 500 lubricant grades.

Our approach aligns with ESG principles, including ISO 9001:2015 for quality, ISO 14001:2015 for environment, and ISO 45001:2018 for health and safety across all facilities, ensuring zero product recalls and 100% customer complaint resolution in recent years.

Key Strategies for Supply Chain Resilience

We build resilience by diversifying sources, leveraging technology, and fostering ethical partnerships:

9. How do changing global standards and regulations influence your approach to compliance and innovation?

APAR Industries views changing global standards and regulations as both a challenge and a catalyst for enhancing our compliance frameworks and driving innovation in our lubricants business. In an era of heightened ESG scrutiny, stricter emission norms, and sustainability mandates, we proactively adapt to ensure product safety, environmental responsibility, and market leadership. This influences our approach by integrating regulatory foresight into R&D, supply chains, and operations, resulting in innovative, compliant products that support the global energy transition and electrification trends.

For instance, our lubricants portfolio – contributing 25.74% to turnover – emphasises bio-based, biodegradable formulations tested to standards like OECD 301B and ASTM D5988, while maintaining certifications such as ISO 9001:2015, ISO 14001:2015, and ISO 45001:2018. In FY25, this led to innovations like 99% biodegradable natural ester transformer oils and EV-specific lubricants, amid a global lubricants market shifting toward low-emission, efficient solutions.

10. Looking ahead, what major shifts do you foresee in the lubricants industry, and how is APAR preparing for them?

APAR Industries anticipates several transformative shifts in the lubricants industry over the next 5-10 years, driven by sustainability imperatives, technological advancements, and evolving market dynamics amid a global market projected to grow from USD 178.14 billion in 2025 to USD 204.10 billion by 2030 at a CAGR of about 2.8%, with automotive lubricants reaching USD 87.40 billion by 2035. These changes are influenced by stricter emission regulations, the rise of electrification, and a push toward circular economy principles, prompting a pivot from traditional mineral-based products to innovative, eco-friendly alternatives. As India's 9th largest lubricant manufacturer by volume, we are preparing through substantial R&D investments (Rs 20.65 crore in FY25), capacity expansions, strategic partnerships, and a focus on premium, sustainable formulations to capture growth opportunities while aligning with India's net-zero goal by 2070 and global ESG standards.

Improving Hobbing Efficiency

- By Sanjay Gupta, Director - ESGI Tools Pvt Ltd.

What is the first thing that comes to our mind when we are falling short of hobbing capacity? Most likely, it will involve adding new machines and then starting the process of procuring them, allocating space and manpower, as well as other regular expenses such as oil and power.

Have we ever given a thought to the ideal capability of our existing CNC hobbing machines? It could be a possibility that we might be under-utilising the machine capacities.

You would be surprised when you look at the maximum spindle RPM that the machine can run in comparison to what is running on the machine.

We find such gaps where the review process of machine capability is missing. Another part of the story is that, at times, users are not aware of the availability of better tool materials to support the increased cutting speed. With the ever-increasing volatility in business due to various unknown factors, we must find ways to avoid the huge capital investments, if the objective can be achieved with the involvement of all stakeholders by changing the tool specifications.

We at ESGI have two ranges of special series called ES-Cut hobs for Modules 1 to 7 & and ES-H for modules more than 7. The different grades of ES_40, ES-65 & ES-90 are chosen based on the machine capability, component specifications and customer targets.
ES-Cut hobs are used for the automotive sector with components of mass volume and are used for new CNC Hobbing Machines, where cutting time has been reduced substantially by not only changing the tool material but also optimising the hob specifications like outside diameter, overall length, number of starts and number of gashes.

While undertaking the study, the foremost parameters to be considered are chip thickness, feed marks on the component, the desired accuracy level of the component, the spindle, & Cutting load.

ES-H hobs are designed for higher modules – typically above 7 – and are suitable for use on manual machines as well. They feature an increased number of cutting edges, making them specially engineered tools that are also critical and challenging to manufacture.

Then the next critical part of the exercise is the implementation by conducting the trials. The process of trials is as important as the first part of supplying the right tool. The user conducting the trial must interact with the tool supplier on a regular basis on the actual results and feedback. Since the process also includes key machine settings like Spindle RPM, Axial feed rate, shifting amount and V-offset to obtain the judicial mix of improved cutting time and better life per sharpening.

We are sharing below a few case studies for the successful trials conducted:

Module	2.14		4.8		1.75	
PA	15°		22.5°		20	
Z	135		39		69	
Hob Material	ASP2052	ES65	S390	ES65	MAC7	ES90
Coating	Al Pro	Al Pro	Al Pro	Al Pro	Al Pro	Al Pro
Hob Size (mm)	90X180X40	90X180X40	100X130X32	90X180X32	70x180x32	70x180x32
Cutting speed (metre per minute)	115	150	90/100	160/180	157	230
Axial Feed (mm/work revolution)	1.5	2	1.5/1.8	2.8/3.0	1.2	1.3
Cutting time (Seconds)	420	286	282	165	88	59
Life per sharpening	750	1505	600	950	2500	3600
Time Reduction	-32%		-41%		-33%	
Life Increase	101%		58%		44%	

As is evident from the data, the results are encouraging with the reduction in cutting time as well increase in life per sharpening.

ES-Cut Hobs

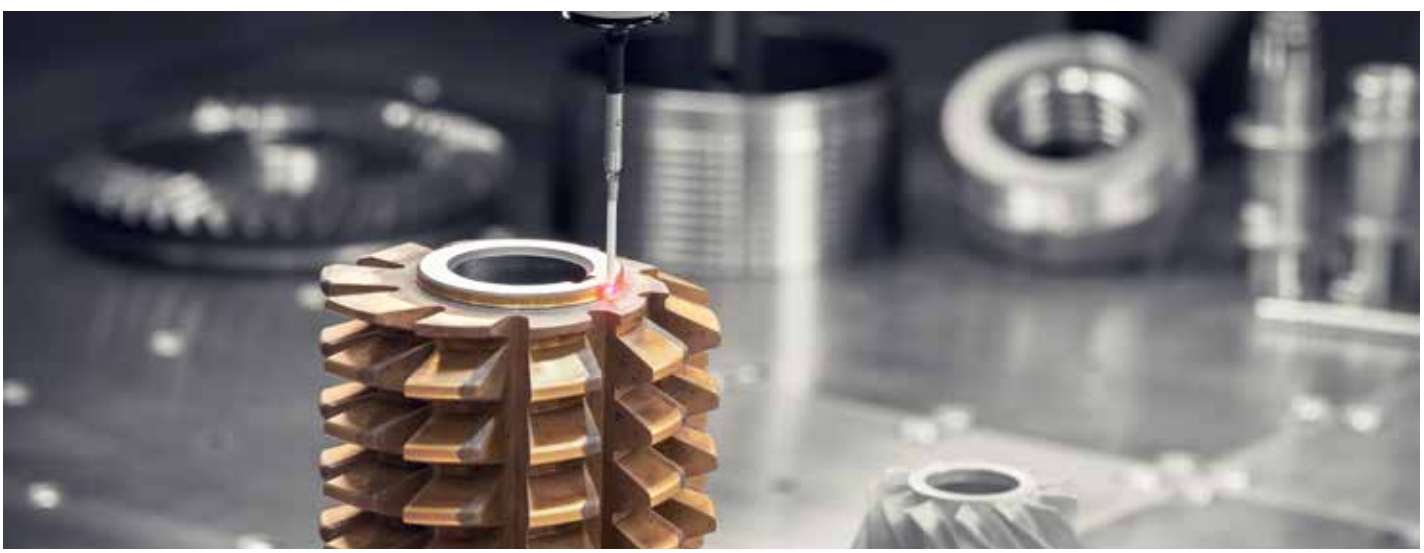
ES-H hobs

Multiple benefits

- Increasing Plant capacity with the same machines by reducing the cutting time.
- Reduces Cost per component
- Lesser inventories
- Lesser variables for production
- Saves capital investment, land, energy & manpower for installing new machines.

Considering the above, we must encourage such engineered study-based activity to improve production efficiency and, at the same time, reduce the cost per component and avoid capital investment.

Sanjay Gupta
Director
ESGI Tools Pvt. Ltd., India
www.esgitools.com
esgi@esgitools.com



Bevel Gears India: From Specialisation to Global Leadership

- By Sushmita Das

Mushtaq Jamal
Director - Engineering & Business Development
Bevel Gears India Pvt Ltd

In this exclusive interaction, Mushtaq Jamal, Director – Engineering & Business Development at Bevel Gears India Pvt Ltd, shares his perspectives on the company's evolving journey in high-precision bevel gear manufacturing. In conversation with Sushmita Das, Editor of Gear Technology India, he reflects on BGI's strategic focus on niche applications, advanced CNC technologies, dual-system expertise, and global market expansion. The discussion offers valuable insights into innovation, custom engineering, leadership, and the future of bevel gear manufacturing in an increasingly digital and competitive landscape.

1. Bevel Gears India has specialised in bevel and related gears for several decades. How has your vision for the company evolved in recent years with rapid changes in manufacturing technology?

BGI's focus shift over the last five years was based on diversifying business applications and entering multiple global markets. The thrust remains niches - both technical and customer-driven, specialised spaces – rather than high volume products. The technical focus is now on providing bevel gear solutions using CNC bevel gear technology, which begins with the software, CNC grinding, and CNC gear metrology, giving the customer a comprehensive solution. The customer offering has been enhanced by producing an extremely wide range of parts, by global standards, of bevel gears from 5 mm to 1,600 mm in diameter.

Today, we offer customers two hard finishing solutions. The first is CNC bevel gear grinding, which we began 20 years ago. Our multiple CNC bevel machine range starts at sub 1-module and includes high ratio hypoids (HRH ®) and will be increased from 650 mm to 850mm by June 2026 with the introduction of a Klingelnberg Oerlikon G80. The second option is hard finishing upto 1,700 mm diameter on our 5-axis DMG.

In the past decade, the shift within the company was from a generalist bevel gear manufacturer to more specific application knowledge for aerospace, mining, crushing, performance motorsport, and optical control devices, to name a few. BGI has watched technology evolve and carefully selected equipment to enhance the focus on high-precision bevel gear manufacturing. While consumer electronics evolve rapidly, and many cases annually, gear equipment is purchased with a usable life of 15 to 20 years, so the equipment selection has to be very well thought out.

2. Custom gear solutions and reverse engineering are key strengths of your organisation. How do you balance customised engineering with efficiency and scalability?

Reverse engineering is a facet of custom gear solutions, albeit from a different lens. We look at a bouquet of applications which have drastically different realisation timeframes from a few months to 5 years, so we have to be nimble and reverse engineering plays a key role. In several instances, we reverse-engineered multiple international MNCs' own parts because they were either locked in with a supplier, and thus had limited gear information, or they lost their internal talent over the years or both. For these companies, it is essential to find a partner that can re-evaluate what they have been sourcing for decades, offer improvement suggestions, and reverse engineering services prove essential and lead to long-term contracts for custom bevel gears.

3. Your company works with both Gleason and Klingelnberg bevel systems. How has this dual capability strengthened

your competitive position in domestic and global markets?

The transition to offering both Gleason and Klingelnberg bevel gear tooth-forms was customer-driven. While the end application is a bevel gear, the technology, equipment, and calculations behind it differ significantly between the two systems, and this is appreciated by the discerning gear buyer. There was a strategic decision by BGI over a decade ago, since globally, very few companies offer both systems comprehensively. We offer an array of cutting systems, including straight bevel Coniflex ®, spiral bevel 5-cut spread blade, duplex / completing, and cyclo-palloid.

Offering both systems has been welcomed by international and domestic customers because they can purchase the same established high precision components as before, and they do not have to perform arduous and time-consuming verification or life cycle tests when changing systems.

Alternatively, some customers benefit from having the option to choose if the project is starting. We put forth both options, so they can select what suits them and the application best.

4. You serve diverse sectors such as aerospace, mining, and heavy engineering. What are some of the most challenging applications you have handled recently?

For that question to be answered, we would need a page just for this query! We successfully developed motorsport parts for extreme use, which required DIN 4 hypoid gears which had previously been failing quite spectacularly. To withstand the incredible 5,000 hp, this challenge brought together material selection, heat treatment, special coating processes and, of course, technical hypoid grinding experiments. We continue to benefit from taking on this program because what we learnt lends itself to many of the other applications we continue to make.

Another challenge during an international technology transfer project can arise from perceptions and cultural differences. Subtle differences in the usage of a word in a drawing can have a massive impact on the technology level required. We spend a fair bit of time with customers to ensure they get what they want, and that can extend beyond just the print.

5. What major trends do you see shaping bevel gear manufacturing in the next three to five years, especially in terms of automation and digitalisation?

Both automation and digitisation are going to be essential on the shop floor and in the office alike. Flexible automation is playing an increasingly interesting role that will bring tangible benefits. The challenges of the West, where people retire, and knowledge is lost whilst wages rise, will present themselves rapidly in India, so embracing what technology has to offer is a logical step.

Additive technologies are still rapidly evolving as well. Who knows what the environment will look like in 5 years, but it will certainly be a different landscape.

6. Bevel Gears India has a strong presence in export markets. What opportunities and challenges do you foresee in expanding internationally?

If a product is specialised enough, the marketplace is global rather than solely local. With this in mind, we began our export marketing decades ago, and today we continue to look for positions in different markets. The challenges will always remain, but we prefer to look at the opportunities and how we can make them happen. The time to develop supply lines is significant, and changing suppliers is not a trivial task, so getting involved with multiple projects is essential and ongoing.

7. What leadership lessons and industry insights would you like to share with young professionals and emerging gear manufacturers in India?

In one line: do what others do not. Manufacturing is essential and will endure for generations, so find your own niche. If you are involved and passionate about something, go ahead and give it your best shot, and you will be surprised by what you learn about yourself and business during the journey.

RZ 410 – The Job Shop Machine for the Digital Age

- By Proteck Machinery Group

Precision, Flexibility, and Power in One Platform

The Reishauer RZ 410 represents the perfect balance of versatility, precision, and productivity in modern gear manufacturing. Designed for job shops and flexible production lines, it combines high material removal capability with outstanding production stability.

Illustration: Reishauer gear grinding machine RZ410 4.0 plus compact loader RCL 410

With a grinding diameter range of 0.5 to 410 mm and a module range of 0.5 to 10 mm, the RZ 410 covers a broad array of applications. Sharing its technological base with the larger RZ 550 and RZ 1000 models, it delivers the same accuracy and dependability in a compact size. Quick setup times, easy access, and intuitive operation make it a machine designed for dynamic production settings

Unmatched Performance and Flexibility

At the heart of the RZ 410 is the most powerful workpiece spindle drive in its class, providing superb control accuracy and adaptability for every grinding task. This makes it particularly effective in workshops where frequent part changes are the norm. The machine supports all major grinding and dressing operations, including profile grinding and line dressing. A swiveling dressing axis allows all Reishauer dressing technologies, such as topological dressing and multi-rib full-profile dressing, ensuring precise tooth geometries and surface finishes.

Generation 4.0 – Where Mechanics Meet Digital Intelligence

The latest model, the RZ 410 4.0, enhances these strengths with digital intelligence. Particularly in small and medium-batch production, retrieving setup data from internal or external databases shortens setup times and boosts productivity. process consistency. Powered by the Reishauer Software Platform (RSP) and the Siemens SINUMERIK ONE controller, the RZ 410 4.0 ensures stable, efficient, and future-ready gear grinding operations.

Smart Connectivity and Integration

Connectivity defines the RZ 410 4.0. Equipped with fully digital sensors and IO-Link communication, it enables real-time monitoring and parameter adjustment directly from the control panel. Optional interfaces, such as Gear Data Exchange (GDE) and OPC UA, ensure seamless communication with factory systems, MES environments, and external devices, making the RZ 410 ready for Industry 4.0.

Intuitive Operation and Ergonomics

The RSP software offers a unified, easy-to-navigate interface across all Reishauer machines. Its graphical, input-based process guidance reduces operator training time while maintaining the logical structure familiar to experienced users. The height-adjustable HD touchscreen display consolidates all major functions, providing direct access to multilingual manuals and support — ensuring optimal ergonomics and user confidence.

Optimized Setup and Process Creation

Setting up a grinding process is now easier than ever. The RZ 410 4.0 guides operators through sequences and checks, ensuring that each step is accurately validated before proceeding. Processes can also be created offline using Reishauer RZDesk software and then transferred to the machine later. Existing data can be retrieved or analyzed for troubleshooting, allowing for efficient maintenance consistent and repeatable setups across production shifts.

Digital Services – myReishauer and ARGUS

Reishauer's digital ecosystem enhances machine transparency, efficiency, and knowledge sharing through two platforms: "myReishauer" and "ARGUS."

myReishauer is built on three pillars:
1. Monitoring – providing real-time insights into machine and process performance.
2. Service – offering predictive maintenance and maximizing machine availability.
3. Academy – granting access to expert training and maintenance tutorials.

It bridges physical machines with digital applications, empowering users to make data-driven decisions and continually

improve performance.

ARGUS is Reishauer's advanced process monitoring system. It evaluates both dressing and grinding data in real-time using vibration, acceleration, force, and process sensors. ARGUS not only detects deviations before they impact production but also assesses the health of machine components, enabling predictive maintenance planning. Data visualization through intuitive dashboards – accessible directly on the machine or via a web application – provides clear insights into both real-time and historical operations.

Maximum Flexibility: Profile and Generating Grinding

The RZ 410 4.0 offers a wide range of machining options. For prototypes and small batches, profile grinding on the main spindle can handle modules up to 14 mm with minimal changeover time. The optional PSK D20 profile grinding head attaches in less than 20 minutes and allows high-speed CBN grinding of gears with interfering contours.

For generating grinding of complex geometries, a small spindle attachment extends the RZ 410's range. Operating at speeds of up to 10,930 rpm, it achieves ISO/DIN class 5 accuracy or better, while maintaining the economic advantages of continuous grinding. Setup time is under 45 minutes – making it an ideal solution for high-mix, low-volume manufacturing.

Conclusion – Setting the Benchmark in Gear Grinding

With the RZ 410 4.0, Reishauer again sets the standard for efficiency, digital integration, and flexibility in gear grinding.

Whether in job shops, tool rooms, or automated production systems, it provides stable processes, intuitive operation, and

unmatched precision. Combining mechanical excellence with digital intelligence, the RZ 410 4.0 represents the next step in Reishauer's "Circle of Competence" – another benchmark for the future of gear manufacturing.

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Advancing Gear Cutting Performance: Tool Design, Materials, and Strategy Behind Addison's Broaches and Hobs

- By Sushmita Das

G. Giridhara Gopal
Director & Chief Executive
Addison & Company Limited,

G. Giridhara Gopal is the Director & Chief Executive of Addison & Company Limited, a flagship company of the Amalgamations Group. With a strong blend of technical and financial expertise, he brings a balanced and strategic approach to leadership and business growth.
He holds an Engineering degree from Guindy Engineering College, Chennai, one of India's premier institutions, and has also pursued Cost and Management Accounting (CMA) from the Institute of Cost Accountants of India, equipping him with deep insights into manufacturing, operations, finance, and corporate governance.
Under his leadership, Addison & Company Limited continues to strengthen its legacy of precision, quality, and innovation, while adapting to evolving industry needs and global standards. His vision is focused on sustainable growth, operational excellence, and long-term value creation for customers, employees, and stakeholders alike.

1. Where do broaches and hobs stand today in terms of strategic importance?

Broaches and hobs remain central to high-volume, high-precision gear manufacturing. Wherever manufacturers seek consistent quality, tight tolerances, low cost per gear and fast delivery, these tools play a critical role, even though the initial tooling investment can be high.

Across the global gear industry, precision cutting tools are no longer viewed as simple consumables. They are increasingly treated as part of an integrated manufacturing system that directly influences productivity, quality, and total cost of ownership. This aligns closely with Addison's philosophy of "Tools for a Changing World", where our focus is on enabling customer competitiveness in demanding and evolving applications.

2. Which end-use industries are shaping demand for gear-cutting tools?

Any application involving motion, power transmission or moving components depends on gears. Automotive, off-highway equipment, industrial machinery, and energy applications continue to be the primary demand drivers.

More recently, electric and hybrid drivetrains have accelerated the need for customised gear solutions, lower noise, higher efficiency, and longer service life. This has driven greater adoption of advanced finishing technologies such as PCBN and diamond honing, as well as hard-turning tools. OEMs today expect cutting tools not only to deliver dimensional accuracy but also to ensure surface integrity and process stability.

3. What trends will shape the future of broaches and hobs?

The future will be shaped by the rapid growth of EVs, increasing automation, including LCSA (Low-Cost Simple Automation), disruptive drivetrain architectures and the continuous demand for higher productivity, better quality, and faster manufacturing cycles.

Key technical trends include higher dimensional accuracy, dry and near-dry machining, and wider adoption of advanced hard-finishing technologies. Hard finishing using PCBN

is increasingly being applied alongside, or in some cases instead of, grinding to improve energy efficiency and throughput.

With Van Moppes as a strategic partner for PCBN and PCD technologies, Addison is well-positioned to support these developments. We continue to invest in gear-cutting technologies, and several new solutions aimed at EV and high-precision applications will be introduced in the coming years.

4. How has the gear-cutting tool segment evolved within Addison's overall business?

Over the last decade, gear-cutting tools at Addison have evolved from a supporting product line into one of our most important and fastest-advancing technology portfolios. As drivetrains across automotive, off-highway and industrial sectors have become more performance-driven, customers are no longer looking for tools alone – they expect application-specific solutions that improve accuracy, productivity, and cost per gear.

Rather than attempting to cover every gear-manufacturing operation, Addison has taken a focused strategic approach. Today our core strength lies in broaches, selective hobs, PCBN and diamond honing tools for gear finishing, and PCBN tools for hard turning of gears – the stages where precision and process stability have the greatest influence on final gearbox performance.
We also offer re-grinding of broaches of any make, helping customers significantly reduce tooling cost, especially in markets where imported broaches are expensive and subject to long lead times.

While our current hob manufacturing range is selective, Addison is actively working with suitable overseas partners to bring new technologies and design perspectives to gear manufacturers, and to expand our hob manufacturing capability over the next few years.
In addition, Addison is evaluating the introduction of gear shaving cutters through overseas partners to address high-precision finishing requirements for advanced gear applications.

5. What core design and performance aspects define Addison's broaches and hobs?

Addison's broaches and hobs are engineered to deliver high precision, stability, and predictable life. Key elements include:

- Selection of application-specific raw materials
- In-house tool design by a dedicated engineering team
- Optimised tooth geometry for smooth chip flow
- High profile accuracy and pitch control
- Stable cutting edges for vibration-free machining
- Long and predictable tool life
- Application-specific performance coatings
- In-house validation before release to customers

In gear manufacturing, Addison's broaching solutions cover all critical internal and form features, including:

- Internal gear teeth (spur and helical)
- Splines and serrations in gear hubs
- Keyways for torque transmission
- Form and tooth-space broaching for special gear profiles
- Ratchet and pawl profiles
- Special internal geometries and face-gear features

These broaches are widely used in automotive transmissions, planetary gear sets, differential gears, and high-volume drivetrain components, where accuracy, repeatability, and throughput are essential.

Manufacturing is carried out on advanced Japanese and German machines, ensuring high precision and repeatability. All broaches and hobs are validated on in-house inspection and test platforms to confirm profile, pitch, and functional accuracy before release to customers.

Indicative capability:

- Broaches: Diameter from 15 mm to 150 mm; length up to 2000 mm
- Hobs: Diameter up to 180 mm; length up to 150 mm; module range 1 to 8

We also have in-house coating capability for broaches up to limited sizes, with larger tools supported through qualified coating partners.

6. What ensures consistent quality in tight gear tolerances?

Consistent quality is achieved through a disciplined and systemised approach – well-maintained machines, robust in-process quality controls, and continuous improvement across all operations.

Equally important is the ability to anticipate customer requirements, comply with evolving standards and adopt new technologies quickly. At Addison, this is driven by our strong belief in FANTA – Faster Adoption of Newer Technological Advancements.

7. What role do materials and coatings play in tool performance?

Materials and coatings are fundamental to tool performance. Based on the application, different substrate grades are selected to balance toughness and wear resistance.

Advanced coatings significantly extend tool life, enable higher cutting speeds, and reduce cost per component. They also support eco-friendly machining such as dry and MQL processes, helping customers lower energy use and environmental impact.
In demanding gear-cutting applications, substrate quality and coating technology are among the most critical performance drivers.

8. How does Addison balance tool life, accuracy, and productivity?

This balance is achieved through a holistic, systemised approach – application-specific materials, intelligent tool design, optimised manufacturing processes, performance coatings, continuous R&D and stringent in-process quality control.
In-house validation, careful handling, and protective packaging further ensure that customers receive tools capable of high cutting speeds, tight tolerances, and predictable tool life, resulting in a lower cost per gear.

9. How does Addison approach customised gear-cutting solutions?

Customisation is a key strength at Addison. With an established national footprint, a dedicated application team and close collaboration with research institutions, we work closely with customers to tailor tools to their specific processes.

In broaching and finishing, where imported tools often carry a high landed cost, Addison focuses on locally engineered tools, optimised processes, re-grinding support, and continuous performance improvement to deliver a strong cost-performance advantage.

Our portfolio includes PCBN, PCD, diamond and honing tools for superior gear finishing and surface integrity.

10. How is digitalisation influencing gear-cutting tools?

Digitalisation has become essential in modern gear manufacturing. Digital tools are used to optimise tool design, predict cutting behaviour, and analyse field performance, reducing development time and improving first-time-right outcomes.

