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Anitha Raghunath
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Dear Readers'

As the year comes to a close, the gear manufacturing industry in 2023 saw one of the world's premier trade fairs for the metalworking sector, focusing on machine tools and production systems for cutting and forming metals - i.e EMO Hannover. The event, as we know, is an apt platform for manufacturers, suppliers, and professionals to showcase their products, innovations, and technologies. Our representative, Nishant Kashyap, was at the front and centre at the expo, and detailed the ongoings of the event.

In this issue, we focussed on cutting tools and custom gear manufacturing, which plays one of the many vital roles in gear manufacturing.

A host of informative and engaging technical articles such as Grinding with Galvanically Bonded CBN Tools, The Role of Virtual Prototyping in Gear System Design and Manufacturing for E-Mobility, The Power and Potential of Digital Twin Technology, R 300: Are you still hearing it, or are you measuring it? and Some Mathematical Models in Gear Windage Loss Evaluation: An Application to High Power Gears to name a few await you. We also interviewed some of the leading players in the industry like Abishek Ramesh who spoke of his Make In India gear hobbing machine, and RDMC's Tarun Nahata on custom gear manufacturing, and more.

Gear Technology India's ongoing knowledge sessions through our webinars have been met with resounding success, and we thank the attendees who were a part of these interactive Q&A sessions. Our next edition will feature the IPTEX-GRINDEX exhibition that will be held in Pune. During the 8th and 6th edition of IPTEX-GRINDEX three-day expo, we are proud to announce its first-of-its-kind gear industry business excellence and achievement award show for gear manufacturers on Feb 23, 2024. If you haven't nominated yourselves, we invite you to do so. Nominations close on Jan 15, 2024. Click here to register and nominate your organization here: https://awardsgeartechnologyindia.com/

As always, our steadfast commitment to building a community continues, and we encourage you to join us on our journey.

We also invite you to share your expertise and knowledge with us, and gain from this growing oppurtunity of this niche industry.

Happy reading!

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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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Contents

Some Mathematical Models in Gear Windage Loss Evaluation: An Application to High Power Gears

By: KP Soundarajan

Introduction:

In high-speed gearing, one of the known independent power losses is windage. This is an important area of losses although gearing efficiencies reach 99% in a well-designed gearbox. Windage is rather complicated and less understood fully due to 1) aerodynamic drag forces 2) function of the variety of parameters like shape, size, rotary speed, lubricating oil density, viscosity, 3) operating conditions in rotational resistances, and local heating, and 4) multi-face fluid flows.

Gears connected to gas turbine engines, reduction ratios as well as fluid mixture behavior can offer complex situations to measure and correct optimally.

In dealing with calculations involved in estimations of windage, the gear dimensions, weight, speed, shape and many gearing related geometry as well as simplicity of understanding the flow around a rotating body helps to derive a frictional moment M in a laminar flow which can be expressed as:

$$2M = 0.616\pi\rho R^4(\nu\omega^3)^{1/2}$$

Fig 1

based on Schlichtang's functional resistance of an ideal disk considered in place of a gear.

When the laminar flow gets into the turbulent flow the same 2M [[Image Pg 14 of Computational Investigation of Gear Windage equation 1.6] as the viscous torque where:

$$2M = 0.073\pi\omega^2 R^5(\nu/\omega\ R^2)^{1/5}$$

Fig 2

ρ is the density, R is the radius, V is the Kinematic Viscosity, ω (omega) is the angular viscosity.

These provide a simplest solution only; the effect of the rotating part becoming a gear – its shape, the orientation of diameter/face width, helix angle, and the number of teeth add to the complex solutions.

Physics

The flow physics inside a gearbox are quite complex. Gears are not designed to be aerodynamically efficient. The shape and profile of the gear teeth has an important function in transferring power between gears.

Variations in angular velocity of the driven gear will lead to vibrations in the train and will generally cause fatigue cracks to form in the teeth resulting in early failure of the gear.

The teeth are located at the periphery of the gears where speeds are greatest (speed = ω x r). It is very possible that depending on the rotation rate and size of the gear, the gear tip speeds can enter the range of compressible flow.

Compressible flow effects typically become noticeable above Mach number of 0.3.

However, sonic speed is effective by both the temperature and the composition of (air-only versus air-oil) of the fluid environment.

In 2005, Brennen showed the solid velocity of a homogeneous mixture (air and only) can be much smaller than that of either of its constituents, meaning that compressibility affects could be a concern at lower speeds than an air-only analysis might indicate.

Various Windage Loss Models

We see a few of those areas where research in this field has contributed to a better level of understanding.

Anderson & Lowenthal who researched in turbine class and aerospace applications – considering fluid flow around the gears determine the windage loss:

$$P = C_1 \left(1 + 2.3\frac{t}{R}\right) \rho^{0.8} n^{2.8} R^{4.6} \mu^{0.2}$$

Fig 3

Where C1 is a constant; t is the face width of the gear; R is the pitch radius; n is the speed, ρ and μ are respectively the density and viscosity (centipoise) of the fluid medium surrounding the running gears.

They accounted air and oil to a ratio of 34.25 to one part of oil combination of the lubricating oil to correct the density/viscosity and change their formula to:

$$P_W = C_2 \left(1 + 2.3\frac{t}{R}\right) n^{2.8} R^{4.6} \left(0.028\mu + C_3\right)^{0.2}$$

Fig 4