Simulation and digital-twin technologies are becoming standard practice in advanced gear-manufacturing environments, enabling consistent processes, high repeatability, improved reliability, and lower overall cost.

Understanding Gear Shaper Guide Assemblies: Enhancing Precision in Gear Manufacturing

- By Mayank Pilojpara

Introduction

Gear shaping remains one of the most reliable and widely used processes for manufacturing internal and external gears. Central to the accuracy and performance of a gear shaping machine is the gear shaper guide assembly, which plays a crucial role in maintaining alignment, stability, and cutting precision.

This article provides an overview of gear shaper guide assemblies, their types, functions, and a detailed focus on hydrostatic guide systems.

Fig 1

What is a Gear Shaper Guide Assembly?

A gear shaper guide assembly is an integral component of a gear-shaping machine. Gear shaping machines are used to generate gear teeth by means of a reciprocating cutting tool that moves in and out of the workpiece.

These machines are capable of producing both internal and external gears. Depending on the guide system used, they can cut:

- Spur gears using spur guide assemblies
- Helical gears using helical guide assemblies

The guide assembly ensures controlled movement of the cutting tool, enabling accurate formation of gear tooth profiles.

Types of Gear Shaper Guide Assemblies

Over the years, different types of guide assemblies have been developed to meet evolving industry requirements. The main types include:

1. Mechanical or Conventional Guides

These are traditional guide systems based on mechanical contact surfaces. They rely on precise machining and lubrication for smooth operation.

2. Hydromechanical Guides

These guides combine mechanical guidance with hydraulic assistance, offering improved smoothness compared to purely mechanical systems.

3. Hydrostatic Guides

Hydrostatic guides use pressurised oil to create a supporting film between moving components. This significantly reduces friction and wear while improving accuracy.

4. NC or Electronic Guides

Modern gear shaping machines increasingly use NC (Numerical Control) or electronic guides. Most of these systems operate on hydrostatic guide principles, offering high precision and automation.

Fig 2

Purpose of a Gear Shaper Guide Assembly

The primary function of a gear shaper guide assembly is to ensure accurate positioning and controlled movement of the cutting tool during the shaping process. Its main purposes include:

- Maintaining proper alignment between the tool and the workpiece
- Guiding the reciprocating motion of the cutter
- Ensuring consistent tooth geometry
- Preventing deviation from the intended cutting path

By performing these functions, the guide assembly directly contributes to the quality, repeatability, and reliability of gear production.

Focus on Hydrostatic Gear Shaper Guide Assembly

Working Principle

A hydrostatic gear shaper guide assembly operates

using pressurised fluid, usually hydraulic oil. The oil is pumped under pressure into specially designed pockets within the guide system.

This pressurised oil forms a thin lubricating layer between moving parts, allowing them to float without direct metal-to-metal contact. As a result:

- Friction is minimised
- Motion becomes smoother
- Wear is significantly reduced

Compared to conventional mechanical systems, hydrostatic guides provide superior motion control and operational stability.

Components of a Hydrostatic Guide Assembly

A typical hydrostatic gear shaper guide assembly consists of the following key components:

1. Male Part (Follower)

The male part, also known as the follower, is mounted at the upper end of the ram or spindle. In some modern machines, this component is integrated directly within the ram or spindle assembly.

Its main function is to move in accordance with the guide body and transmit the required motion to the cutting tool.

2. Guide Body (Female Part)

The guide body, also called the female part, forms the main structural component of the hydrostatic guide system. It is a static element attached to the rotary drive mechanism.

This component acts as a hydrostatic bearing, allowing the male part to reciprocate or oscillate smoothly within it while maintaining precise alignment.

3. Capillaries

Capillaries are small, precisely sized flow restrictors incorporated within the guide body. Their primary function is to regulate oil flow and pressure.

By creating a controlled pressure drop, capillaries ensure that each oil pocket maintains stable pressure, resulting in effective load balancing and uniform support.

4. Pressure Seals

Pressure seals are installed at the main pressure inlet of the guide body. These seals prevent leakage of pressurised oil and ensure that the oil enters the guide system only through the designated orifices.

They play a critical role in maintaining system efficiency and consistent operating pressure.

Advantages of Hydrostatic Gear Shaper Guides

Hydrostatic guide assemblies offer several technical and operational advantages over conventional systems:

Increased Precision

The pressurised oil film enables smooth and vibration-free movement, resulting in higher positioning accuracy and improved gear quality.

Reduced Wear and Tear

The absence of direct contact between moving parts minimises mechanical wear, extending component life.

Higher Load Capacity

Hydrostatic systems can support heavier loads, allowing machining of tougher materials and demanding gear profiles.

Lower Maintenance Costs

Reduced friction and wear lead to fewer breakdowns and longer maintenance intervals, improving overall machine uptime.

Conclusion

The gear shaper guide assembly is a vital element in achieving consistent accuracy and performance in gear shaping operations. Among the various types available, hydrostatic guide systems stand out for their superior precision, durability, and reliability.

With increasing demand for high-quality gears in automotive, aerospace, and industrial applications, the adoption of hydrostatic and NC-based guide systems consists of a hydrostatic function, hydrostatic guide system is the main part of it

More technical details on hydrostatic guides and their components will be covered in the next issue of Gear Technology India.

Industry Support and Contact

For further guidance, technical support, and spare parts related to hydrostatic gear shaper guides, readers may contact:

M/s Master Gears and Machinery
Email: hydrostaticguides@gmail.com
Phone: +91-9904255511

Mayank Pilojpara
Technical Head
Master Gears and machinery

From Make in India to Made for the World: A Conversation with UCAM's Leadership Featuring Indradev Babu, Managing Director, UCAM Pvt Ltd.

- By Sushmita Das

Indradev Babu is the Founder and Managing Director of UCAM Pvt Ltd, a global leader in high-precision CNC Rotary Tables and 5-axis solutions. A visionary technocrat and Past President of the Indian Machine Tool Manufacturers' Association (IMTMA), he established UCAM in 1985 with a mission to bring world-class engineering to India. Under his leadership, the company has become a benchmark for indigenous R&D and innovation, empowering the global manufacturing ecosystem with advanced, technology-driven solutions.

1. UCAM has grown from a domestic manufacturer into a globally recognised CNC rotary table company. What key strategic decisions have played the most important role in this journey?

The most transformative decision was to pursue Technological Sovereignty. We realized that to lead on a global stage, we could not simply assemble components; we had to master the core physics of our product.

This drove our strategy of Deep Backward Integration. We established Nimble Electric to create high-performance torque motors and Nimble Machines to manufacture world-class gears. By owning the critical technology – the very heart and brain of the rotary table – we secured absolute control over innovation and quality. It shifted our trajectory from being a participant in the market to being a creator of standards. We moved beyond "meeting specs" to "defining excellence," ensuring our technology stands tall in the most demanding European and Japanese environments.

2. As Industry 4.0 and smart manufacturing gain momentum, how is UCAM aligning its technology and business strategy to stay competitive globally?

We are elevating the Rotary table from a mechanical component to an Active, Digital-Ready Subsystem. Our strategy is centered on the Digitalization of Precision.

We are embedding advanced sensing and connectivity directly into our designs, particularly with our Direct Drive technology. We view the table as a source of critical intelligence – providing real-time insights on vibration, thermal dynamics, and load. By enabling our products to communicate with the CNC ecosystem, we are helping customers unlock a higher tier of manufacturing intelligence. It's about ensuring UCAM technology is future-proof, serving as the backbone for the smart factories of tomorrow.

3. UCAM emphasises world-class customer experience and continuous improvement. How are these values translated into day-to-day operations across design, manufacturing, and service teams?

Our operations are driven by a philosophy of Uncompromising Excellence.

In design, we cultivate a mindset of "Over-Engineering" for reliability. We utilise advanced simulation not just to validate designs, but to push boundaries, ensuring our products thrive in conditions far exceeding standard requirements. In manufacturing, the focus is on Craftsmanship at Scale – treating every unit with precision.

For service, we have transitioned to a Client Success Model. Our teams engage with customers to optimise their processes and unlock the full potential of their machinery. It is a partnership model where their productivity growth is the metric of our success.

4. What recent product innovations or technological developments at UCAM have had the strongest impact on customer productivity and process efficiency?

Our focus on Velocity and Rigidity has led to two breakthrough innovations.

First, our Direct Drive (DDR) Technology has redefined what is possible in high-speed machining. By eliminating mechanical transmission, we offer instantaneous dynamic response and absolute precision. This allows our customers to achieve production cycles that were previously unimaginable.

Second, our Mint Series and large-bore tilting tables for the aerospace sector represent a leap in structural rigidity. These solutions enable the single-setup machining of complex, critical components. We are effectively giving our customers the gift of precision-at-speed, allowing them to maximise their output without sacrificing a micron of accuracy.

5. How do you approach R&D while balancing customised solutions for specific applications with scalable products for global markets?

We approach this through a strategy of Architectural Integrity.

We invest heavily in developing a robust, world-class "Core Platform" – our fundamental mechanisms and motor technologies are designed for universal excellence and scalability. This strong foundation allows us to be agile in our Application Engineering.

Because our core technology is so versatile, we can rapidly engineer bespoke solutions for unique OEM challenges – be it for energy, defence, or medical sectors – without starting from scratch. It allows us to offer the stability of a global product with the agility of a specialised engineering partner.

6. With the introduction of connected and digital solutions, what tangible benefits are customers experiencing in terms of uptime, monitoring, or predictive maintenance?

The most significant shift is the move from "Reactive Repair" to Strategic Asset Management.

Our digital solutions provide operational foresight. By monitoring motor current signatures and real-time performance data, customers can identify anomalies – like tool wear or load deviations – well before they impact production. This empowers them to schedule interventions strategically, ensuring uninterrupted productivity. It creates a manufacturing environment defined by Predictability and Control, allowing our customers to commit to their own delivery schedules with absolute confidence.

7. UCAM serves diverse industries such as automotive, aerospace, and general engineering. How do you adapt your solutions to meet the varying precision and performance requirements of these sectors?

We engineer for the Mission Profile.

For Automotive, the mission is distinct: high-frequency dynamics and relentless endurance. Here, our solutions are tuned for rapid acceleration and long-term resilience under continuous operation.

For Aerospace, the mission is absolute stability. We engineer tables with massive clamping torque and vibration-damping characteristics to handle high-value, exotic materials. We don't just supply a product; we supply a capability tailored to the specific physics of the customer's industry.

8. What shifts are you observing in customer expectations, both in India and international markets, and how is UCAM responding to these changes?

The market is maturing towards a demand for Holistic Ownership. Customers are looking for comprehensive solutions rather than isolated components.

They seek partners who can take responsibility for the entire 4th and 5th-axis ecosystem – the table, the integration, the fixtures, and the hydraulics. UCAM is responding by becoming a Single-Source Solution Architect. We are delivering fully integrated, "plug-and-play" systems. This ensures that when a machine builder chooses UCAM, they are choosing peace of mind and guaranteed performance integration.

9. Building strong technical teams is critical in precision manufacturing. How do you nurture engineering talent and leadership within the organisation?

We focus on building Intellectual Capital.

We immerse our engineers in a culture of "High-Stakes Innovation." We expose them to the global arena – sending them to premier exhibitions like ENGIMACH and EMO – to benchmark themselves against the world's best. We want them to internalize global standards.

Internally, we practice Empowered Leadership. We give young engineers ownership of critical projects, encouraging them to take calculated technical risks. We believe that to build world-class products, you must first build world-class engineers who possess the vision and confidence to innovate.

10. Looking ahead, what is your long-term vision for UCAM in terms of technology leadership, global expansion, and contribution to India's manufacturing ecosystem?

My vision is for UCAM to be the Global Benchmark for Precision.

We aim to solidify our position among the Top 5 Global Leaders in our domain. Our goal is to be the preferred technology partner for machine builders in Europe, the US, and Japan, recognized purely for our engineering superiority.

For India, UCAM will stand as a pillar of High-Value Manufacturing. We are proving that Indian engineering is synonymous with the cutting edge. We are moving beyond "Make in India" to a reality where we are "Innovating for the World," establishing a legacy of technological leadership that inspires the next generation of Indian manufacturing.

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CONTACT
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Kiseki Machinery's Gear Manufacturing Solutions for India's Future Industries

- By Kiseki Machinery Group

As industries such as electric mobility, robotics, industrial automation, and precision engineering continue to evolve, the role of high-quality gears has become increasingly strategic. Gear accuracy today directly impacts efficiency, noise levels, durability, and overall system performance. For Indian manufacturers striving to meet global benchmarks, advanced gear cutting technology is no longer optional. In this context, Kiseki Machinery plays a significant role in bringing world-class gear manufacturing solutions to the Indian market.

KITAI SANGYO CO., LTD - Japan. Specialised in High Precision Gear HOB Machine Maker with Automation since its founding in 1936. Kitai's 80 Plus years of know-how and technology apply to Aerospace, Zero backlash gearbox making, Robotic gearbox gear, Instrumentation, Auto Parts, General Engineering, etc.

A Strategic Partner in Advanced Manufacturing Technology

Kiseki Machinery is a well-established provider of advanced machine tool solutions in India, offering comprehensive support across marketing, application engineering, installation, commissioning, and after-sales service. With a strong presence across major manufacturing hubs, the company caters to a wide spectrum of industries, including automotive, electric vehicles, aerospace, electronics, medical devices, energy, and general engineering.

In the domain of gear manufacturing, Kiseki Machinery represents Japanese Gear HOB Machine Maker Like Kitai Sangyo Co. Ltd., Kashifuji, which are all globally recognised Japanese technology for Hobbing, Shaping, Skiving, and shaping. This partnership enables Indian manufacturers to access proven gear cutting solutions supported by local technical expertise and responsive service infrastructure.

Japanese Engineering Excellence in Small Gear Hobbing. The gear hobbing machines offered through Kiseki Machinery are designed with a strong focus on mechanical rigidity and precision stability. Rather than relying solely on software compensation, these machines are built on a solid mechanical foundation that ensures accuracy over extended production cycles.

5-axis CNC high-speed automatic small hobbing machine - Hi-PRO 3N

4-axis CNC universal small hobbing machine HOBLON 8-NC

A key feature is the use of hand-scraped slideways, which provide a large contact surface area and superior vibration damping. This design reduces micro- vibrations during cutting, resulting in improved tooth profile accuracy and a better surface finish – critical parameters for high-speed and low-noise gear applications.
Synchronised Spindle Design for Stable Machining

Another important technical advantage is the synchronisation of the work spindle and tailstock spindle. This system ensures stable workholding and prevents damage to centre holes, particularly when machining small-module gears at higher speeds.

By maintaining consistent alignment and load distribution, synchronised spindle operation improves cutting stability, enhances dimensional accuracy, and extends tool life. This becomes especially valuable in continuous production environments where consistency and uptime are critical.

CNC Automation with Practical Flexibility Modern CNC control systems integrated into these gear hobbing and shaping machines simplify operation while expanding machining capability. Operators can input gear parameters directly, with the CNC system automatically manages cutting cycles, feeds, and indexing movements. This results in:

- Reduced setup time
- Faster changeovers between gear variants
- Lower dependence on operator skill
- Improved batch-to-batch consistency. Such capabilities make these machines well- suited for Indian manufacturers handling diverse product mixes alongside growing

production volumes.

4-axis CNC high-speed small gear shaping machine KS-6N

Automatic Hob Rake Face Grinding Machine SKA & SKA III

Double-flank meshing tester KGT
Machine Solutions for Diverse Gear Applications

Kiseki Machinery supports a wide range of gear manufacturing requirements through compact and high-performance machine platforms. These machines are capable of producing:

- Spur gears
- Helical gears
- Worm gears
- Internal gears (model-dependent)

Their compact footprints make them suitable for space-constrained shop floors, while high spindle speeds and rigid construction support both productivity and accuracy.

Energy Efficiency and Space Optimisation

With increasing emphasis on sustainable manufacturing, machine efficiency and floor space utilisation have become important decision factors. The gear machines offered by Kiseki Machinery are designed to be energy-efficient and space-saving, helping manufacturers reduce operational costs while maintaining high output levels.

These machines can also be integrated into automated production lines, aligning well with Industry 4.0 and smart factory initiatives, which are gaining momentum across India.

Supporting India's Growing Gear Manufacturing Ecosystem

As India continues its push toward electric mobility, advanced automation, and export- oriented manufacturing, demand for small, high-precision gears is expected to grow rapidly. Kiseki Machinery's role extends beyond machine supply, offering application support, process optimisation, and long-term service – key enablers for consistent gear quality and manufacturing excellence.

Conclusion

Precision gear manufacturing is no longer just about cutting teeth – it is about engineering reliability, efficiency, and performance into every component. By combining globally proven Japanese gear hobbing technology with strong local support, Kiseki Machinery is helping Indian manufacturers enhance competitiveness in demanding
applications such as EVs, robotics, and industrial automation.
Business Contact: Kiseki Machinery,
Plot No: 1919, J-Block, 3rd Street, Annanagar, Chennai - 600040, Tamil Nadu, India. HP: +91 8807426744, +91 8248583211. E-mail: mgr@kisekimachinery.com,

Bending Deflections and Body Induced Deformation in Cylindrical Gears – Relevance of Various Analytical Methods

- By K.P. Soundararajan

Introduction

In a systematic calculation for load capacity against bending stress in cylindrical gears, all predictable factors were considered in gear design to foresee corrective steps or a corrected tooth form to accomplish.

There were some parameters which were applied for simplification.

i) The gearing and load distribution across face width were assumed uniform, and the tooth form for helical gears was adapted to a similar spur tooth with a virtual number of teeth and a critical section for bending was set at the tooth root at 30° tangent to the fillet.

ii) Working procedures were evaluated and endurance limits established for the material chosen, compared and applied. These procedures were improved by superimposing work experience and test results to alter the bending strength value estimated to optimise the deflection value.

These were practised by various well-known gear manufacturers such as Maag, Switzerland, who pioneered to optimise the calculations to update to better with the ISO.

With the development of computer science technology, the FEM could be used to work swiftly and be applied. Here boundary conditions were to be defined with a degree of discretisation.

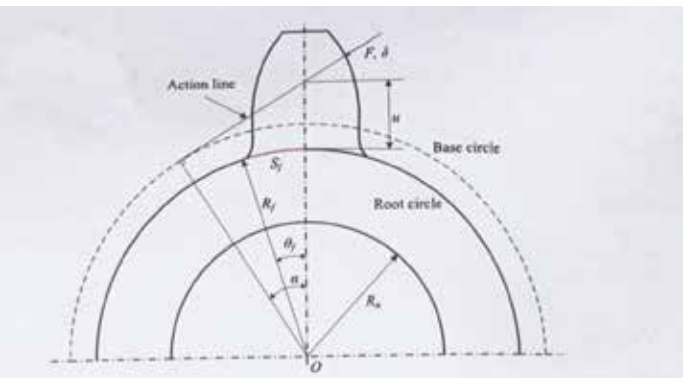
Body-induced deflection is a part of various load-based deformations, which include bending, shear, compression and coupling stresses int two-tooth contact region and the single tooth contact region. This resultant value, as a sum of components together with the contact stress-based deformation account for the mesh stiffness.

Bending Deformation Components

Over a period of time, it has been a practice to first address the contact stress and evaluate contact fatigue limits using the involved factors.

The intensity of Hertzian pressure induced on the tooth flank varies with shape and geometry, and is mostly non-linear. The effective radius of curvature between the meshing flanks takes the instantaneous value.

As mentioned in the previous paragraph, the local body-induced deflection has to be ascertained considering the sources in the gear geometry and solid structure. It is often referred to as fillet foundation stiffness, also as the reciprocal of deflection measured along the deflection angle at the root circle. The base radius deflection angle and the root circle-based arc shift calculations exist.



Trends of Assessment

The basic analytical approach to find the gear body deformation or deflection is considering the potential energy, in which the energies stored in each of the constituents under deformation act as a sum.
Figure 1. An elastic tooth subjected to a force F.

The said deflection is fixed analytically as follows:

$$\delta = \frac{1}{E}\frac{F}{b}\cos^2\alpha\left[L\left(\frac{u}{S_f}\right)^2 + M\left(\frac{u}{S_f}\right) + P\times\left(1+Q\tan^2\alpha\right)\right]$$

Equation 1

The parameters are the load, Young's modulus E, face width of the gear, pressure angle, a quantity u representing the distance between the root circle and the point of intersection of the tooth center line at the meshing zone. This intersection can be through the pitch point relative to the mesh position and the force applied near the tip of the tooth in the mesh, which causes the body-induced deflection.

The coefficients L, M, P and Q are determined to get the estimated value of deflection. This equation is used widely, yet the accuracy can change based on single tooth contact and two-tooth contact zone in a mesh cycle.

In an attempt to calculate mesh stiffness, researchers such as Kissling, Mahr and those from the University in Madrid, Spain applied methods to find bending, shear and compressive stiffness in the form of analytical formulae.

Weber and Banaschek found equations for gear body-induced stiffness as well as contact stiffness. Due to the limitations on the contact stiffness, along the line of action calculations with planar deformation theory remain partially used.

Besides the assumption by Banaschek for the tooth center line remaining rigid and the applied tip load to cause body induced deflection, and the angle shift through theta value applies Beltrami identified partial portions only of this hypothesis has been used in known gear design software.

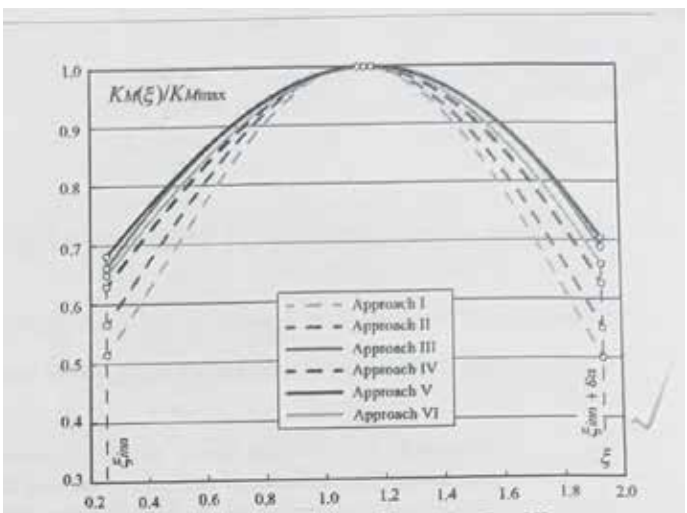


Fig. 2 curves of MS according to approaches)

Equation-2

$$\xi = \frac{z_1}{2\pi}\sqrt{\left(\frac{r_{c1}}{r_{b1}}\right)^2 - 1}$$

The mesh stiffness computation can be done as a function of a contact point parameter ξ, which is a meshing position along the path of contact as:

Equation 3

$$R_i = \frac{F_i}{F_T} = \frac{K_{Mi}}{\sum_j K_{Mj}}$$

The contact load deformation on the line of action on the profile is the least at the centre of the path of contact and close to the pitch circle. The mesh stiffness at the point is maximum by analytical means of display or FE simulation.

Modified form of equation in 1 is necessary on the basis of the following considerations:

i) To enable the inclusion of the two teeth contact phase in the mesh cycle in addition to single tooth contact.

ii) For the above, a coupling stress deformation is necessary to link all the bending-related deformations for better accuracy for the total value.

iii) Values for body deformation theta and a practical ratio for quantities responsible for the variation in its magnitude are to be calculated.

This ratio defines the root dia and the gear hub rim thickness. This quantity takes the gear bore diameter where applicable, instead of the hub diameter.
Consequently, the following equation applies to improve Equation 1.

Equation 4

$$X_i(h,\theta_f) = A_i/\theta_f^2 + B_i h^2 + C_i h/\theta_f + D_i/\theta_f + E_i h + F_i$$

The use of the coupling effect between adjacent engaging teeth and changes in root stress as parabolic as well as cubic to reach an improved solution has come in a few years ago. The stage has arrived with an involved calculation of coupling stress for overall stress level assessment. This has also led to finding a corresponding deformation of total value in knowing the change in transmission error in the presence of lubricated tooth flanks. This branches out separately to a different analysis involving thermo-EHL lubrication regime.

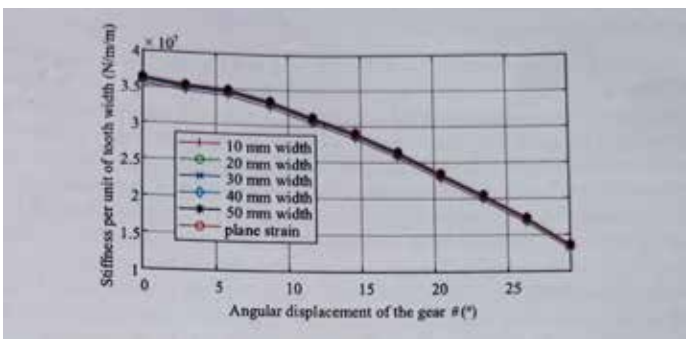
FEM-Based Analysis

Through an assumption and setting the model of the gear body either fully elastic or a portion below the root, there is a possibility to find the deformation induced by the gear body under load.

i) In a prediction where the gear as a total unit as elastic is set, and the load applied at the strategic tip end, and the deflection delta is measured along the line of action, both body-induced deflection and tooth deformation can be seen as total deflection.

Thereafter, fixing the gear body in rigid mode and applying the load on the tip of the tooth at the same location, the resulting deflection delta measured along the line of action becomes the tooth elastic deflection. The difference between the two gives the body induced deflection.

ii) The alternate way is to find the force on the root generated by an applied load at the tip. 0The corresponding forces at the root side in reduced values cause tooth deflection along the path of contact, which is the body-induced deformation directly.



Both methods can give the desired results.

Plane strain model applied to 2D on FEA plane 183 was used to verify the effect of body-induced deflection by evaluating the body stiffness on ordinate versus the angular displacement on the root dia on the abscissa.

This method assessed body stiffness per unit facewidth.

The force at the tip was applied on one tooth, and the effect on the deformation of body deflection angle calculated for five sets of facewidths, keeping the pitch diameter of the gear and bore diameter the same. In other words, the rim thickness remained the same.

The report on the stiffness value showed that the error on facewidths of chosen gears of 20 mm, 30 mm, 40 mm and 50 mm was negligible. When the face width narrows down, the error shows about 10%.

It is true that the module in this exercise shows less or no significant effect on body-induced deflection or the stiffness per unit facewidth for the tested gears of spur type.
Fig. 3 Comparison between 2-D and 3-D models

A comparison between the analytical methods mentioned and optimising the coefficients of these equations for improved results, and the Finite Element analysis-based plane strain model was made. This was done using the adjustment of coefficient values of analytical equations, and inferred as a deviation of up to 20% occurs in the previously reported analytical method that uses the ratio of root circle radius to bore radius or hub radius.

The variables such as the number of teeth, the ratio of root circle to bore radius and relative comparison error were applied.

Inference

The analytical models used for determining the load-induced deflections other than contact stress-based/Hertzian pressure are very useful in knowing the body-induced deflection. This used to be integral in the assessment of bending load deformation, earlier to FEM methods or 2D analytical models.

The single tooth contact and double tooth contact regimes in a mesh cycle have been considered in the improved analytical methods for body-induced deformation value.

The factors responsible for this variable and their validity have been covered.

The facewidths and the pitch diameter of the pinion or driving member have a role in affecting the body-induced deformation in a broader area of applications. This aspect has not been addressed in FEM-based analysis.

In cases of single mesh gears, including helical gears and the pinion gear held in bearings at the ends in a symmetrical manner, the body induced deflection setting integrated into the overall assessment of bending deformation under load is represented as:

$$f_b = -\frac{w' \cdot 2000\left(\eta - \frac{7}{12}\right) \cdot x^4}{\cos\alpha_t' \cdot E \cdot \pi}\left[1 - \left(\frac{\frac{b}{2} - b_x}{\frac{b}{2}}\right)^2\right]$$

Equation 5
i) X ratio of facewidth to pitch diameter

ii) Bearing span to facewidth ratio

Where, on account of partial face width as an arbitrary value, changing the deflection of the other one by 7/12 implies that the deflection gets exaggerated at a higher ratio.

Then it gets compounded in aggregate value.

The corrections to offset the impact of this deflection go into the modification of facewidth.

Conclusion

The precise method to assess the gear body deformation in an aggregate bending deflected tooth under load has been under a detailed study where various observations have been

reported in the last 6 to 8 years.

A review of various factors involved in the methods and a method used for single-stage gear mesh with bearing span, facewidth and pitch dia has been shown. The referred route for integrated bending deflection, where the pitch diameter, face width and bearing span are factored show influencing parameters on body-induced deformation.

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K.P. Soundararajan,
Former MD -
Gleason Works India

KREBS & RIEDEL: Strategic Grinding Solutions for India's Gear and Powertrain Industry

- By Sushmita Das

Amoghanandan. KV
Head of India operations
Krebs and Riedel

Amoghanandan Kv is the Head of India Operations at Krebs and Riedel Abrasives India Pvt Ltd, where he has been instrumental in expanding the business since its establishment in December 2019. With a total of 18 years of experience in the grinding industry, his leadership has contributed to a remarkable increase in business, growing it fourfold over a span of six years. Amoghanandan kv is committed to driving innovation and excellence in operations, ensuring that Krebs and Riedel remain a competitive player in the market.

1. With over 130 years of expertise in precision grinding, how does KREBS & RIEDEL's legacy influence innovation and product development for the Indian market?

Our extensive legacy of over 130 years in precision grinding is the bedrock of our innovation and product development strategies for the Indian market. This deep-rooted experience provides us with an unparalleled understanding of the fundamental principles and evolving nuances of grinding technology. This historical knowledge allows us to anticipate future needs and challenges, rather than just react to them.

For India, our legacy translates into a commitment to developing solutions that are not only cutting-edge but also robust and reliable, tailored to the specific demands of the Indian gear and powertrain industry. We leverage our accumulated expertise to refine existing processes, enhance machine performance, and develop entirely new grinding techniques. This heritage also fosters a culture of continuous learning and improvement within our R&D teams, ensuring that our innovations are grounded in proven success and designed for longevity. We translate this into practical applications by focusing on solutions that offer increased efficiency, improved precision, and longer tool life, all critical factors for manufacturers aiming for global competitiveness.

2. As India's gear and automotive sectors evolve rapidly, what key opportunities and challenges do you see for KREBS & RIEDEL in gear grinding applications?

The rapid evolution of India's gear and automotive sectors presents a dynamic landscape for KREBS & RIEDEL, brimming with both significant opportunities and distinct challenges.

Opportunities:

* Growing Demand for Precision and Efficiency: As Indian manufacturers increasingly aim for global quality standards and production volumes, the demand for high-precision, high-efficiency gear grinding solutions is escalating. This aligns perfectly with our core competencies.

* Electrification and Advanced Powertrains: The push towards electric vehicles (EVs) and hybrid powertrains is creating new types of gears and transmissions, often requiring novel grinding solutions due to different materials and designs. This opens up avenues for us to introduce specialised grinding technologies.

* Skilled Workforce Development: The growing availability of a skilled engineering and technical workforce in India presents an opportunity for us to build strong local teams for support, service, and even application engineering.

Challenges:

* Price Sensitivity: While quality is paramount, Indian manufacturers can be price-sensitive. Balancing the cost of advanced grinding technology with competitive pricing is a crucial challenge.

* Rapid Technological Adoption Pace: The speed at which new technologies and materials are being introduced requires us to

be agile in our R&D and product offerings to keep pace.

* Infrastructure and Logistics: While improving, certain infrastructure and logistical challenges in some regions of India can impact service delivery and support.

* Competition: The Indian market attracts both established global players and emerging local competitors, necessitating continuous differentiation through superior technology, service, and application support.

3. How does KREBS & RIEDEL adapt its global application know-how to address the specific requirements of Indian manufacturers?

Adapting our global application know-how to meet the specific requirements of Indian manufacturers is a multi-faceted process that centres on understanding, customisation, and collaboration.

* Deep Market Understanding: We invest significantly in understanding the Indian context. This involves not just technological needs but also economic factors, local industry practices, material variations, and regulatory landscapes. Our sales and technical teams actively engage with Indian manufacturers to gather this crucial on-ground intelligence.

* Localised Application Engineering: While our core grinding principles are universal, the specific parameters of a grinding operation can vary greatly. We work closely with Indian clients to tailor our application parameters – such as wheel selection, speeds, feeds, and coolant strategies – to optimise performance for their unique materials, machine capabilities, and desired outcomes.

* Training and Skill Enhancement: To ensure successful implementation and optimal utilisation of our technology, we provide comprehensive training programs for the technical staff of Indian manufacturers. This focuses on machine operation, maintenance, and troubleshooting, empowering them to get the most out of our solutions.

* Local Support Network: We are committed to building a robust local support network in India. This includes having accessible service engineers, readily available stocks, and application specialists who can provide prompt assistance and on-site support, addressing any operational challenges efficiently.

4. With advances in CBN and diamond tools, how is KREBS & RIEDEL enhancing gear accuracy and process efficiency?

KREBS & RIEDEL is committed to leveraging the latest in CBN and diamond tool technology to enhance gear accuracy and efficiency. This involves continuous investment in research and development to refine our tool geometries and coatings, which results in reduced cycle times and improved surface finishes. We also focus on integrating our tools with advanced machine capabilities to achieve optimal performance, ensuring that our clients can achieve high precision with greater consistency.

5. How important are partnerships with machine tool builders and research institutions in driving innovation for the Indian market?

Partnerships with machine tool builders and research institutions are crucial for innovation. Through collaborations, we gain insights into emerging technologies and market needs,

allowing us to develop tailored solutions for the Indian market. These partnerships also facilitate the sharing of knowledge, which helps us push the boundaries of what's possible in tool performance and application.

6. As EV manufacturing grows in India, what changes are you seeing in grinding tool requirements for e-mobility components?

With the rise of electric vehicle manufacturing, we are noticing a significant shift in grinding tool requirements. E-mobility components often demand higher precision and specific material characteristics. Consequently, we are adapting our product offerings to include tools specifically designed for new materials and geometries, focusing on enhancing thermal stability and durability to meet the evolving needs of this industry.

7. Looking ahead, what will be the key growth drivers for KREBS & RIEDEL in India over the next three to five years?

The Indian automotive sector, especially the electric vehicle (EV) market, will be a significant growth driver. As you asked earlier, EV components have unique grinding requirements, and KREBS & RIEDEL is well-positioned to provide specialised solutions for this rapidly expanding segment. Our advanced tooling and expertise in precision grinding align perfectly with the needs of EV manufacturers.

India's continuous push towards 'Make in India' and its ambition to become a global manufacturing hub mean a sustained demand for high-precision and efficient manufacturing processes. Industries like aerospace, defence, and general engineering will continue to invest in advanced grinding solutions to improve product quality, reduce costs, and increase competitiveness. KREBS & RIEDEL's innovative products are designed to meet these demands.

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esgi@esgitools.com

www.esgitools.com

The 2026 Mpma Annual Meeting: A Strategic Forum For Manufacturing Leaders

- By Mary Ellen Doran, AGMA—Director, Emerging Technology

In an era defined by economic uncertainty, supply chain disruption, and rapid workforce change, senior manufacturing leaders need more than tactical updates – they need strategic clarity. The 2026 MPMA Annual Meeting, held April 23–25, 2026, at the Sunseeker Resort in Charlotte Harbor, Florida, is designed specifically to deliver that clarity. Hosted by the Motion + Power Manufacturers Alliance (MPMA), this member-only gathering convenes top executives from across the power transmission and motion control industry for high-level dialogue, peer connection, and forward-looking insight.

The MPMA Annual Meeting is a purpose-built executive forum where leaders step away from day-to-day operations to focus on long-term positioning, risk mitigation, and growth strategy – alongside peers who face the same market realities.

Executive-Relevant Insights, Not Noise

The 2026 agenda centers on the issues that most directly impact executive decision-making. Each session is curated to provide context, perspective, and actionable intelligence, without the clutter of sales pitches or surface-level commentary.

Key sessions include:

- **Economic Outlook & Market Forecast**

Veteran economist Jim Meil delivers a clear, data-driven outlook on the U.S. and global economy, with specific implications for manufacturing demand, capital investment, and customer markets. Executives leave with a grounded understanding of what 2026 is likely to bring for the power transmission industry and its suppliers. And attendees will receive the tools to plan accordingly.

- **Trade, Tariffs, and Regulatory Risk**

With trade policy continuing to evolve, Nate Bolin provides an executive-level briefing on tariffs, trade remedies, and regulatory developments that affect cost structures, sourcing strategies, and competitive positioning. He will be able to bring the most up-to-the-minute on this information available.

- **Manufacturing Competitiveness & Operational Strategy**

Laurie Harbour addresses the current state of manufacturing performance, including productivity, capacity, supply chain resilience, and best operational practices. She will present the findings in the 2026 Q1 – MPMA Pulse Survey results and compare the results to other industries who took similar surveys to be able to offer insight into how leading companies are adapting in a volatile environment.

- **Strategic Foresight for Leaders**

Kristine Metter explores how executive teams can use strategic foresight to improve decision-making, anticipate disruption, and align leadership around long-term priorities rather than short-term reaction.

- **Workforce & Generational Dynamics**

Workforce challenges remain a top concern for power transmission executives. Cam Marston examines how generational shifts are reshaping leadership expectations, company culture, and customer relationships. He will provide senior leaders with tools to help their companies remain relevant and competitive.

- **Innovation Through Curiosity**

Nash Fung challenges leaders to rethink innovation not as a function of technology alone, but as a leadership mindset – one that drives adaptability, engagement, and breakthrough thinking.

Each session is structured to respect executive time while delivering insight that informs strategic planning, board discussions, and investment decisions.

Peer-to-Peer Value That Can't Be Replicated

What truly differentiates the MPMA Annual Meeting is the caliber of attendees. This is a closed-door environment populated by presidents, CEOs, owners, and senior executives from across the industry. Conversations are candid. Relationships are meaningful. Insights are shared openly.

The program intentionally blends structured sessions with informal networking opportunities to create space for real discussion about challenges, opportunities, and best practices.

For many attendees, the most valuable moments occur outside the general sessions: a strategic conversation over dinner, a shared challenge discussed on the golf course, or a connection that leads to collaboration months later.

While executives from both AGMA and ABMA have gathered for several years, this will be the first time that they are coming together under the same MPMA umbrella. Join the combined board of director members for a who's who in the power transmission industry.

An Environment Designed for Focus and Perspective

Set on Florida's Gulf Coast, the Sunseeker Resort offers a relaxed, premium setting that encourages reflection and engagement. The meeting's thoughtful balance of business and hospitality allows executives to step back, recharge, and return to their organizations with renewed perspective.

Why Senior Leaders Attend

Executives attend the MPMA Annual Meeting to:

- Gain strategic insight on economic, trade, and market forces
- Benchmark their organization against industry peers
- Strengthen leadership perspective beyond daily operations
- Build trusted relationships with fellow decision-makers
- Leave better prepared to guide their companies forward

The 2026 MPMA Annual Meeting is an investment in leadership effectiveness, strategic alignment, and long-term success.

For executives focused on navigating complexity, managing risk, and positioning their organisations for sustainable growth, this is a meeting worth prioritising.

Mary Ellen Doran
AGMA—Director, Emerging Technology

High-Performance Cutting Oil: SpezÖl SPEZOL FC-32

- By SPEZOL Group

SPEZOL FC-32 is a premium, high-performance neat cutting oil developed to meet the demanding requirements of modern machining operations. Formulated with fatty oils, esters, and extreme pressure (EP) additives, it delivers excellent lubrication, superior surface finish, and extended tool life, even under high operating temperatures.

Product Description

SPEZOL FC-32 forms a strong and stable lubricating film that effectively resists cutting stresses and prevents metal-to-metal contact. Its low evaporation rate, combined with superior cooling characteristics, ensures reduced oil consumption and minimised fume generation. This makes it an ideal solution for high-precision and heavy-duty machining environments.

Applications

SPEZOL FC-32 is recommended for a wide range of machining operations, including:

- Gear cutting
- Broaching and threading
- Turning, drilling, and milling
- Machining of high tensile steel
- Severe-duty machining of stainless steel alloys

It is especially suitable for operations requiring high load-bearing capacity and excellent surface integrity.

Technical Characteristics (Typical Values)

- Kinematic Viscosity at 40°C: 20.0–24.0 cSt / 28–34 cSt
- Flash Point (COC): 160°C
- Copper Strip Corrosion (3 hrs at 100°C): 4a
- Saponification Value: Min. 10 mg KOH/gm
- Four Ball Weld Load: 800+ kg
- Pour Point: Max. 0°C

These values are typical and may change as part of continuous product improvement.

Key Advantages

- Low evaporation rate and reduced oil consumption
- Minimal fumes for improved workplace safety
- Excellent surface finish and enhanced tool life
- Prevents localised welding between chip and the tool
- Low carry-forward loss due to reduced stickiness
- Improved machining efficiency and productivity

Quality and Safety Assurance

SPEZOL cutting oils are manufactured using highly refined base oils and high-quality additives to ensure consistent performance and reliability. Like all mineral oil-based products, proper handling and personal hygiene are recommended during use.

Comprehensive safety, health, and environmental information is provided in the Safety Data Sheet (SDS), covering:

- Risk assessment
- Handling precautions
- First-aid measures
- Spill management
- Disposal procedures
- Environmental impact guidelines

Conclusion

With its advanced formulation and proven performance, SPEZOL FC-32 is a reliable solution for demanding machining applications. It supports manufacturers in achieving superior surface quality, longer tool life, and optimised operating costs, making it a valuable addition to high-precision and heavy-duty production environments.

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Leadership, Innovation, and Sustainability: Kunal Marathe on Lubeco Green Fluids at PTCPL

- By Sushmita Das

Kunal Marathe, CEO and Executive Director of Pratap Tex-Chem Pvt. Ltd. (PTCPL)

Kunal Marathe, CEO and Executive Director of Pratap Tex-Chem Pvt. Ltd. (PTCPL), is a visionary leader driving innovation and sustainable growth in the metalworking fluids and speciality industrial lubricants industry. With a modern outlook and a strong foundation of values laid by his father, Pratap Marathe—the founder of PTCPL, who instilled principles of integrity, discipline, and commitment —has successfully transformed PTCPL into a dynamic, customer-centric organisation.

Under his leadership, the company has expanded through multiple brands — Lubeco Green Fluids, Fluidmate Fluid Management Systems, Supergen Automotive Lubricants, Krushagra Farm Solutions, and Lubeco Futuristic Greases — each reflecting quality, innovation, and trust.

Known for his positive approach and people-first philosophy, Kunal believes in empowering teams, embracing technology, and delivering excellence with integrity. His vision is to position PTCPL as a globally recognised, innovation-led company committed to performance, sustainability, and continuous growth.

Since its inception in 1999, Lubeco Green Fluids, the flagship brand of Pratap Tex-Chem Pvt. Ltd. (PTCPL), has steadily evolved into a trusted name in metalworking fluids and speciality industrial lubricants, with a strong focus on sustainability, innovation, and application-driven performance. From expanding its manufacturing capabilities and product portfolio to building a growing global footprint, the brand's journey reflects a deep alignment with the changing needs of modern manufacturing industries.

In this interview, Sushmita Das, Associate Editor of Gear Technology India, is in conversation with Kunal Marathe, CEO and Executive Director of Pratap Tex-Chem Pvt. Ltd. (PTCPL), to discuss Lubeco's growth milestones, its approach to serving diverse sectors such as automotive, aerospace, steel, and EVs, and how sustainability, digitalisation, and customised solutions are shaping the company's future. Marathe also shares insights into emerging trends, R&D consistency, and his long-term vision for positioning Lubeco as a globally recognised, innovation-led organisation.

1) Lubeco has grown steadily since 1999. What key milestones define this journey?

Lubeco Green Fluids, the flagship brand of Pratap Tex-Chem Pvt. Ltd. (PTCPL), formally began its journey in 1999 when PTCPL was incorporated with a strategic vision to expand from textile manufacturing into metalworking fluids and speciality industrial lubricants. One of our key milestones was the establishment of a modern manufacturing facility in Pune, equipped with advanced batch reactors and stringent quality control systems, and having a production capacity of 6,000 KL.

Over the years, Lubeco Green Fluids has grown steadily to become a trusted supplier, offering a comprehensive portfolio of more than 150 premium products, including metalworking fluids, rust preventives, industrial cleaners, speciality lubricants, and VCI packaging solutions. Our growth momentum continued with the launch of the Supergen automotive lubricants brand in 2020, Krushagra for the agricultural sector in 2022, and Lubeco Futuristic Greases incorporating nanotechnology in 2023.

We have also significantly expanded our global footprint, with exports reaching markets across Asia, Africa, the Middle East, Russia, and beyond. Achieving key industry recognitions and certifications such as ISO 9001:2015, RoHS compliance, Make in India recognition, Dun & Bradstreet rating, and ABS quality certification reflects our consistent growth, strong governance, and unwavering commitment to quality and excellence.

2) How do you balance the diverse demands of industries like automotive, aerospace, and steel?

We address the diverse and demanding requirements of industries such as automotive, aerospace, and steel through a comprehensive and well-segmented product portfolio, supported by focused R&D and customer collaboration. Our range of water-soluble and neat cutting fluids is engineered to deliver precise cooling, effective lubrication, and reliable rust protection, enabling high-precision machining and superior component finishing.

In addition, our speciality lubricants and VCI packaging solutions play a critical role in protecting metal components during storage and transit. A key strength lies in our ability to customise formulations for different substrates, including cast iron, stainless steel, aluminium, and yellow metals, while ensuring strict compliance with automotive standards such as BS-VI, ACEA, and API, as well as stringent aerospace requirements. This integrated and customer-centric approach allows us to serve these industries with consistency, reliability, and confidence.

3) Sustainability is central to your brand. How do you ensure your products stay eco-friendly and compliant?

Sustainability is deeply embedded in the core philosophy of Lubeco Green Fluids. Our product formulations are developed with a strong focus on biodegradable and non-toxic ingredients, and we consciously exclude harmful additives such as chlorine, sulphur, phosphorus, and heavy metals. Our extensive portfolio of water-based metalworking fluids and industrial cleaners is designed to support environmental safety while consistently delivering superior performance.

In parallel, our Lubeco VCI packaging solutions are developed with sustainability in mind, featuring nitrite-free and secondary amine-free formulations, along with recyclable and biodegradable biopolymer films that actively contribute to zero-waste initiatives. We ensure strict compliance with RoHS and other global environmental standards, enabling our products to meet both current and future regulatory requirements. This commitment is further aligned with the Government of India's Make in India initiative, reinforcing our focus on responsible, sustainable, and locally driven manufacturing.

4) Can you share an example where a customised lubricant solution transformed a client's performance?

One strong example is the implementation of the Fluidmate system by our customers to automate oil skimming and sump cleaning within metalworking fluid systems. This integrated solution has significantly reduced coolant spoilage, extended fluid life cycles, and enabled cleaner shop-floor operations, resulting in improved productivity and meaningful cost reductions.

In addition, our customised Lubeco Futuristic Greases enhanced with nanotechnology have delivered higher reliability and improved equipment uptime in demanding sectors such as steel and mining. These collaborative engagements clearly demonstrate how Lubeco Green Fluids and PTCPL's tailored solutions translate into measurable operational efficiencies and environmental benefits for our customers.

5) With such a wide product range, how do you maintain consistency in R&D and quality?

Maintaining consistency across a wide and diverse product portfolio is driven by our strong in-house R&D and quality infrastructure. Lubeco Green Fluids operates a well-equipped R&D laboratory featuring pilot-scale reactors, tribology testing facilities, and advanced analytical instruments, enabling continuous innovation and rigorous product validation. Our ISO 9001:2015 certification further reinforces the robustness of our quality management systems.

On the manufacturing front, our advanced production lines are supported by integrated inline quality controls, ensuring that every batch adheres to stringent performance and compliance standards. We also operate a customised ERP platform with quality interlocks at every stage – from raw material inspection and intermediate checks to finished goods testing – ensuring that no batch leaves our premises without comprehensive testing.

This strong infrastructure, supported by experienced quality control teams and an agile innovation cycle, enables us to consistently maintain stable quality across more than 150 product variants under the Lubeco Green Fluids portfolio and allied brands.

6) What is Lubeco's approach to serving the fast-growing EV and e-mobility lubrication market?

Lubeco Green Fluids is proactively advancing the development of specialised synthetic lubricants and greases designed specifically for EV and e-mobility applications. Our solutions are engineered for critical components such as high-speed electric motors, gearboxes, and thermal management systems, with a strong focus on high thermal stability, electrical insulating properties, and long service life in demanding operating environments.

Products, including immersion fluid for batteries and motors, non-contact greases, high thermal stability bearing greases, and immersion fluids, have already been developed and are currently being supplied to EV and e-mobility customers. This ongoing work is built on our strong material science expertise and close alignment with evolving OEM requirements, positioning Lubeco Green Fluids as a reliable and sustainable partner for the rapidly growing EV and e-mobility sector.

7) What emerging trends in metalworking fluids or lubricants excite you the most?

Several emerging trends in metalworking fluids and lubricants are particularly exciting for us. One is the rapid advancement of biodegradable and bio-based formulations, along with nanotechnology-enhanced products that significantly improve performance while reducing environmental impact. These innovations are redefining efficiency and sustainability benchmarks across the industry.

Additionally, the increased use of advanced, compostable VCI packaging is playing a crucial role in minimising corrosion risks during storage and shipment, while simultaneously addressing broader sustainability and quality challenges across the industry.

8)How is Lubeco integrating digital tools or Industry 4.0 concepts into its operations?

Lubeco Green Fluids has embraced digital tools and Industry 4.0 principles across its operations to enhance precision, traceability, and customer transparency. Our manufacturing facilities employ automated batch reactors coupled with real-time inline quality monitoring, ensuring consistent product performance and compliance.

Our Fluidmate systems integrate sensors and automation to optimise oil skimming and filtration processes, directly reflecting Industry 4.0 practices in shop-floor operations. Beyond manufacturing, PTCPL has implemented digital supply chain management and dealer network platforms to improve responsiveness and service excellence across markets.

In addition, we have developed a QR-code–based performance monitoring platform, Lubeco Smart, that captures, records, and presents fluid management data with real-time analytics to our customers. By leveraging such digital solutions, Lubeco Smart not only enhances operational efficiency but also ensures accountability and complete transparency in every step of our service.

9) What strategies help you build and support a strong dealer and distributor network?

Lubeco Green Fluids strengthens its pan-India dealer and distributor network through continuous technical training, application support, and collaborative product development. We empower our partners with localised solutions tailored to specific market requirements, ensuring they can effectively serve their customers.

Reliable logistics, competitive lead times, and consistent product quality form the foundation of trust and long-term confidence with our partners. Industry recognitions and compliance certifications, such as Dun & Bradstreet ratings, further reinforce our credibility. Additionally, initiatives like structured discount schemes, channel partner financing options, and both on-field and laboratory support provide distributors with tangible value, fostering lasting business relationships built on trust and mutual growth.

10) What is your vision for Lubeco in the next five years, and what challenges do you foresee?

Lubeco Green Fluids envisions expanding its leadership in sustainable industrial fluids over the next five years, with a focus on advanced synthetic and biodegradable solutions that address evolving regulatory requirements and customer expectations globally. Our strategic priorities include deeper digital integration, increased engagement in the EV sector, and greater penetration into international export markets.

We anticipate challenges such as pressures on raw material sustainability, intensifying competition, and navigating increasingly complex compliance landscapes. However, backed by Pratap Tex-Chem Pvt. Ltd.'s strong R&D and operational foundation, Lubeco is confident in meeting these challenges through innovation, collaboration, and strategic partnerships. To cater to the growing market demand, we are also planning to expand our production capacity by 100%, supported by more advanced and automated manufacturing facilities and enhanced laboratory infrastructure.

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Last Tooth Error in Gear Shaping: Analysing the Error, Detection and Prevention in gears cut on the CNC Gear Shaping machine

- By Vishwajit Rajkumar Kothari, Director Cyber Gear

Abstract

Last Tooth Error (LTE) is a distinctive surface imperfection encountered in the gear shaping process, particularly in helical gears. It manifests as a linear mark on the tooth flank at the completion of the finish rotary pass. Although subtle, LTE can significantly affect gear quality perception and, in some cases, functional performance. This article explains the nature of Last Tooth Error, differentiates it from sudden variations, discusses its probable causes, and outlines best practices for detection and prevention.

Introduction

Gear shaping is a highly synchronised generating process in which the cutter and workpiece rotate in a precisely timed relationship. Any transient disturbance in this synchronisation – especially at the completion of a rotary cycle – can leave behind a visible signature on the gear tooth flank. One such signature is known as Last Tooth Error (LTE).

LTE is often overlooked because it may not consistently appear in conventional inspection graphs. However, with increasing helix angles and higher machine dynamics, its occurrence has become more noticeable and relevant to both manufacturing engineers and quality professionals.

What is Last Tooth Error?

Last Tooth Error is identified as a straight vertical line on the tooth flank, running parallel to the gear axis. The mark typically appears at the end of the finish rotary pass, corresponding to 360° rotation of the workpiece. It may appear on a single tooth flank or multiple adjoining flanks.

Salient features include:

- Linear mark parallel to the gear axis
- Typical width of 0.1–1.0 mm - Visible under reflected light and distinguishable from feed marks
- Appears on one or adjoining flanks

- More pronounced in helical gears than in spur gears

The term “Last Tooth Error” originates from its consistent occurrence at the angular position corresponding to the completion of one full rotary cycle of the workpiece.

Location and Visibility

Unlike classical profile or lead errors, LTE does not necessarily appear at the pitch circle diameter or reference diameter. Its position may shift toward the tooth face or flank, and its length may not extend across the entire face width.

As a result:

- LTE may escape detection in standard lead and profile measurements
- Limited inspection sections may miss the defect entirely

The visibility and severity of LTE increase with increasing helix angle, owing to the higher degree of axial and radial synchronisation involved.

Occurrence in Spur and Helical Gears

LTE can occur in both spur and helical gears. In spur gears, the vertical nature of the mark causes it to merge with feed marks, making it narrower and less conspicuous. Consequently, LTE in spur gears is rarely detected through measurement or visual inspection. In contrast, helical gears exhibit clearer and wider LTE marks due to their geometry and motion characteristics.

Distinction Between Last Tooth Error and Sudden Variation

Last Tooth Error is sometimes mistaken for sudden variation. While both may appear as localised deviations on the tooth surface, their origin and behaviour differ fundamentally.

- LTE appears at a specific angular location corresponding to the completion of a rotary pass
- Sudden variation can occur randomly at multiple locations
- LTE is usually not detected by ballpoint measurement
- Sudden variation is often detectable through ball measurements

Although LTE may be interpreted as a form of sudden variation, not all sudden variations can be classified as Last Tooth Error.

Probable Causes of Last Tooth Error

The occurrence of LTE is primarily associated with synchronisation disturbances and mechanical or control-related instabilities at the end of the generating cycle.

Synchronisation and Control Factors

- Undershoot or overshoot of the worktable relative to the cutter spindle
- Momentary stoppage of feed during spindle speed change prior to finish cut
- Momentary feed interruption during feed rate changes
- Acceleration–deceleration mismatch or phase lag between leading and following axes at the start or completion of 360° rotation

Mechanical Factors

- Backlash in the radial slide
- Hunting or oscillatory movement of the radial slide
- Shake or looseness in the table slide perpendicular to the X-axis during disengagement
- Insufficient back-off cam amount, particularly critical for high helix angle gears

Process and Setup Factors

- Improper timing of the exit spiral, especially during the cutting downstroke
- Incorrect cutter lateral offset setting at the upright

The sporadic nature of some of these factors explains why LTE may appear on only a few components within a production batch.

Detection Challenges

One of the defining challenges of Last Tooth Error is its inconsistent detectability through standard inspection methods. Reliable identification requires:

- Careful visual inspection under reflected light
- Lead and profile measurements taken across at least three axial sections
- Correlation of deviations at a consistent angular position

Ballpoint measurement alone is insufficient for confirming LTE.

Preventive Practices and Machine Testing

To minimise the occurrence of Last Tooth Error, special attention must be given to machine synchronisation during testing and setup, particularly when using electronic gear linking systems.

Recommended practices include: -

- Testing synchronisation across multiple cutter-to-work RPM ratios, not limited to 1:1
- Verifying performance across the full speed range of both spindles
- Conducting tests for less than, equal to, and greater than 360° workpiece rotation
- Performing tests in both rotational directions
- Alternating leading and following axes during evaluation
- Correct programming ensuring the cutter exits from the work piece in the finish cut

In addition, ensuring mechanical rigidity, eliminating backlash, providing adequate back-off, and setting correct cutter offsets are essential preventive measures.

Conclusion

Last Tooth Error is a subtle yet distinct manifestation of synchronisation imperfection in the gear shaping process. While it may not always influence functional performance, its presence reflects the dynamic behaviour of the machine–process system, particularly after the generating cycle.

With increasing demands on gear quality and higher helix angles, understanding and controlling LTE has become increasingly important. Through disciplined machine synchronisation, robust mechanical integrity, and thoughtful process setup, Last Tooth Error can be effectively minimised or eliminated.

Vishwajit Rajkumar Kothari,
Director Cyber Gear

Vishwajit Rajkumar Kothari is a highly experienced professional in gear manufacturing and CNC machine tools, with over three decades of hands-on industry exposure. His work spans technical sales, application engineering, CNC programming, tooling and fixture development, and machine commissioning. He has led turnkey projects for leading automotive and defence customers and has gained international experience through training and commissioning assignments in Germany and Italy.

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Beyond Bearings: How Timken Is Shaping the Future of Power Transmission

- By Sushmita Das

Sanjay Koul
Chairman and Managing Director
President – India and Southeast Asia, and Managing Director - Timken India

He oversees business and manufacturing operations, financial performance, and growth acceleration across the Indian market. He assumed this role in September 2022, and in January 2025, his responsibilities were expanded to include sales management for the Middle East and Africa.
Koul joined Timken in 1990 as a Production Engineer and was among the first set of employees of the company in India. Since then, he has served in additional positions within the rail and supply chain & Sales organizations. In 2007, he was named general manager of the Jamshedpur Plant. Two years later, he was named general manager of supply chain operations in Asia, working out of Wuxi, and in 2011, he was named director of manufacturing and supply chain management for Asia. He was named managing director of all operations in India in October 2012. Before joining Timken, Koul served with Union Carbide India Ltd. as a production supervisor and as an engineer with an urban environmental agency of India.
Koul holds a bachelor's degree in mechanical engineering from the Birla Institute of Technology and Science and a master's degree in business management from Xavier Labour Relations Institute. He completed the EDGE executive development program for senior Timken leaders at the University of Virginia Darden School of Business in 2008. He was conferred with an honorary PhD this year by CIAC in collaboration with the University of South Korea. He sits on the Executive Committee of AMCHAM India and on the Board of ELCIA, apart from being involved with the manufacturing committee of CII.

1. What is Timken's strategic vision for the next decade, especially with electrification and EV-driven demand?

Timken's strategic vision for the coming decade is to enable efficient and reliable power transmission as the world electrifies and automates. Building on more than 125 years of bearing expertise, Timken is expanding into integrated motion and power-transmission solutions; combining advanced alloys, surface engineering, chip-to-detect condition sensing, and cloud analytics to meet rising EV and automation demand while reducing lifecycle cost and emissions.

Timken bearings and assemblies are deployed across diverse sectors. In automotive and EVs, wheel-hub bearings, e-motor support bearings and precision gearbox bearings reduce friction and thermal losses to improve range and reliability. In commercial transportation (trucks, rail, off-highway), heavy-duty tapered roller bearings increase load capacity and service life.

Coupled with remanufacturing, aftermarket services and digital condition monitoring, Timken's materials and sensor investments position the company as a systems partner for a more efficient, durable, and sustainable future.

2. How do Timken's engineered bearings enhance performance and reliability in modern gear systems?

At Timken, bearings are designed and validated as core components of complete gear and power-transmission systems with optimised geometry, metallurgy and surface technologies that reduce friction, heat and vibration. This system-level is strengthened by capabilities from Philadelphia Gear, enabling optimised interaction between gears and bearings to improve load-carrying capability, enhance reliability, and extend service life in demanding industrial environments.

In heavy industry mining, steel, pulp and paper, robust roller bearings and sealed assemblies resist shock, contamination and high axial loads in crushers, conveyors and mills. For heavy-duty transportation, tapered roller bearings enhance durability under high loads and frequent duty cycles, reducing downtime and lifecycle cost. In industrial gearboxes and marine propulsion, precision-graded bearings and engineered clearances reduce noise and vibration while improving gear mesh life. In aerospace and defence applications, speciality materials and tight-tolerance bearings meet strict safety and certification standards for accessory drives and actuation systems.

Paired with lubrication engineering and condition-monitoring sensors, Timken's system approach enables predictive maintenance, spare-parts optimisation, and sustainability gains through extended component life and reduced energy losses.

3. How is Timken's R&D and tribology expertise shaping next-generation solutions for gear applications?

Timken's innovation strategy is anchored in deep expertise in materials science and application engineering, supported by global R&D centers and full-scale testing facilities. Metallurgical capabilities include proprietary alloy design, vacuum-degassing and tailored heat-treatment processes that increase fatigue resistance, toughness and dimensional stability for rolling-element and plain bearings. Timken advances hybrid bearings, case-hardened steels and surface engineering to improve wear performance, corrosion resistance and high-temperature operation.

Timken also integrates digital tools such as embedded condition sensors, signal processing and cloud analytics to enable predictive maintenance and continuous product improvement. Sustainability targets guide material selection and remanufacturing programs that lower lifecycle carbon and scrap.

Combined, these capabilities let Timken deliver next-generation bearing and motion-system solutions that reliably withstand extreme loads, variable lubrication and harsh environments across automotive, energy, heavy industry and aerospace markets.

4. Can you share an example where close OEM collaboration led to a breakthrough bearing or drivetrain solution?

Timken's innovation model centers on close, early-stage collaboration with OEM partners to embed bearing and drivetrain expertise into system designs. Timken engages at concept and validation phases, providing application engineering, bearing selection, finite-element analysis, NVH optimisation, and thermal management studies to ensure components meet packaging, weight and performance targets. Co-development activities include joint labs, hardware-in-the-loop testing, full-scale dynamometer trials and on-site field pilots that accelerate time-to-market and de-risk new vehicle and equipment programs.

Through design-for-manufacturability reviews and supply-chain integration, Timken aligns production tolerances, material sourcing and logistics with OEM program to support stable ramp-up and volume production. Customised solutions range from e-motor support bearings with integrated sealing and sensor interfaces to heavy-duty tapered roller assemblies engineered for higher dynamic load ratings and longer mean time between failures. Timken also provides tailored aftermarket strategies; spare part kits, remanufacturing, warranty analytics and condition-based service contracts, for making customers realise lower total cost of ownership.

With the added expertise of Philadelphia Gear, the company delivers integrated drivetrain solutions, combining gears, bearings, and services that improve performance, reduce downtime, and deliver measurable value throughout the equipment lifecycle.

5. How do Timken's manufacturing operations ensure consistent global quality and precision?

Timken's manufacturing operations are founded on precision, repeatability and a culture of continuous improvement supported by standardised global quality systems. The company uses ISO aligned processes, Six Sigma methodologies and statistical process control (SPC) across machining, heat treatment and assembly lines to ensure consistent tolerances and surface finishes. Advanced process controls, CNC machining with closed-loop feedback, automated grinding, induction hardening, and robotic assembly cells reduce variation and improve throughput while maintaining micron-level dimensional accuracy for rolling elements and raceways.

Supply-chain quality is managed through approved-supplier programs, PPAP (Production Part Approval Process) documentation, and vendor audits to secure material consistency for proprietary alloys and lubricants. Environmental, health and safety protocols and energy-efficiency initiatives further standardise operations and support sustainability goals. By combining global standards with localised execution and data-driven controls, Timken reliably produces high-precision bearings and assemblies that meet strict industry specifications and customer performance requirements.

6. What role does aftermarket support play in Timken's value proposition for gearbox and rotating equipment users?

Aftermarket support is a core element of Timken's value proposition, extending far beyond spare-parts supply to a full suite of lifecycle services that improve reliability and lower total cost of ownership. Timken offers engineered replacement bearings, seals and assemblies alongside remanufacturing and repair services that restore components to OEM tolerances, while reducing material waste and procurement lead times. Field services include on-site inspections, vibration analysis, oil and grease analysis, laser alignment and balancing to diagnose root causes and recommend corrective actions.

Digital offerings embedded with condition sensors, wireless monitors, and cloud-based analytics enable predictive maintenance programs that shift customers from time-based to condition-based servicing, typically reducing unplanned downtime by measurable margins. Timken's reliability engineers deliver application audits, bearing selection reviews and tailored lubrication strategies that increase mean time between failures and improve energy efficiency through lower friction losses. Spare-parts optimisation tools and consignment inventory programs help customers reduce working capital while ensuring rapid access to critical components. By combining parts, diagnostics, digital monitoring and engineering services, Timken helps customers maximise uptime, extend asset life and achieve predictable operational performance.

7. How is Timken balancing global integration with localisation and supply-chain resilience?

Timken balances global integration with local responsiveness through a diversified manufacturing and supply-chain network spanning around the world. Global engineering standards, centralised product lifecycle management and common digital systems ensure consistent design data, process controls and traceability across facilities. Timken employs dual-sourcing strategies, safety-stock policies, and regional distribution centers to maintain service levels; strategic inventory locations and consignment programs further reduce customer lead times. Cross-regional manufacturing flexibility, qualified tooling, transferable work instructions and trained multi-skilled teams allow capacity shifts during demand surges or supply interruptions.

Continuous improvement initiatives and supplier quality development raise local execution to global standards. This integrated yet localised model strengthens supply-chain reliability and enables Timken to support customers with speed, stability and adaptability across markets.

8. How is Timken building future-ready engineering talent in advanced bearing and motion technologies?

Developing future-ready engineering talent is a strategic priority at Timken, supported by structured programs across recruitment, training and career development. Timken partners with universities and technical schools for co-op programs, internships and sponsored research to attract early-career engineers with expertise in materials science, mechatronics and controls.

Mentorship, knowledge-capture tools and communities of practice preserve institutional know-how while accelerating skill transfer. Performance metrics, i.e., certification rates, time-to-competency, reduced failure-rates on first-article parts and internal promotion rates, measure program effectiveness. By investing in continuous learning, practical experience and cross-functional exposure, Timken builds engineering teams capable of innovating and delivering high-value bearing and motion solutions for electrification, automation and heavy-duty applications.

9. How do Timken products contribute to energy efficiency and sustainability in power transmission systems?

Timken advances sustainability by designing products and processes that reduce energy use, material waste and lifecycle emissions across power-transmission systems. Low-friction bearing geometries, advanced alloys, ceramic hybrid rolling elements and precision surface treatments lower frictional losses in rotating equipment, translating directly into improved motor and drivetrain efficiency and measurable energy savings over operating life. Extended service intervals achieved through optimised materials, seals and lubrication decrease maintenance frequency, reduce spare-parts consumption and cut associated logistics emissions.

Timken's remanufacturing and repair programs restore bearings, diverting components from landfill and lowering embodied carbon compared with new production. Product design for serviceability and modular assemblies simplifies field repairs, further reducing downtime and resource use. In manufacturing, Timken applies energy-efficiency initiatives, waste-reduction programs and water-conservation measures in plants, alongside supplier engagement for responsible sourcing of proprietary steels and lubricants.

Digital condition monitoring enables customers to operate assets closer to peak efficiency and plan interventions that minimise unplanned outages and emergency repairs, reducing idle energy and spare inventory needs. Timken tracks performance through metrics such as reduced kWh per unit of output, lower CO2e from remanufacturing vs. new, first-pass yield improvements and decreased scrap rates. Together, product innovation, circular services and operational improvements enable Timken and its customers to meet regulatory targets and sustainability goals while lowering the total cost of ownership.

10. What key challenges and opportunities do you foresee for the bearings and gear industry?

The bearings and gearing industry is being reshaped by three converging forces: electrification, automation and heightened sustainability expectations. Electrification drives demand for e-motor support bearings, high-speed precision bearings and integrated e-drivetrain assemblies that must deliver higher power density, lower friction and improved thermal management. Automation and robotics increase requirements for precision angular-contact bearings, zero-backlash solutions and longer life under continuous duty, while Industry 4.0 adoption raises the need for embedded sensing and predictive-maintenance capabilities.

Challenges include escalating performance requirements; higher rpm, greater torque density and tighter NVH targets alongside supply-chain complexity from specialised materials, semiconductor shortages for sensor electronics, and geopolitical sourcing risks. Regulatory and customer sustainability mandates add pressure to reduce lifecycle emissions and increase circularity.

These shifts create sizable opportunities: growth in EVs, wind and grid modernisation, industrial automation, and aftermarket services for condition-based maintenance. Companies that combine materials innovation (advanced alloys, ceramic hybrids), system-level engineering, digital analytics and robust global manufacturing will capture the most value. Timken's investments in tribology, metallurgy, sensor integration, remanufacturing and OEM partnerships position it to meet stricter performance specs, shorten development cycles and provide lifecycle solutions that lower emissions.

By leveraging engineering excellence, integrated product-service offerings and a resilient supply network, Timken can sustain leadership and resilient long-term growth amid industry transformation.

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Multi-Axis CNC Grinding: Programming Strategies for Complex EV Shafts

- By Neha Basudkar Ghate

The shift to electric mobility has quietly but decisively changed the rules of shaft manufacturing. While internal combustion engine (ICE) shafts were designed around moderate rotational speeds and forgiving noise environments, electric vehicle (EV) rotor shafts operate in a radically different regime. Rotational speeds exceeding 18,000 RPM, instant torque delivery, and near-silent drivetrains mean that even microscopic form errors now translate directly into noise, vibration, and durability issues.

In this environment, grinding is no longer just a finishing operation; it is a functional enabler. Surface waviness, runout, taper, and residual stress patterns all influence NVH behaviour at high speed. Conventional 2-axis plunge grinding, while still effective for simpler geometries, struggles to deliver the consistency and cycle-time efficiency demanded by modern EV shafts. As a result, manufacturers are rapidly adopting multi-axis CNC grinding, typically with 3 to 5 controlled axes.

However, the true performance leap does not come from the machine configuration alone. The decisive factor is how intelligently the machine is programmed. Advanced CAM strategies, axis synchronisation, and data-driven compensation are what separate a capable multi-axis grinder from a truly production-ready EV shaft process.

Grinding EV Shafts at Micron Levels

EV rotor shafts are geometrically deceptive. At first glance, they appear to be simple, long, cylindrical components with bearing seats, seal journals, and spline interfaces. In practice, they are among the most challenging parts to grind accurately.

Their length-to-diameter ratio makes them inherently flexible, even when supported by centres and steady rests. Grinding forces that would be negligible on a short ICE shaft can cause measurable deflection in an EV shaft, leading to barrel shapes, taper, or lobing. At the same time, functional requirements have tightened dramatically. Runout values below 3 microns are increasingly common, and surface finishes in the Ra 0.1 µm range are no longer exceptional.

Compounding the challenge is the NVH sensitivity of EV drivetrains. Any discontinuity witness marks at shoulders, waviness at bearing seats, or imbalance due to uneven stock

removal can excite high-frequency vibration modes that are immediately audible to the end user. Grinding strategies must therefore prioritise continuity of form and surface texture, not just size control.

The Role of Multi-Axis Grinding in Form Control

Multi-axis CNC grinding introduces an additional degree of freedom, fundamentally changing how material is removed. The most influential of these axes is the B-axis, which allows the grinding wheel to swivel relative to the workpiece. This capability transforms grinding from a sequence of discrete operations into a continuous, vector-controlled process.

In traditional 2-axis grinding, each feature diameter, shoulder, and radius is ground independently. The wheel approaches, plunges, retracts, and repositions. While accurate, this method almost inevitably introduces transition marks where features meet. At high rotational speeds, these transitions become stress concentrators and NVH triggers.

By contrast, a multi-axis approach allows the wheel orientation to change dynamically while remaining in contact with the part. When properly programmed, the grinding process becomes a single, flowing motion that preserves geometric continuity across the entire shaft.

B-Axis Vector Grinding: Eliminating Geometric Discontinuities

One of the most powerful programming strategies in multi-axis grinding is B-axis vector grinding. Instead of treating each feature as a separate entity, the CAM system calculates the instantaneous normal vector of the shaft profile and continuously aligns the wheel to that vector.
This has two critical benefits. First, it eliminates witness marks at transitions between diameters and shoulders. Second, it distributes grinding forces more evenly, reducing localised heat input and wheel wear.

In practice, this requires CAM software capable of true 5-axis interpolation rather than indexed positioning. The contact point between the wheel and the shaft must be recalculated continuously, and the CNC controller must synchronise linear and rotary axes with high precision. When executed correctly, the result is a surface that appears visually seamless and behaves mechanically as a single, continuous form.

For EV shafts, this continuity directly translates into lower excitation of bending modes at high speed, improving both noise behaviour and fatigue life.

Angular Wheel Engagement and Surface Functionalization

Beyond form accuracy, multi-axis grinding also enables surface engineering through the use of wheel orientation. By intentionally programming the B-axis to operate at non-traditional angles such as 15°, 22.5°, or even continuously varying angles, the programmer can control the directionality of grinding marks.

This is particularly valuable on bearing and seal seats. Linear plunge grinding tends to produce circumferential lay patterns that can promote lubricant migration or uneven wear. An angular approach, using the wheel periphery across both diameter and face, generates a subtle cross-hatched texture that improves oil retention and seal performance.

The key is consistency. The CAM strategy must ensure that the wheel orientation remains stable across the entire functional surface. Any abrupt angular change can introduce texture variation, which becomes a noise contributor at high speed.

Peel Grinding: Combining Accuracy with Throughput

One of the most effective strategies for reducing cycle time without sacrificing accuracy is peel grinding, also known as Schälschleifen. Rather than engaging the full wheel width in a plunge, peel grinding uses a narrow wheel to remove material in a helical path, much like a turning operation.

From a programming standpoint, peel grinding shifts the challenge from force management to synchronisation. The axial feed rate, wheel speed, and workpiece rotation must be precisely coordinated to maintain constant chip thickness. Any mismatch results in surface waviness or thermal instability.

Advanced CNC programs address this by using variable feed rate control. As the wheel approaches sensitive features such as shoulders, fillets, or spline roots, the feed is automatically reduced. Once the geometry stabilises, the feed ramps back up. This dynamic behaviour is impossible to manage manually and must be embedded directly into the CAM-generated toolpath.

When paired with CBN wheels, peel grinding allows high material removal rates while maintaining excellent surface integrity. For high-volume EV shaft production, it is often the single biggest contributor to cycle time reduction.
Constant Surface Speed: A Non-Negotiable Requirement

One of the most overlooked aspects of grinding programming is constant surface speed (CSS) control. As grinding wheels wear and are dressed, their effective diameter changes. Without CSS, this leads to variations in peripheral speed, directly affecting surface finish and thermal behaviour.

In EV shaft grinding, even a small drop in wheel speed can push a bearing seat out of specification during noise testing. Modern CNC programs, therefore, use real-time calculations to adjust spindle speed dynamically, ensuring the programmed surface speed remains constant regardless of wheel diameter.

This becomes especially critical in peel grinding, where chip thickness is tightly linked to surface speed. CSS is not an optimisation; it is a prerequisite for process stability.

Managing Deflection Through Intelligent Compensation

Mechanical solutions such as steady rests are essential for long shafts, but they are only half the solution. Without intelligent CNC logic, steady rests can introduce as many problems as they solve.
On advanced grinders, steady rests are often controlled as programmable axes. Rather than remaining static, they can move and adjust pressure dynamically as the wheel traverses the shaft. This follow-grinding approach ensures consistent support directly opposite the grinding force.

Pre-process probing adds another layer of control. By measuring the raw shaft's runout before grinding, the CNC can shift the coordinate system to remove stock symmetrically. This prevents unbalanced mass distribution, a critical factor at 18,000 RPM and reduces the risk of post-grinding vibration issues.

Dressing Strategies: Preserving Form Over Time

In multi-axis grinding, wheel condition is inseparable from part accuracy. Complex shaft profiles place uneven loads on the wheel, leading to non-uniform wear. Traditional time- or part-count–based dressing strategies are inadequate in this context.

Instead, advanced programs use material-removal–based dressing logic. The CNC tracks the total volume of material removed and initiates dressing only when a defined threshold is reached. This ensures consistent wheel sharpness while minimising abrasive loss.

Acoustic emission (AE) sensors further refine the process. During dressing, AE signals allow the CNC to detect wheel–dresser contact within microns, eliminating air-dressing and ensuring precise truing. Over long production runs, this precision preserves form accuracy and stabilises cycle time.

Eliminating Non-Productive Time

In high-volume EV manufacturing, seconds per part accumulate into hours per shift. One of the most effective ways to reduce cycle time is to conduct an air-cut audit of the CNC program.

Excessive safety clearances, conservative approach speeds, and redundant positioning moves are common in legacy programs. Modern CNCs with look-ahead capability allow high-speed positioning until the wheel is within a millimetre of the part, switching to grinding feed only at the last moment.

Machines equipped with multiple wheel heads unlock even greater potential. By programming simultaneous operations such as grinding a main diameter with one wheel while finishing a spline with another, total cycle time can be reduced by up to 40%, without increasing risk.

Closed-Loop Manufacturing: Learning from Every Shaft

The final evolution in EV shaft grinding is data-driven compensation. Modern CNCs can receive feedback from post-process measurement systems such as CMMs or in-line gauging stations.

When measurement data indicates a consistent deviation, such as taper or lobing the CNC automatically updates compensation parameters in the grinding program. This closed-loop approach transforms grinding from a reactive process into a self-correcting system, ensuring long-term consistency even as tools, machines, and environmental conditions change.

Conclusion: Programming Is the Differentiator

Multi-axis CNC grinding has become a technical necessity for EV shaft manufacturing, but hardware alone is not enough. The real gains come from intelligent programming, from B-axis vector paths and peel grinding strategies to adaptive compensation and closed-loop control.

In the EV era, success is defined by the ability to grind complex shafts with micron-level accuracy at automotive production volumes. Achieving this requires moving beyond traditional plunge cycles and embracing CAM and CNC strategies that think, adapt, and learn.

In high-speed electric drivetrains, precision is no longer static; it is in motion.

Neha Basudkar Ghate
Techical Writer -
Gear Technology India

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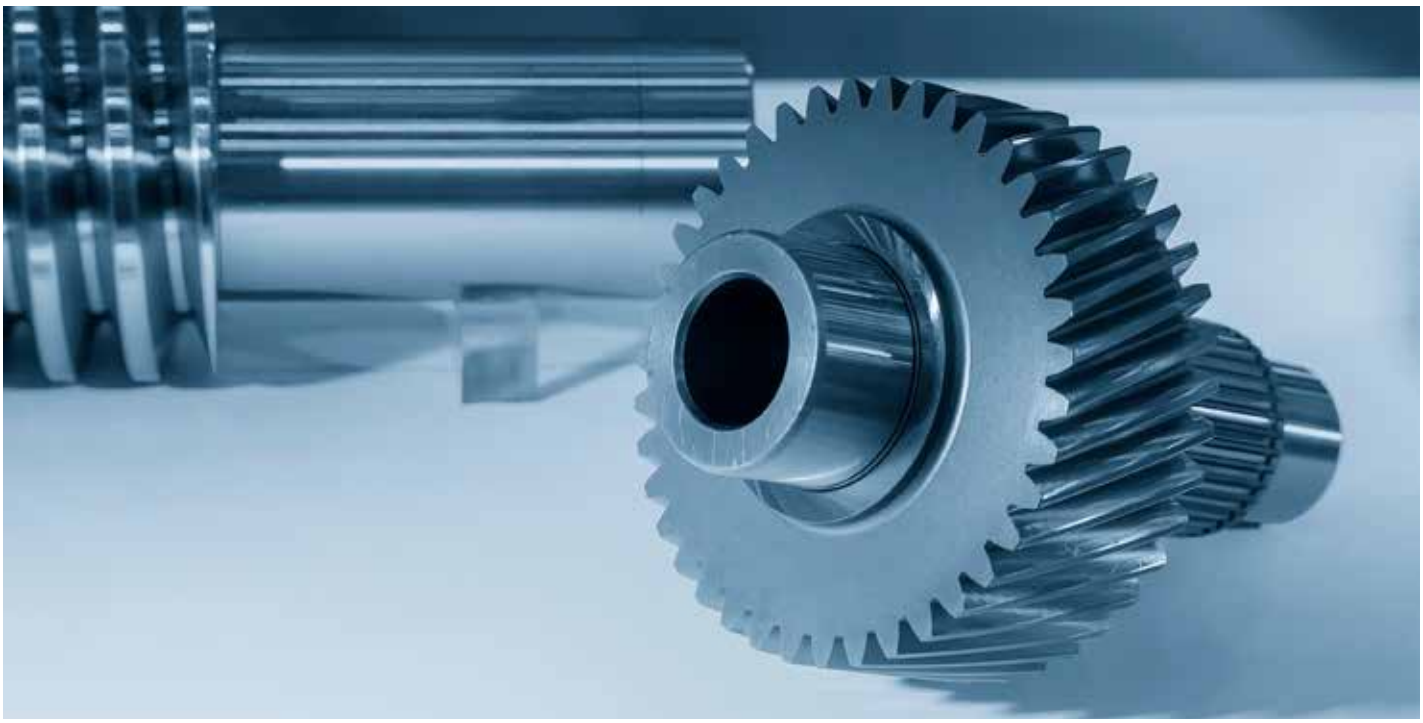
Influence of Surface Roughness & Micro-Notches on Tooth-Root Bending Fatigue

- By Vivek Singh



India's drivetrain ecosystem is going through a structural shift. High-speed EV motors, small reducers, wind-turbine stages, off-highway equipment, and two-wheeler EV platforms now require extremely high bending fatigue margins at the tooth root, which were not previously necessary in traditional ICE-era transmissions. Modern torque specs include higher reversals, steeper acceleration ramps, and significantly elevated meshing frequencies in compact gear sets. These conditions increase the sensitivity of the gear to surface integrity, especially in the fillet region where bending forces are the highest.

Indian gear makers, particularly Tier-1/Tier-2 suppliers, are balancing global PPAP/FAIR audits, export-program fatigue benchmarks, and aggressive cost-per-part requirements. This set of requirements holds a structural gap: whereas macro-geometry and heat treatment are largely controlled, surface-condition variability at the root fillet remains the most important uncontrolled fatigue factor for many Indian gear manufacturing shop floors.

The majority of the gear field data from EV reducers, agricultural transmissions, and construction equipment show that the majority of tooth-root bending failures in India are caused by a few repeatable surface-toughness deviations. The most common ones are fillet micro-grooves from tool wear, burn pits from inconsistent grinding coolant, temper-damaged zones from poor sparkout, burr-induced curvature changes, and heat-treatment roughness resulting in dense micro-notches. Each of these defects effectively sharpens the fillet, reducing the notch radius and pushing the local stress concentration from roughly 1.6 to well above 2.0. When that happens, cracks start much earlier than the design predicts. Even microscopic flaws, sometimes just 10–40 µm, are enough to disturb the residual stress layer and cause early-life gear failures in high-speed EV gears.

The purpose of the article is to demonstrate how these Indian shop floors relate directly to stress amplification and short-crack kinetics. To explain practical approaches that restore fatigue without losing significant capital costs, allowing domestic gear suppliers to achieve export-grade quality

Why is root surface integrity becoming the new strength standard?

As Indian OEMs move beyond basic AGMA compliance toward the tighter Cp/Cpk expectations typical of German and Japanese export markets, a key limitation for many domestic gear manufacturers remains gear tooth fillet consistency. Among local suppliers, bending-fatigue scatter correlates far more strongly with variations in surface finish than with metallurgical factors. This evolution effectively elevates fillet quality from a secondary

concern to a critical quality benchmark. Even minor changes in roughness, grinding burn, or local geometry can significantly alter stress concentrations and increase fatigue-life scatter. For Indian suppliers aiming for export-grade performance, maintaining consistent root surface quality must be treated with the same priority as controlling hardness or case depth.

Typical Roughness & Notch Profiles in Indian Gear Shops

- Surface Roughness Patterns in Indian Workshops

Hobbing generates Ra values of 0.8-1.6 µm, whereas finishing-ground gears can achieve 0.2-0.6 µm. Local defects, such as 10-20 µm scratches from grit contamination, uneven shot-peening from worn nozzles, and white-layer formation during hard turning on lower-rigidity machines, pose a difficulty rather than the average. These localised properties have a significantly greater impact on root behaviour than the nominal Ra.

- Common Micro-Notch Sources in India

Worn hobs leave burr rollovers, grinding chatter causes ripple marks, heat treatment introduces small pits, SME deburring frequently leaves sharp micro-edges, and EDM prototypes typically have recast layers, all of which operate as micro-notches. These form notch radii in the 5-50 µm range, which can magnify local stresses and considerably increase Kt, even if drawings appear compliant.

Why Micro-Defects Matter for Root Fatigue

On Indian gear fillets, roughness peaks, scratches, pits, and burrs behave more like tiny notches than as a fundamental surface texture. Using the √area approach, deeper valleys indicate early fracture initiation, whereas sharper peaks limit the effective notch radius. Even if Ra satisfies the design, peak heights greater than 8-10 µm have been connected to 20-40% lower bending life in EV programs. Typical defects observed on Indian shop floors raise stress levels in a variety of ways: Temper-burn pits can produce early cracks even after passing surface-finish tests, burr-type flaws range from 1.6 to 2.0, and sharp grinding marks frequently raise the stress concentration (Kt) to 2.1-2.5. Actually, the rate at which cracks form at the root is determined by the micro-geometry of these faults rather than the overall roughness.

The Usual Tooth-Root Crack Initiation Mechanics

In India, the commonly used case-carburised steels for gear manufacturing are EN353 and 20MnCr5, which are extremely notch sensitive. When there are high-stress areas, the short cracks may appear because the local bending stress increases highly due to minor surface defects. The initial fracture's occurrence is significantly influenced by the hardness gradients. These occur as a result of normal heat-treatment irregularities, which induce softer or harder zones along the fillet due to uneven quenching or tempering.

As the cracks deepen, the case depth becomes uneven, leading to non-uniform crack fronts. Surface defects, such as burrs, grinding marks, and micro-pits, which interact with residual tensile stresses due to insufficient tempering, accelerate propagation. The movement from tiny cracks at the early stage of tooth-root to large failures that can bend an object occurs when the microgeometry, local stress amplification, and material variation interact. It thus underscores the critical importance of the accurate control of both surface and heat treatment.

Practical Fatigue Life Solutions for Indian Gear Fillets

Murakami's √area Method, which measures the influence of surface and micro-notch defects on bending strength, can determine the fatigue life of gears in India. Surface finish factors (Ka) are modified to match the typical machining ranges seen on Indian shop floors. By using this method and the ISO 6336-3 bending stress ratings, engineers can predict root-bending life for local faults.

Modelling the actual as-built fillet shape is required for accurate life prediction. Fillet sub-models are built by 3D scanning micro-roughness and notches. This allows for exact stress-gradient computations, which are especially useful for high-speed EV gears. This method is becoming increasingly important for exporting parts to US and EU programs that require precise as-built modelling due to demanding fatigue certification criteria.

Indian plants can now record fillet topography in real time using affordable online 3D scanners. By feeding this data into digital twins, we can estimate RUL predictably and find defects early. Tier-1 and Tier-2 suppliers can use digital twins to improve quality assurance, reduce life scatter, and meet international fatigue standards without requiring major capital investments.

Experimental Validation and Fractography Insights

Important factors influencing tooth-root fatigue in Indian gearmaking are typically overlooked during experimental validation. The lack of controlled fillet-surface preparation in many STBF (single-tooth bending fatigue) experiments restricts their ability to simulate actual shop-floor faults. Advanced monitoring, such as acoustic emission (AE) sensors or high-frequency vibration (HFV) signatures, which are still uncommon in the majority of domestic rigs, is also required for early fracture detection.

A realistic validation technique includes STBF testing with controlled micro-notches to calibrate design margins, residual stress measurement with XRD after grinding, and profilometer and 3D optical scans before heat treatment.

Fractography explains how these defects appear in failures. SEM study of gears produced in India frequently reveals step-like initiation fronts caused by unequal carburising, micro-burn pits that act as local stress risers, and chatter-induced fluted crack origins. NCR diagnosis requires distinguishing between shop-floor-induced cracks and service-load fractures. This enables manufacturers to concentrate on the root reason, whether it is machining, heat-treatment, or assembly issues,

rather than blaming failure on operational stress.

Ideal Immediate Steps for Indian Manufacturers

Indian gearmakers can start by implementing high-impact, low-cost process innovations to increase tooth-root reliability. Strict coolant control during grinding, fillet polishing for EV gears to reduce notch sensitivity, replacing manual deburring with controlled brushing or thermal deburring, and developing "notch severity maps" for each gear family can all help to reduce early-life failures significantly.

To achieve consistent, export-grade fatigue performance in the future, medium-term capabilities such as 3D optical metrology for fillets, automated burr identification, in-line micro-crack monitoring for hardened gears, and low-distortion heat-treatment processes will be required. Combining fast modifications with strategic technology adoption allows Indian manufacturers to regulate root-surface integrity, decrease life scatter, and meet the dependability needs of modern EV, wind, and high-speed industrial gear applications.

Vivek Singh is a mechanical engineer turned content strategist with a deep passion for machines and storytelling. With hands-on exposure to manufacturing environments through short-term stints at companies like Mahindra and other precision engineering firms. With a passion for both machines and storytelling, he has built a niche in creating technical content that bridges the gap between shop floor insights and digital communication. His experience spans writing for the tooling, CNC machining, and industrial automation sectors, delivering content that is both technically sound and strategically aligned.

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Shaping Technology with Insight: A Woman Leader's Perspective on Industrial Marketing at Marposs

- By Sushmita Das

Mariangela Bettini
Global Marketing Head – Marposs Worldwide

Nitika Sharma
Marketing Head – Marposs India

As manufacturing moves steadily toward automation and data-driven quality control, the role of precision measurement has never been more central to industrial success. At the forefront of this evolution is Marposs, a global leader in inspection, measurement, and monitoring solutions that enable manufacturers to achieve consistent accuracy and productivity across complex processes.

In conversation with Sushmita Das, Associate Editor of Gear Technology India, Ms Nitika Sharma, Head of Marketing at Marposs India, discusses her journey into the world of industrial technology, what sets Marposs apart in the highly specialised field of precision measurement, and how marketing serves as a critical link between engineering innovation and customer value. She shares her approach to communicating complex technologies across sectors such as automotive, aerospace, and semiconductors, reflects on her experiences as a woman in a technical domain, and outlines how Marposs' marketing strategy is adapting to the rise of smart manufacturing and digital engagement.

1. What attracted you to working at Marposs specifically? What aspects of the company's mission, values, or products do you find inspiring?

What attracted me to Marposs was its strong global reputation for precision, innovation, and quality, combined with a clear commitment to long-term customer value. The company's culture of engineering excellence, continuous improvement, and ethical business practices resonated strongly with my own approach to building credible, customer-focused brands.

I was particularly inspired by Marposs's ability to translate advanced technology into measurable manufacturing performance, which motivated me to contribute by strengthening its brand presence and market impact in India.

2. What drew you to Marposs, and what do you think sets the company apart in the field of precision measurement and inspection?

Marposs stood out to me for its unmatched legacy in precision measurement and its strong focus on innovation, reliability, and customer-centric engineering. What truly sets the company apart is its ability to combine deep application knowledge with advanced inspection and monitoring solutions that directly improve manufacturing quality and productivity.

Equally compelling is Marposs's long-term partnership approach with customers, which transforms technology into sustained value rather than standalone products.

3. How do you approach marketing complex and highly technical products to diverse industries like automotive, aerospace, or semiconductors?

I approach marketing in a technical industry by first deeply understanding the application, customer challenges, and performance outcomes rather than just the product features. The focus is on simplifying complexity—translating advanced technical capabilities into clear, value-driven messages around quality, productivity, reliability, and ROI.

For diverse industries such as automotive, aerospace, and semiconductors, I tailor communication by aligning solutions to each sector's specific standards, precision requirements, and business objectives. Close collaboration with technical teams and continuous customer feedback ensures that the messaging remains accurate, relevant, and credible across all markets.

4. What strategies help you translate Marposs's technical expertise into messaging that resonates with both engineers and decision-makers?

I focus on understanding the real manufacturing challenges behind the technology and then structure messaging around outcomes rather than complexity. For engineers, communication highlights precision, reliability, and process performance, supported by data and application examples.

For decision-makers, the same expertise is translated into business impact—improvements in quality, productivity, cost efficiency, and ROI. By using a layered communication approach and staying closely aligned with application and sales teams, the messaging remains technically accurate while clearly demonstrating value at a strategic level.

5. How is Marposs leveraging digital tools like content marketing, online events, or social media to engage with customers and strengthen its brand presence?

Marposs leverages digital tools strategically to enhance customer engagement and strengthen brand presence. Through content marketing, they share insightful articles, technical case studies, and product updates that demonstrate expertise and industry leadership. Online events and webinars provide interactive platforms for customers to learn about the latest innovations and solutions, fostering direct engagement. Additionally, social media channels are actively used to showcase company achievements, product capabilities, and thought leadership, creating a continuous dialogue with the audience and reinforcing Marposs' position as a trusted, innovative brand.

6. What are some key challenges of marketing in the manufacturing and measurement sector, and how do you stay adaptive to industry changes?

Marketing in the manufacturing and measurement sector comes with unique challenges. The audience is highly technical, decisions often involve multiple stakeholders, and the sales cycles are long. Additionally, communicating complex solutions in a clear and engaging way requires a fine balance between technical accuracy and simplicity.

To stay adaptive, we focus on continuous market intelligence, understanding evolving customer needs, and leveraging digital tools, content marketing, and thought leadership to remain relevant. We also actively monitor industry trends and competitor innovations, ensuring our marketing strategies are flexible and aligned with both technological advancements and customer expectations.

7. As a woman working in a technology-driven company, how do you view the evolving role of women in the industrial and tech sectors? What changes would you like to see?

As a woman in a technology-driven company, I see the role of women in the industrial and tech sectors evolving rapidly. Women are increasingly taking on leadership positions, driving innovation, and shaping strategies that impact the future of technology and manufacturing.

However, there's still room for progress. I would like to see more inclusive work environments, greater mentorship and sponsorship opportunities, and initiatives that encourage young women to pursue STEM careers. By fostering diversity, companies not only empower women but also benefit from a broader range of perspectives that fuel creativity and growth in the industry.

Working in a technical and industrial domain has been both challenging and rewarding. I've experienced strong support from colleagues and mentors who value expertise over gender, which has been encouraging. At the same time, like many women in traditionally male-dominated fields, I've occasionally encountered unconscious biases and the challenge of proving credibility in technical discussions.

These experiences have reinforced the importance of resilience, continuous learning, and building supportive networks. Over time, I've seen the environment becoming more inclusive, with organisations increasingly recognising the value of diversity in driving innovation and growth.

8. How do you envision the marketing function at Marposs evolving over the next few years, particularly in light of the rise of automation and smart manufacturing?

At Marposs, under the leadership of Ms Mariangela Betteni, "Global Marketing Head" of Marposs, we envision a marketing function that is data-driven, customer-centric, and digitally integrated, while reinforcing a strong and consistent global brand image and strategy.

In the era of automation and smart manufacturing, marketing will demonstrate the tangible value of Marposs solutions through globally aligned yet locally relevant case studies, technical content, and interactive digital platforms.

By leveraging analytics, AI, and digital tools, we will deepen customer insight, personalise engagement, and deliver a coherent global narrative that reflects Marposs's leadership in precision and innovation. Marketing will evolve from a communication function into a strategic partner, supporting a unified global strategy and guiding customers through the evolving industrial landscape.

From Manual to Autonomous: How Mii Robotics Is Shaping the Future of Automated Gear Finishing

- By Sushmita Das

Prasad Deshpande
Founder & Managing Director
Mii Robotics Pvt. Ltd.
(Subsidiary of Patil Automation Limited)

Prasad Deshpande is the Founder and Managing Director of Mii Robotics Group, an Indian organisation specialising in advanced robotics and automation solutions for the defence, aerospace, and high-precision manufacturing sectors. He founded Mii Robotics in 2017 with a focused vision to support Indian Ordnance Factories and the defence ecosystem by developing world-class, indigenous automation solutions aligned with global benchmarks. An Electrical Engineering graduate with over 25 years of experience, Prasad Deshpande has an extensive background in executing large turnkey projects in robotics and industrial automation. His professional career includes leadership roles in multinational organisations, where he developed strong expertise in project management, business strategy, and technology-driven execution. He is an accomplished management professional with a proven ability to blend profitable business models with cutting-edge engineering technologies. A strong believer in continuous improvement, He ensures that the Mii Robotics (MiiR) team remains updated with the latest skills, tools, and technologies required for the defence and aerospace industries. Deshpande is a recognised expert in automation systems for high-explosive and hazardous material handling, with deep experience in the design and manufacturing of safe, reliable, and mission-critical robotic solutions. These competencies have positioned Mii Robotics as a trusted partner for sensitive defence and strategic applications.

As gear manufacturers move toward higher precision, automation, and consistency, deburring has emerged as a critical determinant of final gear performance. In this interview, Sushmita Das, Associate Editor of Gear Technology India, engages with Prasad Deshpande, Founder & Managing Director of Mii Robotics Pvt. Ltd., a subsidiary of Patil Automation Limited, to examine how robotic automation is reshaping gear finishing.

The discussion highlights the shift from manual intervention to autonomous, data-driven processes, addressing challenges such as repeatability, tool life, workplace safety, and sustainability – key factors shaping the future of advanced gear manufacturing.

1. Traditionally, deburring was viewed as a secondary "cleaning" step. How is your technology elevating deburring into a primary quality assurance pillar?

We have redefined deburring as a critical "edge-conditioning" phase. Modern power transmissions, especially in EVs, demand extreme precision to minimise noise and maximise power density. Our technology ensures that the edge geometry is treated with the same importance as the tooth profile itself, making it a foundational element of the gear's final performance rating.

2. Manual deburring is inherently difficult to standardise and physically demanding. How does the integration of robotic handling with your specialised deburring machines eliminate 'operator fatigue' and ensure absolute consistency across high-volume production runs?

Human variability is the primary enemy of precision. In our systems, we decouple the operator from the process by utilising robotics exclusively for high-precision loading and unloading. This ensures the gear is seated with 100% repeatability, while the machine's dedicated deburring logic dictates the pressure and contact time. By removing the physical strain of handling heavy or sharp components, we eliminate the 'fatigue factor,' allowing the machine to maintain a CPK (Process Capability Index) that manual processes cannot match. Whether

it is the first or the thousandth gear of the shift, the edge radius remains identical.

3. How can the long-term value and ROI of an automated deburring cell be justified to CAPEX-conscious manufacturers?

The ROI is found in three areas: the immediate elimination of manual labour costs, a drastic reduction in scrap and rework, and, most importantly, the prevention of catastrophic field failures caused by loose burrs. Most of our clients see full capital recovery within 12 to 18 months through these efficiency gains alone.

4. How does robotic precision optimise the life cycle of consumables compared to manual methods?

Manual operators often apply uneven pressure, which "glazes" or destroys abrasive media prematurely. Our systems maintain the "Golden Zone" of optimal cutting force. This precise engagement extends tool life by up to 40%, significantly reducing the cost-per-part and minimising downtime for tool changes.

5. Looking at the next five years, do you foresee a shift toward AI-driven autonomous finishing?

Absolutely. We are moving toward "self-optimising" machines. Future systems will use AI to analyse tool wear and surface finish results, automatically adjusting their own parameters to maintain peak quality without human intervention. The machine will essentially "learn" the most efficient way to finish any alloy it encounters.

6. In a shop that makes many different types of gears, isn't it time-consuming to reset the machine for each new part?

Not anymore. We have replaced complex coding with "Parametric Programming." Now, an operator simply selects a part profile from a library or enters a few basic measurements. The system automatically calculates the new path. This slashes changeover time from several hours to just a few minutes, making "one-click" setups a reality.

7. How do you handle deburring for complex parts like internal splines or deep holes that are hard to reach?

We have engineered ultra-compact, high-speed carbide tools that can fit into very tight spaces. By combining these with advanced technology, our machines can navigate complex geometries that used to require hours of tedious manual work. We've turned a "handwork only" job into a fast, automated process.

8. How do you ensure the deburring process doesn't overheat the metal and weaken the gear teeth?

Excessive friction creates "grinding burn," which can soften the metal. Our machines use "cool-cut" logic, which carefully manages the speed and pressure of the tool. By optimising these contact intervals, we remove the burr while keeping the gear's hardness and metallurgical integrity perfectly intact, especially at the sensitive tips of the teeth.

9. Traditional manual deburring creates significant dust and noise. How does moving to an enclosed automated machine improve the working environment?

Safety is a major driver for automation. Our machines are fully enclosed, which keeps hazardous metal dust and debris contained within a filtration system rather than in the operator's breathing zone. Additionally, the sound-dampening enclosures significantly reduce shop noise. We aren't just improving the gear; we're creating a cleaner, safer, and more professional workplace for the entire team.

10. With the global push for "Green Manufacturing," how do your automated deburring machines contribute to a company's sustainability and energy-efficiency goals?

Efficiency and sustainability go hand-in-hand. By automating the deburring process, we significantly reduce the amount of energy wasted on "re-work" and scrap parts. Furthermore, our precise control over the deburring tools ensures that we only remove the exact amount of material necessary, extending the life of consumables and reducing industrial waste. We've designed our machines to prove that high-precision manufacturing doesn't have to come at a high environmental cost; it can actually be a cleaner, leaner way to produce.

Building India's Gear Future: A Technical Outlook from Rupkala Engineers

- By Sushmita Das

Viral Panchasara is a third-generation entrepreneur with over 24 years of hands-on experience in gear manufacturing. He leads the technical functions at Rupkala Engineers with a clear, growth-oriented vision—to build a globally benchmarked organisation known for world-class quality gears. His deep technical involvement, combined with long-term thinking and continuous improvement, drives Rupkala's journey toward excellence in precision manufacturing.

1. How has Rupkala Engineers evolved technologically over the decades, moving from conventional gear cutting to precision grinding and advanced metrology?

Rupkala Engineers' technological evolution has been gradual and deliberate. Established in 1972, the company initially began gear manufacturing on conventional milling machines, catering to basic industrial requirements of that period.

As customer demands increased and component complexity grew, Rupkala progressed from milling to gear shaping machines, followed by upgrades to gear hobbing machines, which enabled higher productivity and improved consistency in gear manufacturing.

Recognising early on the importance of profile accuracy and surface finish, Rupkala began gear grinding operations in 1995. This capability was further strengthened in 2006 with the introduction of CNC gear grinding machines, marking a decisive shift towards precision-controlled manufacturing.

A major inflection point came with the establishment of a modern manufacturing facility in 2007, which enabled focused investments in CNC machining, advanced gear cutting, profile and generation grinding technologies, and structured metrology systems. Today, manufacturing decisions at Rupkala are driven by measurement data, process capability, and repeatability, ensuring consistent achievement of DIN 5 quality levels.

2. Your product range serves demanding sectors such as rail, renewables, compressors, and construction equipment. What core engineering strengths allow you to meet the performance needs of such diverse industries?

Across these sectors, material integrity and process discipline are as critical as dimensional accuracy. Rupkala's core engineering strength lies in maintaining material quality and executing every manufacturing process in a technically correct and controlled manner.

The company has developed strong capability in manufacturing large-module and large-diameter gears, including components produced from die-forged blanks. Equal emphasis is placed on material quality assurance, control over gear geometry, profile modifications, and surface finish.

Close coordination between manufacturing engineering and quality teams ensures that each component is produced with the required reliability and consistency, enabling Rupkala to serve diverse and demanding applications effectively.

3. Maintaining DIN 5/6 quality consistently requires precision. Which processes, machines, and quality systems are most critical in helping you achieve these tolerances?

Consistently achieving DIN 5 quality is the result of integrated process control, rather than reliance on a single machine or inspection step.

Critical elements include advanced profile and generation gear grinding machines, controlled pre-grinding processes to minimise cumulative errors, and robust in-house inspection systems in close environments such as gear testers and roll testers. Structured inspection plans and in-process checks ensure deviations are identified early.

Equally important is the feedback loop between inspection and manufacturing. Process corrections are driven by actual measurement data, ensuring accuracy is embedded within the system and not dependent on individual operators.

4. Heat treatment distortion is a common challenge in gear manufacturing. How does your team manage post-heat treatment corrections and ensure accuracy in large gears and shafts?

Heat treatment distortion is addressed at Rupkala through comprehensive metallurgical control, preventive planning, and corrective capability.

The process begins with raw material testing in the in-house metallurgical laboratory, ensuring uniform grain flow, appropriate chemical composition, and hardness suitability. As a standard practice, Rupkala performs normalizing or isothermal annealing on 100% of components as pre-machining treatments to stabilise the material and minimise distortion during subsequent operations.

Pre-machining sequences are planned with suitable allowances, and close coordination is maintained with qualified heat treatment partners regarding process selection, fixturing, and loading patterns.

Post heat treatment, dimensional and geometric accuracy is restored through profile and generation grinding, supported by hard turning where applicable. Inspection-driven correction strategies ensure consistency, particularly in large gears and shafts where distortion behaviour must be carefully managed.

5. Rupkala handles both precision batch production and highly customised components. How do you balance flexibility and efficiency while keeping lead times competitive?

Rupkala balances flexibility and efficiency through a modular and engineering-driven manufacturing approach. Operations are structured to accommodate both batch production and customised components without disrupting overall flow.

Flexible machine configurations, standardised tooling methodologies, and strong involvement of manufacturing engineering during the development stage enable smooth execution. By front-loading engineering effort and minimising shopfloor iteration, Rupkala is able to maintain new product

development timelines typically within 8–10 weeks, even for complex components.

6. With your long-standing presence in the Indian manufacturing landscape, what changes do you see in customer expectations in areas such as precision, noise reduction, and material performance?

Customer expectations have evolved significantly over the years. Earlier, gears were primarily evaluated on dimensional compliance and cost. Today, customers increasingly demand tighter tolerances, improved NVH performance, consistent material properties, and predictable service life.

There is greater awareness of gear micro-geometry, surface finish, and profile modifications, with customers expecting suppliers to possess a deeper technical understanding and contribute proactively beyond basic manufacturing.

7. As global OEMs increase their sourcing from India, what strategies are you adopting to position Rupkala Engineers as a trusted export partner?

Rupkala's approach to exports is firmly rooted in its core value of a customer-centric approach, which places the customer's interest first at all costs.

This philosophy is reflected through close coordination with customers at every stage – from development and manufacturing to inspection and delivery. Transparent communication, adherence to commitments, and consistent quality performance are central to Rupkala's export strategy.

By prioritising long-term relationships and customer confidence over short-term gains, Rupkala aims to establish itself as a trusted and dependable export manufacturing partner.

8. What new technologies, whether automation, digital inspection systems, simulation tools, or next-generation grinding machines, are you prioritising to remain future-ready?

Rupkala's focus is on adopting technologies that enhance process stability, repeatability, and decision-making. Priority areas include advanced gear grinding technologies for complex geometries, digital inspection systems, and better integration between manufacturing and quality data.

Selective automation is being evaluated to reduce process variability and manual dependency, ensuring long-term capability improvement rather than automation for scale alone.

9. The gear industry continues to become more competitive and capital-intensive. What major business challenges do you anticipate, and how is Rupkala preparing to address them?

Key challenges include rising capital investment requirements, increasing expectations on quality and delivery reliability, skilled manpower availability, and margin pressure.

Rupkala is addressing these challenges through focused investments, disciplined capacity planning, workforce stability, and by avoiding over-diversification. The emphasis remains on strengthening core capabilities and executing with consistency.

10. What is your long-term vision for Rupkala Engineers over the next five to ten years in terms of technology upgrades and market expansion?

Over the next five to ten years, Rupkala Engineers aims to strengthen its position as a globally benchmarked precision gear manufacturer, with a growing presence in export markets and technically demanding applications.

From a technology standpoint, the focus will be on adopting Industry 4.0 in a practical manner – connecting machines, grinding processes, and inspection systems so that shopfloor decisions are driven by real process data. The objective is better visibility, repeatability, and early correction, rather than automation for scale alone.

Rupkala will continue investing in advanced gear grinding and digital inspection systems, while gradually integrating production and quality data to improve traceability and process stability. By adopting Industry 4.0 step by step, Rupkala aims to support customers with consistent long-term performance and contribute to India's emergence as a trusted source of high-precision gear components, pursuing growth in a disciplined and sustainable way.

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Forged for Reliability: KLM FORGE's Role in Strengthening India's Industrial Backbone

- By KLM FORGE Pvt. Ltd.

Introduction: Forging the Backbone of Industrial Strength

In today's competitive manufacturing landscape, precision, reliability, and metallurgical integrity define success. KLM FORGE, based in Pune, Maharashtra, stands at the forefront of India's forging industry, delivering engineered steel forgings that power critical sectors across automotive, oil & gas, railways, infrastructure, and heavy engineering.

With fully integrated capabilities — from Open Die Forging to Ring Rolling, Closed Die Forging, Heat Treatment, and Precision Machining — KLM FORGE offers complete end-to-end manufacturing under one roof.

"At KLM FORGE, we don't just shape steel — we engineer strength, reliability, and long-term performance."

Integrated Forging Excellence Under One Roof

KLM FORGE's manufacturing ecosystem is built around process control, metallurgical precision, and customer-centric engineering solutions.

Open Die Forging – Built for Heavy-Duty Performance

KLM FORGE manufactures robust open die forgings designed for demanding industrial applications.

Key Capabilities:

- Shafts, blocks, bars & customised profiles
- Alloy steel, carbon steel & stainless steel grades
- Superior grain refinement
- High structural strength & durability

Ideal for large cross-sections and critical load-bearing applications, open die forging ensures enhanced mechanical properties and long service life.

Ring Rolling – Seamless Strength, Superior Accuracy

The company's advanced Ring Rolling capability enables production of seamless rolled rings with exceptional concentricity and grain flow orientation.

Applications Include:

- Bearing rings
- Flanges
- Gear blanks
- Slewing rings
- Oil & Gas components

Advantages:

- Optimised material utilisation
- Improved fatigue resistance
- Cost efficiency for large diameters
- Dimensional precision

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KLM FORGE delivers high-volume closed die forgings engineered for dimensional accuracy and repeatability.

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- Tight tolerances
- High production consistency

Products serve automotive OEMs, industrial machinery manufacturers, and engineering enterprises requiring performance-critical components.

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To ensure superior mechanical properties, KLM FORGE operates a fully controlled Heat Treatment facility.

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- Stress Relieving

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- Custom finishing solutions

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- Complete traceability
- Tight dimensional control
- Ready-to-assemble components

Quality & Traceability – Our Core Commitment

Quality is embedded at every stage of production.

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- Railways
- Infrastructure & Construction
- Power Generation
- Heavy Engineering

Strategic Vision: Forging Global Partnerships

KLM FORGE continues to invest in advanced technology, process automation, and skilled workforce development to strengthen its position in domestic and international markets.

With a customer-first philosophy and engineering-driven mindset, the company is poised to become a globally recognised forging partner.

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Sometimes the more is the better: Profile Grinding Machines for Large Gears

For manufacturers of wind turbines, Zahnradfertigung Ott GmbH & Co. KG is a highly requested supplier. The production of ring gears with diameters of 2500 mm and especially internal gears requires a high level of expertise, qualified employees and the right machines, such as the ZP I/E profile grinding machine from Kapp Niles. The solid construction and the large grinding head - the more is here the better – ensure maximum precision.

Zahnradfertigung Ott GmbH & Co. KG is based in Bodelshausen, in the district of Tübingen. Founded in 1957, the family-owned company now has 156 employees and about 10,000 m2 floorspace. The production range includes a wide variety of gears and gearboxes for industry, transport, logistics, oil and gas extraction, etc.

Wind power: large gears, high demands

Wind power increasingly characterises the portfolio of the company, which has established itself as one of the first suppliers for this industry in Europe. Already in 1999, Ott converted a machine for the manufacture of helical ring gears for this purpose. It was clear that the quality requirements for wind turbine gearboxes could only be achieved with ground gears. The customer requirements according to DIN ISO 1328-1 are usually quality 7 or 6, sometimes even 5, as Siegfried Nill, Production Manager at Ott, confirms: 'The desired surface quality, pitch and profile accuracy can only be achieved by grinding. In addition, corrections are made to the tooth profile and the flank line, such as tip and root relief, end relief and a defined crowning or taper.' This enables optimising power transmission within the gearbox and thus improves running smoothness, as Nill explains: 'Today, it is possible to simulate deformations and displacements of components under load. In the past, this could only be estimated theoretically, but today the designers know in advance how a tooth will deform under load, and it can be compensated for in advance. In this way, the contact ratio of the gear under load can be maximised.' The pinions or ring gears are, to exaggerate a little, ground conical so that they straighten under load. Machines for grinding internal gears up to 2,500 mm in diameter have therefore long been part of the production portfolio. Nill again: 'Wind turbines are becoming increasingly larger and more powerful. This results in ever larger gearboxes and thus tooth widths. Year after year, gearbox manufacturers have planned larger types and asked us whether we can do this. Of course, we agreed, bought the appropriate machines or even had them converted to fit. That's how we grew into the wind business, especially in the area of ring gear production, in other words, internal gears for large parts.'

Precise, robust and flexible – grinding machines from Kapp Niles

Kapp Niles was not part of Ott's machine park for a long time. This only changed in 2018, when an old grinding machine needed to be replaced. Ott became aware of a used Kapp Niles ZP I/E machine through a machine dealer. These gear profile grinding machines are used for high-precision grinding of large-module internal gears. A special feature is the grinding head: It can be rotated by 180° so that the machine can be converted for grinding external gears and special profiles in a very short time (Image 1). The largest version of the series enables the machining of internal gears with a root circle diameter of up to 2,900 mm. The used machine was designed for 2,500 mm. Jens Haag (Image 2),
member of the board, remembers it well: 'The machine was interesting in terms of price and only had a short running time. Although it was second-hand, its quality was impressive. That's why we bought a second, new machine a few years later, which complements our production very well.'

Markus Reißenweber, Sales Manager America and Europe at Kapp Niles, describes the highlights of the machine: 'With the solid grinding head, we achieve a high level of thermal stability. At the same time, the rigid construction prevents the grinding wheel from being displaced during grinding. Another competitive advantage is the low effort required for tool changes. The grinding wheel is mounted on one side so that the grinding head does not have to be dismantled, and the grinding wheel can be changed in just a few simple steps.' (Image 3)

The quality of the machine is also shown in the achievable surface roughness, as Roland Löffler, the responsible department manager at Ott, reports (Image 4): 'The majority of orders require a Ra value of less than 0.8 µm. We already achieve values between 0.4 and 0.6 µm as a standard. We also try to grind Ra values of 0.2 µm as a test, as the trend in the wind energy sector is clearly moving towards higher surface requirements, which means Ra below 0.4 µm. We have to be prepared for this, even as a contract gear manufacturer.' The reason for this trend is the increasing output of wind turbines and, therefore, the need to maximise the efficiency of the turbine. The integrated measuring system for gear measurement is also helpful during production. Haag explains: 'We measure during production in order to maintain our quality. Once the system is set up and the external influences are appropriate, you can rely on the results.'

A machine that stands on its own feet – cost factor foundation

Normally, machines of this size require a foundation that goes down to the ground. Required can be three or even six metres down. A special basement must then be created in the excavation pit to which the machine is bolted. Not like this with the ZP I/E. The floor simply has to bear the weight, which a modern heavy-duty floor can often do already. The shop floor at Ott dates

back to the seventies and therefore had to be reinforced (Image 5). Despite this, the base was far more cost-effective than the foundation required by other manufacturers. Haag comments: 'This also played a major role in my decision. The foundation can easily cost €200,000 for such large machines. That is not to be neglected.'

Nill adds: 'During a site meeting about the assembly times, Kapp Niles stated three or four weeks. I thought that was impossible. But if you know that you don't have to screw the structure to the ground, then it works. At that time, I realised how stable the machine is.'

Another benefit is the flow guide for the grinding media. Some manufacturers require a chute under the machine to collect the coolant, etc., as it drains away. With Kapp Niles, all units are on the same level as the machine.

Flexibility: A cardinal value for contract gear manufacturers

'Flexibility is very important for us as a contract gear manufacturer. In high-volume production, there is sometimes a separate machine for each workpiece. We grind internal gears in the morning, external gears at lunchtime, and a shaft the next day. It makes a difference whether the head change overtakes five or just two hours,' says Haag, describing his day-to-day work (Image 6). He is referring to the change of the grinding head from internal to external gearing. In addition to the quick tool change, this is another highlight of the grinding machine. The connectors for hydraulics and electrics can remain on the head during the changeover. Disconnecting and reconnecting them not only takes time. It can also easily lead to contamination, contact faults or leaks. Haag again: 'It takes just two hours from the start of the head change to the start of the new workpiece. That's an important point for us.'

The ZP I/E in practice

The decision to use Kapp Niles proved to be the right one for Ott Zahnradfertigung in every aspect. 'There have been no quality issues with our standard gears, but there are more and more customised products where our machines were reaching their limits,' says Nill, describing the initial situation (Image 7). One criterion for the new grinding machine was therefore that we could accurately reproduce the flank line, especially the area where the grinding wheel goes into the workpiece. With Kapp Niles, you notice that the tools are hardly forced out of the centre. The construction is impressive all along the line.' Haag confirms this: 'We have always had problems with the flank lines. We have already got the issue under control with the used machine, even when we grind modifications.' Löffler is also impressed by the quality: 'With some other machines, we had deviations where the grinding wheel is entering or leaving the gear, a kind of nose. We were able to solve the problem. At a face width of 600 mm, you can apply a ruler and see no deviation. That impressed us.'

The service fits as well

The Ott Zahnradfertigung team already felt well advised in advance (Image 8), recalls Nill: 'We felt that we were taken care of when we made contact and visited the factory. All the important people were at the table. There were solid answers, and promises were kept.' Löffler can also confirm this: 'When we came to Berlin with our requirements, Kapp Niles had already dealt with them and had answers ready. That was very convincing. This also applies to the after-sales service. The machines run reliably, but if there is ever a problem, we can rely on a technician coming the next day.'

Haag is also convinced: 'We are known in the market for our quality and for the fact that we maintain this consistently, not just for one particular article, but always. This requires expertise, qualified employees and the right machines. When it comes to Kapp Niles, you could say that everything is a little simpler, from the foundation to changing the head. And yet the quality is just right. That's a great combination.'

Image source: Martin Witzsch

Lead image (KappNiles_Ott_00.jpg)

Image 1 (KappNiles_Ott_01.jpg): The grinding head can be reversed and converted from internal to external gearing in a very short time.

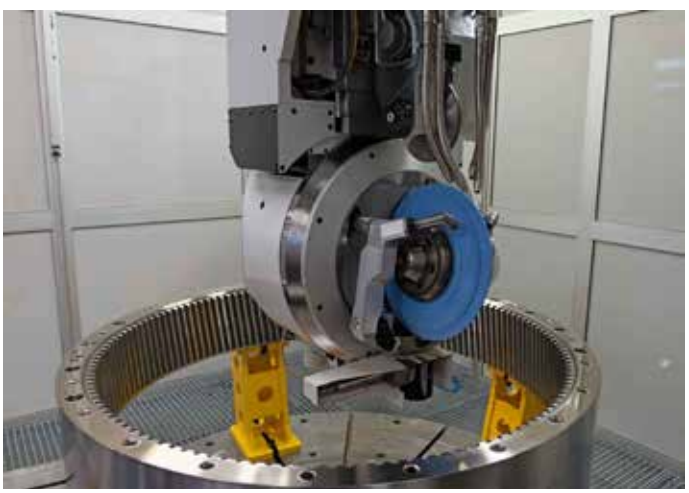

Image 3 (KappNiles_Ott_03.jpg): The grinding wheel is mounted on one side and can be exchanged in just a few simple steps from the other side.

Image 5 (KappNiles_Ott_05.jpg): The Kapp Niles ZP I/E 25 does not require a special foundation. Only the old shop floor from the 70s had to be enforced.

Image 2 (KappNiles_Ott_02.jpg): Jens Haag, member of the management of Zahnradfertigung

Image 4 (KappNiles_Ott_04.jpg):
Roland Löffler: 'There is a trend in the wind energy industry clearly moving towards higher standards.'

Image 6 (KappNiles_Ott_06.jpg): Jens Haag: 'For us as a contract gear manufacturer, it is crucial whether the head change takes five or just two hours.'

Image 7 (KappNiles_Ott_07.jpg):
Siegfried Nill: 'With Kapp Niles, you realise that the tools are hardly pushed out of center.

Image 8 (KappNiles_Ott_08.jpg):
The Ott Zahnradfertigung team – Siegfried Nill, Roland Löffler and Jens Haag – with Markus Reißenweber from Kapp Niles (from left to right)

Authored by:
Dipl.-Phys. Martin Witzsch
Freier Journalist im Auftrag der Kapp GmbH & Co. KG
Haßfurter Str. 20 – 91056 Erlangen – Germany
Telefon: +49 (0) 9131-9266725
E-Mail: info@witzsch.com

Ministry of Defence Inks ₹4,666 Crore Defence Deals for CQB Carbines and Torpedoes; Bharat Forge Ltd & PLR Systems Secure Carbine Contract

- By Sushmita Das

In a significant step toward strengthening India's defence preparedness and indigenous manufacturing capabilities, the Ministry of Defence (MoD) signed contracts worth ₹4,666 crore for the procurement of Close Quarter Battle (CQB) Carbines and Heavy Weight Torpedoes. The contracts were inked in the presence of Defence Secretary Shri Rajesh Kumar Singh at South Block, New Delhi.

Indigenous Boost with CQB Carbines

A major portion of the procurement involves over 4.25 lakh CQB Carbines, along with accessories, valued at ₹2,770 crore for the Indian Army and the Indian Navy. The contracts were signed with Bharat Forge Ltd. and PLR Systems Pvt. Ltd., marking a key milestone in India's journey toward self-reliance in defence manufacturing under the Aatmanirbhar Bharat initiative.

Designed as a cornerstone of the modern infantry arsenal, the CQB Carbine offers a compact configuration and high rate of fire, delivering enhanced lethality in close-combat and confined-space operations. The induction of these carbines will replace legacy systems, significantly upgrading the firepower and effectiveness of frontline troops.

Beyond operational advantages, the project reflects strong public–private sector collaboration and is expected to provide a substantial boost to the Make in India programme. It will stimulate economic activity, generate employment, and strengthen indigenous defence ecosystems by encouraging MSME participation in component manufacturing and raw material supply.

Enhanced Undersea Warfare Capability

In a parallel development, the MoD also signed a contract worth approximately ₹1,896 crore with WASS Submarine Systems S.R.L., Italy, for the procurement and integration of 48 Heavy Weight Torpedoes along with associated equipment for the Indian Navy's Kalvari Class (P-75) submarines.

The acquisition will significantly enhance the combat capability of the Navy's six Kalvari Class submarines, equipping them with advanced undersea warfare systems featuring state-of-the-art operational and technological capabilities. Delivery of the torpedoes is scheduled to commence from April 2028 and conclude by early 2030.

The procurement underscores the Government's commitment to meeting the evolving operational requirements of the Indian Navy through the induction of niche technologies and advanced weapon systems.

Modernisation Momentum Continues

The latest contracts add to the MoD's strong modernisation push. In the Financial Year 2025–26 alone, the Ministry has signed capital acquisition contracts worth ₹1,82,492 crore, reinforcing India's focus on upgrading its armed forces while simultaneously building a robust domestic defence manufacturing base.

Together, these procurements highlight a dual strategy – enhancing combat readiness across land and maritime domains while deepening indigenous capability and industrial participation in India's defence sector.

Picture Courtesy: PIB India

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Research Synopsis: Mapping the Future of Industrial Gears Through Gear Technology India's Multi-Sector Analysis

- By Gear Technology India

In a major industry initiative, Gear Technology India's research team has recently conducted a comprehensive study on the role and performance of gear systems across multiple industrial sectors, including aerospace and defence, energy and power generation, mining and quarrying, marine and shipbuilding, agriculture, food processing, steel, cement, and advanced manufacturing.

This exclusive research publication highlights how gears continue to serve as the silent backbone of modern industry, enabling motion, power transmission, and precision across critical infrastructure and production systems. With the global industrial gear market valued at nearly USD 222 billion in 2025 (as per Mordor Intelligence report), the research reflects the growing strategic importance of gear technology in driving efficiency, safety, and long-term reliability.

Drawing upon engineering expertise, industry data, and field-level insights, the study examines extreme performance demands – from high power-density aerospace gearboxes to ultra-high torque systems in sugar mills and mining machinery. It presents how modern material science, advanced surface treatments, and precision CNC manufacturing are enabling gears to perform under harsh operating environments and heavy load conditions.

A strong emphasis is placed on compliance with international standards established by bodies such as the American Gear Manufacturers Association and the International Organisation for Standardisation, outlining their influence on quality assurance, benchmarking, and global competitiveness.

The report also highlights India's emergence as one of the world's leading gearbox markets, supported by established manufacturers including Triveni Engineering & Industries Ltd., Elecon Engineering Company Ltd., and Shanthi Gears Ltd. These companies continue to deliver critical solutions for power, defence, marine, and infrastructure projects in India and overseas.

Aligned with Industry 4.0, the research highlights the industry's shift towards intelligent gear systems driven by IoT, artificial intelligence, and predictive maintenance technologies. It also examines emerging sustainability and electrification trends, marked by the growing use of electric and low-emission equipment, along with increased localisation supported by public-sector procurement initiatives involving Coal India Limited.

With detailed technical tables, industry benchmarks, and India-focused case studies, this research serves as a strategic knowledge resource for engineers, plant heads, technology consultants, procurement leaders, and policymakers. It reflects GTI's commitment to strengthening the manufacturing ecosystem through high-quality, actionable research.

To receive the complete research report and explore detailed insights on sector-wise applications, performance benchmarks, and emerging industry trends, please get in touch with:

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Our team will be pleased to assist you with further information and access to this exclusive publication.

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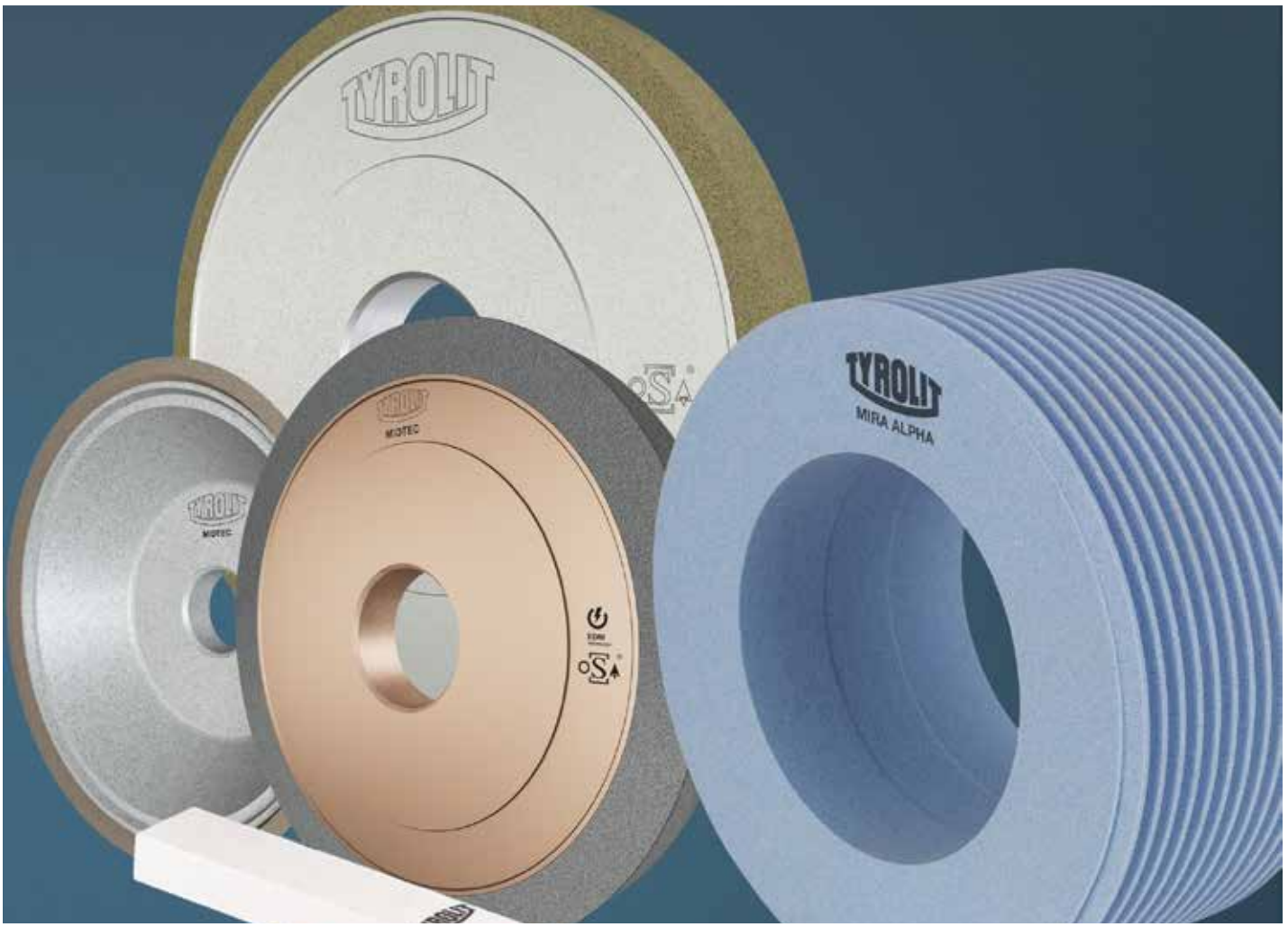
Shaping the Future of Gearing: A Manufacturing Perspective from Tyrolit

- By Tyrolit Group



From Tyrolit's perspective, the gearing industry today stands on firm ground. It remains one of the most technology-driven and innovation-led segments within mechanical engineering, and this is clearly reflected in current market dynamics. Over recent years, steady growth has given manufacturers a degree of confidence, even in an otherwise volatile global environment. What is driving this momentum is not just volume demand, but a clear shift towards higher precision, performance reliability and application-specific solutions.

Across sectors such as automotive, wind energy, agriculture, robotics and aerospace, gears are increasingly expected to deliver more within tighter design envelopes. Lightweight constructions, improved efficiency and reduced noise emissions are no longer optional features but core requirements. This evolution is directly influencing how gear components are manufactured and finished.

Electrification and the New Demands on Gear Systems

Electrification, particularly in mobility, has introduced a fundamental change in how gear systems are designed and produced. Electric drivetrains operate at significantly higher speeds than conventional combustion engines, while simultaneously demanding compact designs and extremely low noise levels.

From a manufacturing standpoint, this places exceptional importance on surface quality and profile accuracy. High-speed gear systems for electric vehicles must manage different torque and load characteristics, making precision

grinding and finishing processes critical. For Tyrolit, this trend reinforces the need for grinding solutions that combine accuracy, consistency and process stability – especially as production volumes scale.

Precision Manufacturing Enhanced by Data and AI

Precision has always been central to gear manufacturing, but today it is being taken further by digitalisation and intelligent process control. Advanced CNC machines, paired with modern grinding technologies, are capable of achieving the tightest tolerances with remarkable repeatability.

Increasingly, artificial intelligence is supporting these processes by analysing machine-generated data in real time. From Tyrolit's experience, this allows potential deviations to be detected at an early stage, while process parameters can be adjusted automatically to maintain consistent quality. The result is a more stable production environment, reduced rework and greater confidence in component performance over the full lifecycle.

Wind Turbine Gears: Precision as a Prerequisite

Wind energy remains one of the most demanding applications for gear systems. Wind turbine gearboxes are expected to operate reliably for decades, often in remote or offshore locations where maintenance is complex and costly.

For these applications, flawless surface quality is essential. Even minor imperfections can significantly impact service life under continuous load conditions. Tyrolit observes a growing demand for advanced grinding solutions that ensure maximum precision and durability from the outset. As global investment in renewable energy continues to rise, this segment is expected to remain a key driver for high-end gear manufacturing technologies.

Advanced Materials and New Production Methods

Material innovation is also reshaping the industry. Lightweight alloys and composite materials are increasingly used to achieve superior strength-to-weight ratios, particularly in high-performance and energy-sensitive applications. These materials, however, present new challenges in machining and finishing, requiring tailored abrasive solutions and process know-how.

Additive manufacturing is another area gaining attention. While not yet a mainstream production method for gears, 3D printing is proving valuable for rapid prototyping, design validation and specialised end-use components – especially in aerospace, robotics and advanced automotive applications. From Tyrolit's viewpoint, this trend complements rather than replaces conventional manufacturing, offering greater flexibility during development phases.

Market Outlook Towards 2026

Looking ahead, Tyrolit expects overall gear demand to continue rising through 2026, supporting sustainable industry growth. The Asia-Pacific region – particularly China and India – remains a key growth engine, alongside NAFTA countries and Brazil. Strong industrial expansion and ongoing investments in renewable energy are underpinning this positive outlook.

This growth is further supported by Team Tyrolit in India, whose strong regional presence and application expertise enable close collaboration with customers and effective support of evolving market requirements.
However, growth will increasingly favour manufacturers who can deliver precision, efficiency and reliability at scale, rather than volume alone.

Challenges Facing the Industry

Despite strong fundamentals, several challenges remain. Supply chain disruptions following the pandemic continue to affect availability and lead times, while rising raw material prices and fluctuating tariffs – particularly between the USA, China and the EU – are putting pressure on cost structures.

Electrification also requires rapid adaptation. Manufacturing processes and product portfolios must evolve to meet new technical requirements, often within shorter development cycles.

Environmental regulations represent another critical factor. Across the entire value chain, the shift towards more sustainable materials, cleaner processes and socially compliant operations is accelerating. For manufacturers and technology partners alike, staying ahead of regulatory requirements is no longer optional – it is essential.

A Measured Path Forward

From Tyrolit's standpoint, the future of the gearing industry is one of opportunity balanced by responsibility. Precision manufacturing, intelligent processes and sustainable practices will define success in the coming years. Companies that invest early in technology, process stability and environmental compliance will be best positioned to support their customers in an increasingly demanding market.

The gearing industry has always evolved through engineering excellence. Today, that excellence must be combined with adaptability, data-driven decision-making and a clear commitment to long-term sustainability.

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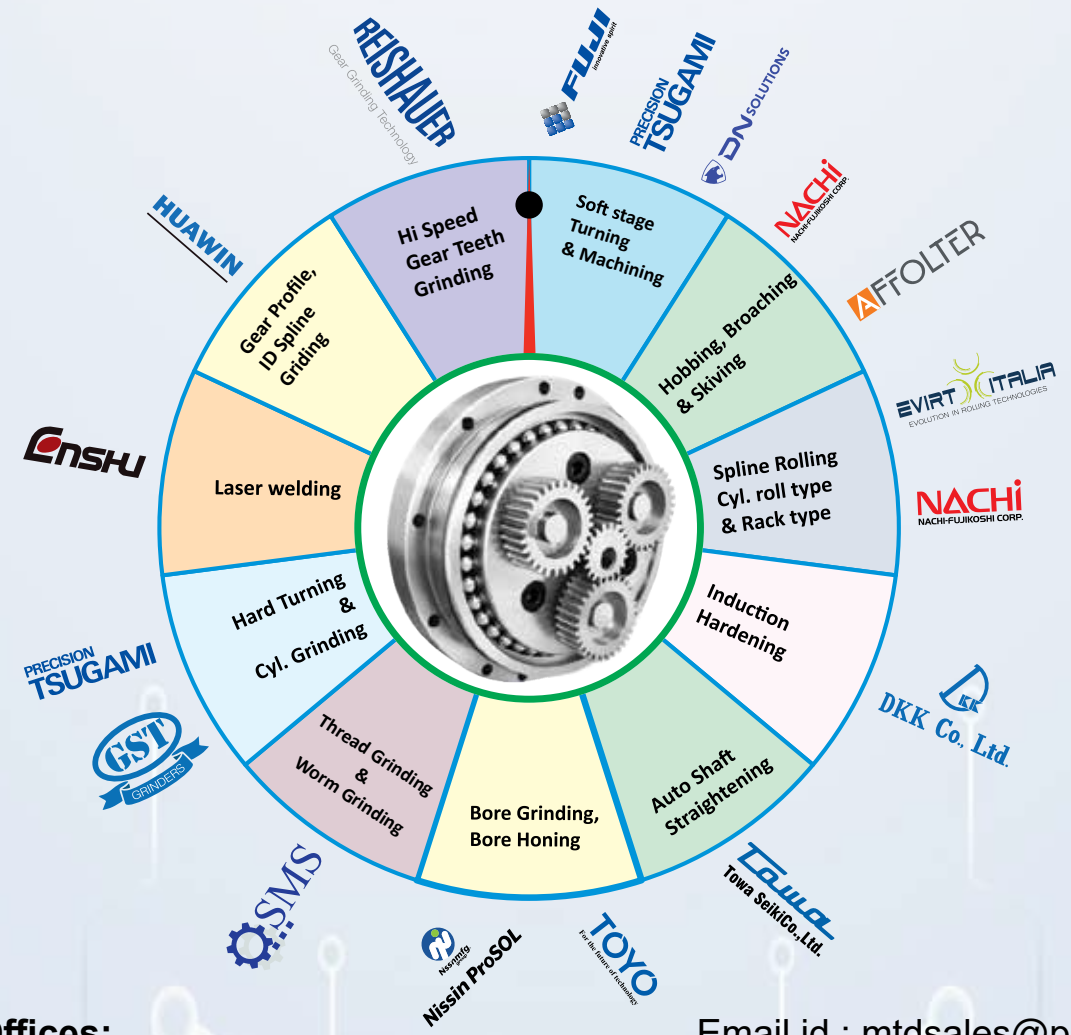

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Supply-Risk Mitigation in the Gear Industry

- By Nishant Kashyap, Guest Editor - Gear Technology India

Supply chain disruptions pose significant threats to the gear industry, where precision components are vital for automotive, aerospace, and heavy machinery sectors. Recent global events, including geopolitical tensions and material shortages, have underscored the need for robust risk mitigation strategies tailored to gear manufacturing.

This article synthesises case studies and research focused exclusively on the gear sector, drawing from supplier management practices and resilience frameworks to outline actionable approaches.

Challenges in Gear Supply Chains

Gear production relies on specialised alloys, high-grade steels, and precision tooling, making it vulnerable to raw material scarcity and supplier failures. Disruptions often stem from single-source dependencies on critical inputs like carburising steels or rare earth additives used in high-performance gears. For instance, fluctuations in alloy prices due to trade restrictions can halt production lines, as seen in automotive transmissions requiring exact tolerances.

Research highlights that 70% of gear manufacturers face supply risks from concentrated sourcing in regions like China and Europe. These vulnerabilities amplify during events like port strikes or pandemics, delaying deliveries by weeks and inflating costs by up to 25%. Mitigation begins with mapping the entire supply chain, identifying tiers from raw material extractors to finish machinists.

Case Study: Aerospace Gear Component Risk Management

A prominent case study from the aerospace and automotive gear sectors illustrates effective supplier risk navigation for critical engine and gear components. Facing heightened scrutiny post-2024 supply crunches, a leading manufacturer segmented suppliers into risk tiers: high-risk for sole providers of titanium gears, medium for standard helical gears, and low for commodity parts.

The firm implemented dual-sourcing for 60% of critical gears, reducing dependency on any single vendor by 40%. Buffer inventories of 90-day stocks for high-wear gear spares were established, coupled with nearshoring to Mexico and India for proximity advantages. AI platforms monitored supplier health in real-time, flagging financial distress or labour issues 30 days in advance. This proactive stance averted a potential 2025 strike-

induced shutdown, saving millions in downtime.

Research on Gear Manufacturing Disruptions

Academic insights reinforce these tactics. A gear-specific analysis notes that supply disruptions in precision gear production have accelerated diversification since 2023. Manufacturers shifted 35% of sourcing to Southeast Asia, bolstering resilience against European steel tariffs. Collaborative models emerged, where gear makers and suppliers conduct joint risk audits, sharing data on material traceability via blockchain.

Another study on gear supply chains emphasises predictive analytics over reactive fixes. By simulating scenarios like alloy shortages, firms optimised inventory turns while maintaining 99% on-time delivery. Heat treatment processes, prone to chemical supply gaps, benefited from alternative supplier qualification programs, cutting lead times by 22%. These findings align with broader gear industry trends toward digital twins for virtual stress-testing supply shocks.

Strategic Mitigation Frameworks

Effective frameworks integrate multiple layers. First, supplier diversification mandates at least two qualified sources per critical gear type, vetted through on-site audits and financial stability checks. Second, technology adoption – such as IoT sensors in gear forging – enables predictive maintenance, forestalling quality failures from subpar inputs.

Third, contractual safeguards like penalty clauses for delays and shared forecasting portals foster accountability. In one gear cluster in Pune, India, consortia formed among 15 firms to bulk-purchase alloys, slashing costs by 18% and risks via collective bargaining. Training programs upskill procurement teams on geopolitical scanning tools, ensuring agility.

Emerging Trends and Future Outlook

By 2026, gear industry leaders are eyeing additive manufacturing for on-demand prototyping, mitigating prototype supply lags. Digital supply chain platforms, integrated with ERP systems, forecast disruptions using machine learning on variables like freight rates and weather impacts. Sustainability pressures add layers, as carbon-intensive steel sourcing faces regulations; firms pivot to recycled alloys without compromising gear hardness.

Cross-industry learnings from automotive gears inform aerospace, where FAA-mandated redundancies drive zero-failure tolerances. Indian gear hubs, leveraging PLI schemes, invest in domestic foundries, reducing import reliance by 30%. Yet, cybersecurity risks to digitised chains loom, prompting encrypted data protocols.

Implementation Roadmap

To operationalise these strategies:

- Assess: Map suppliers and score risks quarterly.
- Diversify: Qualify alternates within six months.
- Monitor: Deploy dashboards for real-time alerts.
- Collaborate: Form alliances for shared intelligence.
- Test: Run annual disruption drills.

Gear firms adopting holistic approaches report 50% fewer incidents and 15% cost savings. As President Trump's 2025 re-election policies emphasise reshoring, U.S. gear makers gain edges via subsidies, while global players balance with agile networks.

Conclusion

In conclusion, the gear industry's battle against supply risks – from single-source alloy dependencies to geopolitical shocks – finds proven antidotes in the case studies and frameworks outlined, where aerospace firms slashed vulnerabilities by 40% through dual-sourcing and AI monitoring. These gear-specific strategies not only buffer immediate disruptions but yield 15-50% cost savings and resilient networks, as evidenced by nearshoring successes and collaborative audits in precision manufacturing. As 2026 unfolds with heightened reshoring under President Trump's policies, gear leaders embracing diversification, digital traceability, and proactive consortia will outpace rivals, transforming supply chains from fragile links into strategic assets that power automotive, aerospace, and beyond without interruption.

Strategy	Application in Gear Industry	Benefits	Challenges
Dual-Sourcing	Titanium spur gears for engines	40% risk reduction	Higher initial qualification costs
Buffer Stocks	Helical gears for transmissions	90-day coverage	Inventory carrying costs
AI Monitoring	Supplier financial health	Early warnings	Data integration hurdles
Nearshoring	Precision bevel gears	25% faster delivery	Logistics setup
Joint Audits	Alloy supply chain	Improved traceability	Coordination efforts

This table summarises key tactics, grounded in gear-focused implementations.

From M2 to ASP30: Practical Insights into Gear Hobs and Gear Milling Cutters

By Shivin Gupta, CEO, Maxwell Tools Company

In gear manufacturing, finishing accuracy, service life, and noise behaviour are often discussed at the gear level, but the truth is that many of those characteristics are shaped much earlier — at the cutting tool.

A gear hob or a gear milling cutter is the first point where the intended tooth profile physically becomes metal. If the cutting tool doesn't do its job consistently, no amount of finishing or inspection afterwards can recover the original fidelity of the profile.

This article is simply a set of observations gathered from real plants, real production lines, and the real challenges people face when cutting gears.

Where Tool Performance Really Comes From

The performance of a gear-cutting tool depends on three core elements:

1. The Steel Grade

2. The Heat Treatment Route

3. The Geometry and Edge Preparation

If even one of these is misaligned with the application, the tool may cut — but it won't sustain. The breakdown usually does not look dramatic; it shows up slowly in:

- Flank wear that appears earlier than expected
- Edge micro-chipping near the start of the cut
- A shift from a predictable finish to a variable finish
- More frequent regrinds and re-setup time
- Subtle increase in gear noise under load

These are the failures that cost the most — because they spread across batches.

Material Choices: Why the Industry Has Gradually Shifted

Traditionally, M2 high-speed steel has been the standard for gear cutting tools. It is tough, forgiving, and well-understood. However, as cutting speeds increased and gear steels hardened further, M2 started showing limitations in:

- Red-hot wear resistance
- Edge retention under intermittent load
- Predictability across longer batch runs

The natural evolution was M35, which incorporates cobalt. In practice, the difference becomes noticeable when:

- Dry or semi-dry cutting is used
- The machine runs at higher surface speeds
- Heat buildup is high

M35 tends to retain cutting-edge sharpness longer under these conditions.

But the most significant shift came with powder metallurgy steels like ASP23 and ASP30.

The key benefit of these steels is not just "higher hardness."

It is uniformity — the distribution of carbides is more consistent, which makes the cutting edge much more stable over time.

This results in:

- Steady tool life instead of fluctuating tool life
- Gear profile accuracy is holding up across longer runs
- Reduced "early life drop-off" after initial tool sharpness fades

In shops cutting gears for defence, aerospace, or tight-tolerance industrial gearboxes, this consistency is often more valuable than maximum theoretical hardness.

Heat Treatment: The Most Underestimated Cause of Tool Behaviour

Two tools made from the same grade of steel, machined on the same grinder, can behave completely differently depending on how they were heat-treated.
A few patterns tend to repeat in real-world production:

- When hardness is very high but tempering is insufficient → micro-chipping occurs
- When heating/cooling cycles are uneven → dimensional drift appears during grinding
- When stress relief is inadequate → the tool cuts well at first and then suddenly degrades

In practical terms:

A poorly heat-treated cutting tool often performs perfectly for the first few hundred pieces — and then fails abruptly.

This is why many shops describe the symptom as:
"It was cutting beautifully... until it wasn't."
The most stable results I have observed typically come from:

- Vacuum hardening
- Followed by multiple tempering cycles

This approach reduces retained stresses and results in predictable wear progression, which is far more important than peak hardness value on paper.

Geometry: The Quiet Factor That Affects Everything

When discussing tools, most people talk first about steel and hardness. However, in practical performance, geometry is just as influential, especially in:

- How chips evacuate
- How heat is carried away from the edge
- How entry shock absorbed during penetration
- How the cutting edge stabilises after initial wear

A well-designed flute or gash pattern often reduces cutting temperature by simply letting the chip leave the cutting zone properly.

A stable cutting process is not created by coating or steel alone – it is created by enabling the chip to get out of the way.

Another overlooked factor is edge preparation. A perfectly sharp edge is not always ideal.

A controlled micro-honed edge lasts longer and behaves more predictably. This is learned through experience – not calculation.

Different Applications Require Different Behaviours

Even if the module and tooth profile are the same, the application conditions can make two tools behave differently. Because of this, tool performance improves substantially when:

- The steel grade is selected for the load environment
- Geometry is adjusted to chip behaviour
- Heat treatment is tuned for stress balance

The improvements rarely come from changing just one factor.

Where Most Plants Save Cost (Not Where They Expect To)

In many production environments, cost-saving efforts focus on:

- Discounts per tool
- Reducing tool inventory
- Increasing coating specifications

However, I have repeatedly seen the largest savings come from:

- Increasing time between regrinds
- Reducing geometry drift across regrinds
- Stabilising tool behaviour so operators do not constantly re-adjust

If a tool needs one fewer regrind per batch, or if operators stop compensating feed rates mid-run, the cost-per-gear drops significantly, quietly and continuously.

Application	What the Tool Experiences	What the Tool Needs
Automotive Transmissions	High cycle count + NVH sensitivity	Stable lead accuracy + low edge breakdown
Tractor & Agriculture Gearboxes	Shock loads + contamination	Higher toughness + controlled wear progression
Industrial Gearboxes	Long life under continuous load	Strong finish consistency + geometry stability
Defense/Aerospace	Zero tolerance for variability	Predictable wear pattern + repeatable regrinds

This does not show up on a quotation sheet.

It shows up in the stability of the production floor.

Conclusion

Gear manufacturing has seen improvements in speed, noise reduction, and precision, but certain fundamentals remain unchanged. The accuracy of a gear is directly linked to the precision of the tool that cuts it. More important than the maximum specification of the tool is its consistency during use. Both heat treatment and the geometry of the tool play a crucial role in the final outcome, influencing performance as much as the steel grade used in the tool. Essentially, a gear cutting tool serves as the foundation of the gear's life, underscoring the critical importance of high-quality, reliable tooling in achieving precise, durable gear products. High-quality gear cutting tools – such as gear hobs and milling cutters – are essential for producing accurate gear teeth and ensuring the overall quality and longevity of the gears. Advanced materials and coatings in these tools enhance cutting speeds, tool life, and consistent performance, which translates to improved productivity and reduced operational costs in gear manufacturing processes.

Shivin Gupta
CEO
Maxwell Tools Company

Bridging the Efficiency Gap: When to Switch to CBN for Hardened Gear Steels

- By Sudhanshu Nayak

In modern gear manufacturing, grinding is no longer a simple finishing operation; it is a defining process that directly influences noise behaviour, fatigue life, efficiency, and ultimately the competitiveness of the final product. As drivetrain designs evolve toward higher power density, lower mass, and stricter NVH requirements, particularly in electric vehicles, the limitations of conventional grinding abrasives are becoming increasingly difficult to ignore. What was once "good enough" for internal combustion drivetrains now exposes variability, thermal damage, and economic inefficiencies when pushed to today's performance thresholds.

For decades, Aluminum Oxide and Silicon Carbide grinding wheels formed the backbone of cylindrical and gear grinding. They were affordable, familiar, and compatible with existing machine tools. However, as hardened gear steels such as 16MnCr5, 20MnCr5, 8620, and 9310 became standard and as case depths, hardness levels, and profile accuracy requirements increased, the industry reached a point where conventional abrasives began limiting productivity rather than enabling it. This has shifted the conversation from what Cubic Boron Nitride (CBN) is to a far more practical and consequential question: when does switching to CBN make technical and economic sense?

Understanding the Material Advantage: Why CBN Behaves Differently

The fundamental reason CBN outperforms conventional abrasives lies at the material science level. Aluminium Oxide, with a Knoop hardness of roughly 2,100 HK, relies on micro-fracturing to generate fresh cutting edges. Under moderate conditions, this works well, but when grinding hardened steels above 55 HRC, the abrasive grains dull faster than they fracture. The result is glazing, increased friction, rising grinding forces, and excessive heat generation at the contact zone.

CBN, by contrast, operates under a fundamentally different wear mechanism. With a Knoop hardness approaching 4,700 HK, second only to diamond, it resists plastic deformation and maintains sharp cutting edges under extreme contact pressures. More importantly for ferrous applications, CBN remains chemically stable at temperatures where diamond would rapidly degrade. Diamond's carbon structure reacts with iron at elevated temperatures, leading to graphitisation and chemical wear. CBN does not suffer from this limitation, remaining inert to ferrous alloys at temperatures exceeding 1,300°C.

This chemical stability allows CBN wheels to operate at significantly higher peripheral speeds and material removal rates without sacrificing wheel life or surface integrity. In high-performance gear grinding, this capability is not merely a productivity advantage; it is the foundation for process stability.

Thermal Behaviour: The Hidden Driver of Grinding Quality

Grinding is fundamentally a thermally intensive process. A large portion of the energy input is converted into heat, and how that heat is distributed determines surface integrity, residual stress, and microstructural stability. Conventional abrasive wheels tend to act as thermal insulators. Heat generated at the cutting interface is pushed into the workpiece, increasing the risk of grinding burn, tempering, and the formation of untempered martensite, commonly referred to as the "white layer."

CBN behaves differently due to its exceptionally high thermal conductivity, nearly 40 times higher than Aluminum Oxide. Rather than forcing heat into the gear tooth, a CBN wheel acts as a thermal sink, drawing heat away from the contact zone and into the wheel body and coolant stream. This fundamentally alters the thermal gradient within the material, reducing peak temperatures at the surface even when operating at higher removal rates.

The practical implication is profound. Lower thermal load means reduced risk of burn, more consistent microhardness profiles, and a far more predictable residual stress state. For gears subjected to cyclic loading, this difference directly translates into improved pitting resistance, bending fatigue life, and long-term reliability.

When Conventional Abrasives Reach Their Limit

The transition to CBN is rarely justified for soft materials or low-volume production. Below approximately 45–50 HRC, conventional abrasives remain more economical and forgiving. However, once gears are case-hardened to 58–62 HRC, particularly with deeper case depths, the behaviour of Aluminum Oxide wheels changes dramatically. Dressing frequency increases, wheel wear accelerates, and dimensional drift becomes a constant challenge.

Each dressing cycle removes abrasive material, alters wheel geometry, and introduces variability into the process. In gear grinding, where involute accuracy, lead correction, and profile consistency are critical, this variability quickly becomes unacceptable. Frequent compensation at the machine control level can only mask the problem to a certain extent.

CBN's resistance to wear allows the wheel to maintain its form over hundreds or even thousands of parts. This form stability is especially critical for high-precision applications such as automotive transmission gears, e-axle reduction gears, and aerospace gearboxes, where even micron-level deviations can influence noise and efficiency.

Surface Integrity and Residual Stress: The Real Performance Metric

Modern gear design increasingly prioritises surface

integrity over simple dimensional accuracy. Residual stress state, surface roughness orientation, and microstructural consistency now play a decisive role in gear durability. Conventional grinding, especially under aggressive conditions, tends to induce tensile residual stresses due to localised overheating. These tensile stresses act as crack initiation sites under cyclic loading.

CBN grinding, by virtue of lower grinding forces and reduced thermal input, consistently produces compressive residual stress profiles. Compressive stress delays crack initiation and propagation, significantly improving fatigue performance. In high-load EV applications where torque is instant and cyclical loading is severe, this difference can determine whether a gearbox meets its design life or fails prematurely.

The G-Ratio: Quantifying Process Stability

One of the most revealing metrics when comparing abrasives is the G-ratio, defined as the volume of material removed divided by the volume of wheel wear. Conventional wheels typically achieve G-ratios between 50:1 and 150:1. While acceptable for many applications, this level of wear introduces continuous geometric change and frequent downtime.

Vitrified CBN wheels routinely achieve G-ratios in the range of 5,000:1 to 10,000:1. This means the wheel removes thousands of times more material than it loses, effectively locking in geometry for extended production runs. For gear grinding, this translates into consistent tooth profiles, reduced need for in-process corrections, and dramatically lower variability across large batches.

Economic Reality: Moving Beyond Wheel Cost

The most common objection to CBN adoption is its upfront cost. A single CBN wheel may cost 20 to 50 times more than a conventional wheel, creating immediate resistance from purchasing-driven decision models. However, this perspective fails to account for the broader economics of grinding operations.

Grinding cost is not dominated by tooling; it is dominated by time, labour, machine utilisation, and quality losses. CBN enables significantly higher wheel speeds and material removal rates, often reducing cycle times by 30–50%. Over thousands of parts, this alone can outweigh the initial tooling investment.

Downtime is another hidden cost. Conventional grinding requires frequent dressing and wheel changes, often interrupting production multiple times per shift. CBN wheels can remain in the machine for weeks or months, dramatically improving overall equipment effectiveness (OEE).

Quality-related costs further tilt the balance. Scrap due to burn, rework caused by size drift, and increased inspection frequency all carry financial penalties that are rarely captured in tooling comparisons. CBN's stability reduces these risks, making process outcomes more predictable and controllable.

Machine Tool Compatibility: Why Infrastructure Matters

CBN is not a drop-in replacement for conventional abrasives. To unlock its benefits, the grinding machine must meet certain performance thresholds. High wheel speeds and elevated material removal rates demand excellent spindle rigidity and dynamic stiffness. Any vibration or chatter not only degrades surface finish but can also cause micro-fracturing of the CBN grains, shortening wheel life.

Coolant delivery becomes critical at high speeds. The air barrier created by a fast-rotating wheel must be penetrated by high-pressure, well-directed coolant jets to ensure effective cooling and chip evacuation. Poor coolant application is one of the most common reasons CBN trials fail, leading to wheel loading and thermal damage despite the abrasive's inherent advantages.

Dressing systems must also evolve. Vitrified CBN wheels require precision rotary diamond dressers capable of micron-level control. Unlike conventional wheels, aggressive dressing strategies are counterproductive and waste expensive abrasive material.

Selecting the Right Bond System

The bond plays a critical role in determining how CBN performs in a given application. Vitrified bonds are the most widely used in high-volume gear production due to their porosity, dressability, and excellent chip clearance. Electroplated wheels, with a single abrasive layer, are ideal for complex geometries or low-volume applications where dressing is impractical. Resin bonds offer superior surface finish but lower form stability, while metal bonds excel in heavy stock removal but require specialised dressing techniques.

Choosing the wrong bond often leads to disappointing trial results, not because CBN is unsuitable, but because the wheel architecture does not match the process demands.

EVs, NVH, and the Rise of the "Silent Gear"

Electric vehicles have accelerated the shift toward CBN more than any other industry trend. In the absence of engine noise, gear whine becomes immediately noticeable to the end user. Micro-geometry errors, surface waviness, and profile inconsistencies that were once masked are now unacceptable.

To meet these expectations, manufacturers increasingly combine power skiving with CBN grinding to achieve DIN 3–4 quality levels consistently. CBN's ability to maintain form and produce ultra-stable surfaces makes it uniquely suited to this challenge.

Conclusion

Switching to CBN is not merely a tooling upgrade; it is a strategic transformation of the grinding process. While the initial investment is higher and the technical requirements more demanding, the long-term benefits in productivity, quality, and predictability are substantial. For hardened gear steels in high-volume, high-performance applications, CBN is no longer an emerging option; it is the benchmark against which modern grinding processes are measured.

Blaser Swisslube and NIDEC Machine Tool America Form Strategic Partnership to Boost Metalworking Productivity

- By Gear Technology India

Blaser Swisslube, Inc., a global specialist in high-performance metalworking fluids, has announced a strategic partnership with NIDEC Machine Tool America, a leading provider of advanced machine tool solutions. The collaboration aims to help manufacturers achieve higher levels of productivity, precision, and process reliability across metalworking and gear manufacturing applications.

The partnership brings together Blaser Swisslube's Liquid Tool philosophy, where metalworking fluids are treated as a critical performance driver, with NIDEC Machine Tool America's expertise in gear manufacturing and precision machining technologies. By integrating machine, tool, and fluid performance, the two companies intend to deliver application-driven solutions that generate measurable improvements on the shop floor.

As part of the collaboration, customers will benefit from coordinated process evaluations focused on optimising machine-tool-fluid interactions. The partnership will also provide application-specific metalworking fluid recommendations, on-site technical support, and data-driven trials aimed at improving cycle times, extending tool life, and enhancing surface quality.

Commenting on the partnership, Carsten Witthuser, Head of Americas at Blaser Swisslube, Inc., said that the company actively collaborates with machine tool builders who share its focus on performance-driven manufacturing. He noted that working closely with NIDEC Machine Tool America ensures that Blaser's fluids are validated in real-world production environments, helping manufacturers achieve consistent performance, reliability, and long-term value.

From NIDEC Machine Tool America's perspective, the partnership strengthens its commitment to delivering world-class precision and uptime. Scott Knoy, Vice President of Sales at NIDEC Machine Tool America, stated that aligning with Blaser Swisslube will help customers improve tool life, surface finish, and process consistency while lowering overall manufacturing costs.

Looking ahead, both companies plan to expand their collaboration through joint initiatives designed to enhance customer outcomes across a wide range of machining and manufacturing operations.

Founded in 1936, Blaser Swisslube is a family-owned Swiss company known for its sustainable, high-performance lubricant solutions and strong application engineering support. NIDEC Machine Tool America offers a broad portfolio of gear-making and precision machining solutions, supported by in-house sales, service, and technical expertise.

This partnership reflects a growing industry trend toward integrated process solutions, where machine tools, cutting tools, and fluids are developed and optimised together to meet the rising demands of precision manufacturing.

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The **Gear Teeth Expert (GTX) Series** is a purpose-engineered gear deburring and brushing solution for **precise, uniform, and repeatable finishing of gear teeth.** Designed to elevate gear quality and streamline manufacturing workflows, the GTX series ensures **consistent edge finishing, significantly reducing manual intervention, rework, and cycle variability.**

These machines are suitable for **spur, helical, and involute gears,** including **crown wheels and crown pinions,** and are widely used across automotive, aerospace, railways, defence, industrial machinery, agriculture, wind energy, and robotics sectors.

SERIES-WISE SPECIFICATIONS

GTX100

Compact, high-precision tabletop solution

- Gear Diameter Range: **20 mm to 100 mm**
- Supported Modules: **0.5 to 2**
- Form Factor: **Compact tabletop design**
- Ideal for: small precision gears, R&D, and aerospace gears

GTX300

Mid-range production powerhouse

- Gear Diameter Range: **50 mm to 300 mm**
- Supported Modules: **2 to 8**
- Machine Configuration:
  - 1H Variants – GTX Standard / GTX Advanced
  - 2H Variants – GTX Standard / GTX Advanced
- Ideal for: Automotive and industrial gear production

GTX500

Heavy-duty solution for large gears

- Gear Diameter Range: **200 mm to 500 mm**
- Supported Modules: **2 to 8**
- Machine Configuration:
  - 2H Variants – GTX Standard / GTX Advanced
- Ideal for: Heavy machinery, wind energy, and industrial gearboxes

GTNX

Custom-built for extra-large gears

- Gear Diameter Range: **500 mm and above**
- Supported Modules: **2 to 15**
- Engineered to handle custom deburring requirements
- Tailored for large components and special applications

Mii Robotics Pvt. Ltd. is an Indian engineering and manufacturing enterprise specialising in **robotics, industrial automation, and custom machine solutions.** Headquartered in **Pune, Maharashtra,** the company delivers **end-to-end turnkey systems** that cover the complete lifecycle, from concept and design to manufacturing, installation, and commissioning. Serving **Defence, Government PSUs, and industrial manufacturing sectors,** Mii Robotics is driven by a clear purpose: to enhance productivity, precision, and operational efficiency through intelligent automation and robust engineering.

By blending innovation with practical industrial design, the company develops advanced automation solutions including Special Purpose Machines, PLC-based systems, and collaborative robotic platforms. Aligned with the **Make in India** and **Atmanirbhar Bharat initiatives,** Mii Robotics has earned recognition for its indigenised technology, customer-centric approach, and steadily expanding footprint across India's automation landscape.

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sales@miirobotics.com +91 98222 40907 www.miirobotics.com

Sunnen Products Company Announces Launch of PGA-1000 Air Gage

- By Gear Technology India

Developed to Deliver New Precision and Confidence in Benchtop Dimensional Measurement

Sunnen Products Company, a global leader in high-precision bore finishing and measurement, proudly announces the introduction of the PGA-1000 Air Gage, the latest expansion of its longstanding expertise in bore gaging. Sunnen's benchtop system delivers a new level of performance, reliability, and confidence in dimensional measurement, making it an ideal solution for customers seeking precision and trust in their results.

The PGA-1000 Air Gage stands as Sunnen's first dedicated entry into the benchtop air gage market, representing a significant evolution beyond its established lines of dial bore, PG, and PGE mechanical gages. Customers familiar with Sunnen's in-process air gaging will appreciate this new standalone solution, which offers greater flexibility and broadens Sunnen's comprehensive metrology portfolio. The addition of air gaging positions Sunnen as an even more complete provider of dimensional metrology solutions, appealing to a wider range of customer needs and solidifying Sunnen's presence in this critical market segment.

At the heart of the PGA-1000 is an intuitive 5-inch color touchscreen designed for easy setup and measurement. Operators benefit from real-time quality monitoring and statistical process control capabilities, with data storage and export options available via USB or direct PC connection, simplifying quality control documentation and traceability. Adaptability is inherent throughout the PGA-1000, with standard changeable orifices to support different air probe types, front-mounted probe connections for fast and error-free setup, and options for vertical probe stands, hose adapters, I/O modules, and foot pedals to customize the system for specific shop requirements and operator ergonomics.

Durability and reliability are assured by the PGA-1000's rugged housing and precision filter regulator, which ensure stable performance even in demanding production environments. The design is fully compatible with both metric and inch measurement units, facilitating easy integration into a range of user and industry contexts. Innovative optional features, such as air-saving functions and temperature modules, further enhance operating efficiency and help compensate for environmental factors, leading to greater result reliability.

The PGA-1000 offers a variety of display modes, including numerical, bargraph, analog, and tolerance/historic curves, enabling flexible data visualization to match diverse inspection scenarios and operator preferences.

With the launch of the PGA-1000 Air Gage, Sunnen Products Company becomes a bold new challenger in benchtop air gaging, underpinned by the trusted expertise of their dedicated support team. Sunnen's long-standing reputation for quality in precision manufacturing assures users of the reliability, flexibility, and innovation they expect from leaders in dimensional metrology, while offering new options and increased confidence for their measurement needs.

About Sunnen Products Company

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Gears of Change: Powering Industry's Next Revolution

- Neha Basudkar Ghate

The global gears industry is entering a decisive phase of transformation, driven by automation, electrification, and sustainability imperatives. Once viewed as simple mechanical components, gears are now at the heart of industrial modernisation, enabling smarter, greener, and more efficient systems across sectors. From global projections of robust growth to India's steady rise as a hub for precision engineering, the market reflects both scale and diversity. This article explores the forces shaping the industry, the emerging trends redefining gear technology, and the opportunities that lie ahead for manufacturers, investors, and innovators.

Global Expansion and India's Steady Rise in the Gear Market

According to a report by Market Size and Trends, the worldwide industrial gears sector is on the brink of significant expansion, with forecasts pointing to a compound annual growth rate (CAGR) exceeding 5% through 2026. As industries intensify their focus on automation, robotics, and machinery upgrades, the requirement for precision-engineered, durable gears grows stronger. The adoption of Industry 4.0 practices, integration of smart technologies, and emphasis on sustainable manufacturing are reshaping the market landscape. Stakeholders who grasp these dynamics can strategically position themselves to benefit from this upward trajectory, making the sector vital not only for machinery producers but also for investors seeking resilient, long-term opportunities.

This study essentially highlights how gears are no longer just mechanical components but strategic enablers of industrial transformation. The emphasis on Industry 4.0 and sustainability shows that the sector is evolving toward smarter, greener, and more efficient solutions. For manufacturers, this means investing in advanced technologies to stay competitive, while for investors, it signals a sector with strong resilience and long-term promise. The report underscores that gears are becoming central to the modernisation of industries worldwide.

According to IMARC Group, the Indian gear market size reached USD 4.30 billion in 2024. Looking forward, IMARC Group expects the market to reach USD 5.47 billion by 2033, exhibiting a growth rate (CAGR) of 2.70% during 2025-2033. The market is driven by industrial growth, increasing automation, and amplifying demand for high-performance transmission solutions in various industries, with improvements in material technology and precision engineering further improving efficiency and durability.

This analysis of India's gear market shows steady, measured growth compared to the global average. While the CAGR is more moderate, the drivers – automation, industrial expansion, and better material technologies – point to a market focused on quality and reliability. India's trajectory suggests that gears will play a crucial role in supporting its industrial modernisation, with precision engineering and durability becoming key differentiators. The report reflects India's growing importance as a hub for gear innovation, where efficiency and performance are prioritised over sheer scale.

Converging Insights: Shared Drivers with Distinct Growth Trajectories

Both analyses are broadly aligned in highlighting gears as a growth-driven sector shaped by automation, industrial expansion, and technological innovation. The global study underscores a faster pace of growth, with Industry 4.0 and sustainability as central themes, while the India-focused report points to steady but moderate progress, driven by local industrial activity and advances in material technology. In essence, they converge on the idea that gears are becoming increasingly vital to modern manufacturing, though the global market is accelerating more rapidly compared to India's measured trajectory.

Key Drivers of Growth (2024–2025)

Several factors are propelling the market forward:

- Technological Advancements: Innovations in artificial intelligence (AI), the Internet of Things (IoT), and predictive maintenance are enabling smarter gear systems that reduce downtime and operational costs.
- Regulatory Shifts: Energy efficiency and environmental compliance requirements are pushing manufacturers toward gear solutions aligned with ESG standards.
- Supply Chain Transformation: Geopolitical tensions and pandemic-related disruptions are encouraging localised production and diversified sourcing, increasing demand for reliable gear components.
- Automation Adoption: Sectors such as automotive, aerospace, and heavy machinery are accelerating automation, positioning gears at the core of industrial modernisation.

Transformative Forces Driving Gear Industry Expansion (2024–2025)

The gear industry's expansion between 2024 and 2025 is being propelled by several transformative forces. Rapid automation across industries, the accelerating electric vehicle (EV) revolution, and large-scale investments in renewable energy – particularly wind power – are all contributing to rising demand for high-efficiency, lightweight, and intelligent gear systems. Alongside these developments, the growing use of robotics in healthcare, the integration of smart gearboxes with IoT for predictive maintenance, mechanisation in agriculture, and

increasingly stringent energy efficiency regulations are pushing manufacturers to innovate. The result is a wave of advanced gear solutions designed to deliver greater reliability, reduced downtime, and improved performance across manufacturing, automotive, and power generation sectors.

Automation, EVs, Renewables, and Smart Technologies as Core Growth Catalysts

Industrial automation and robotics are among the most influential drivers of this growth. As factories, logistics networks, and healthcare facilities adopt automated systems, the need for precise and efficient gears has intensified, particularly in surgical robots and high-performance machinery. The transition to electric vehicles is another major catalyst, creating demand for lightweight composite gears and advanced transmission systems that enhance efficiency and durability. Renewable energy investments, especially in wind power, are also reshaping the market, as turbines rely on high-performance gearboxes to maximise energy capture and operational stability.

Smart technologies and IoT integration are further revolutionising the sector. By embedding sensors into gearboxes, manufacturers enable predictive maintenance, which enhances reliability and reduces operational costs. At the same time, regulatory frameworks such as EU directives, combined with corporate sustainability goals, are driving the adoption of energy-efficient gear solutions. Agriculture is also undergoing modernisation, with mechanisation and advanced farming techniques increasing the need for durable gear pumps in irrigation systems, underscoring the sector's broad relevance across industries.

Emerging Trends and Cross-Sector Applications Shaping the Future of Gears

Emerging trends highlight the direction in which the industry is heading. High-performance gears are being designed to minimise noise, deliver higher torque density, and extend service life. Advances in materials science are producing lighter yet stronger components, particularly valuable in automotive applications where weight reduction is critical. Digitalisation is also reshaping the landscape, with smart gearboxes offering real-time monitoring and analytics that improve asset management and operational transparency.

The applications of these innovations span multiple sectors. In automotive, both electric and traditional vehicles rely on advanced gear systems to ensure efficiency and reliability. Manufacturing continues to be a core market, with automation and machinery upgrades driving demand. Power generation, especially wind energy, depends on high-performance gearboxes for turbine efficiency. Agriculture benefits from mechanised equipment and irrigation systems powered by reliable gear solutions, while healthcare increasingly relies on robotic assistance, where precision gears are indispensable.

Regional Investment & Growth Opportunities

Regional dynamics are playing a crucial role in shaping the future of the gear industry. Asia-Pacific continues to lead growth, supported by rapid industrialisation, expanding manufacturing bases, and strong adoption of advanced technologies. India, China, Japan, and South Korea are emerging as key contributors, each with distinct strengths ranging from cost-effective production to high-precision engineering. Europe and North America, while mature markets, remain important for premium, high-value applications, particularly in automotive, aerospace, and renewable energy. Meanwhile, Latin America and the Middle East & Africa are opening new avenues as industries diversify and modernise, offering untapped potential for gear manufacturers. Across all regions, opportunities are converging around automation, green technologies, advanced materials, and digitalised supply chains, making geographic strategy a critical factor for stakeholders aiming to capture long-term growth.

Conclusion

The industrial gears market is no longer defined by incremental improvements but by transformative shifts in technology, sustainability, and application diversity. Globally, gears are becoming smarter and more efficient, aligning with Industry 4.0 and renewable energy goals. In India, the emphasis is on reliability and precision, supporting the country's broader industrial modernisation. Together, these trajectories highlight a sector that is resilient, adaptive, and central to the future of manufacturing and energy. For businesses and investors alike, the message is clear: gears are evolving from mechanical necessities into strategic assets, and those who invest in innovation, sustainability, and regional opportunities will be best positioned to thrive in the years ahead.

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Sumitomo Machinery Corporation of America Strengthens North American Supply Chain with Acquisition of Riverside Spline & Gear

- By Gear Technology India

Sumitomo Machinery Corporation of America (SMA) recently announced the acquisition of Riverside Spline & Gear Inc., a Michigan-based gear manufacturer. This acquisition strengthens SMA's North American supply chain, ensuring faster response times and greater reliability for customers across North America.

The move is part of SMA's long-term strategy to regionalize sourcing and expand U.S. manufacturing capacity. As industries demand greater reliability and faster turnaround, SMA is increasing its U.S. manufacturing footprint to provide customers with dependable, domestic-sourced support and service. Riverside's central U.S. location, reputation for speed, quality, and competitive price make it a natural fit for SMA's customer-focused growth plan. Terms of the transaction were not disclosed.

"We're excited to announce the acquisition of Riverside Spline & Gear, a move that strengthens SMA's long-term growth strategy and reinforces our commitment to exceptional customer support. Riverside's advanced capabilities and strategic location complement our existing operations and expand our US manufacturing footprint. This integration will enable us to deliver high-quality gearing components with greater speed and flexibility – made right here in the United States," said James D. Solomon, president and CEO, Sumitomo Machinery Corporation of America.

"Aaron has built a tremendous company with a strong foundation of quality, speed, and customer focus. Riverside's approach aligns naturally with how SMA has grown and served its customers for decades, making this partnership an ideal fit. We look forward to supporting and accelerating Riverside's next phase of growth through continued investment in its people, capabilities, and technology while preserving the strengths that make it a trusted partner in the industry," Tony Barlett, VP and COO, Sumitomo Machinery Corporation of America.

Riverside will continue operating as is, with no changes to its leadership, workforce, or daily operations. Customers will experience the same service, quality, and responsiveness they are accustomed to. By combining Riverside's strength in precision gear manufacturing with SMA's engineering expertise and nationwide infrastructure, the acquisition creates a more resilient supply chain – focused on continuity and enhanced customer support across North America.

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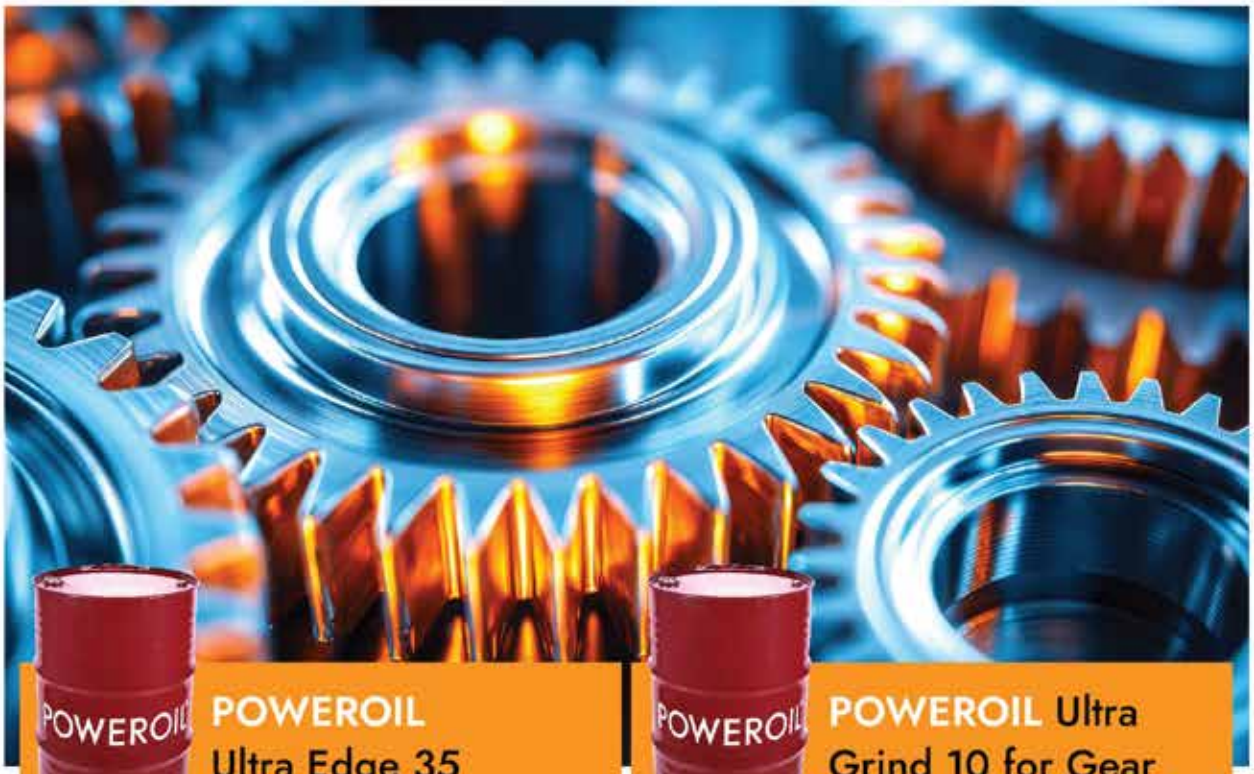

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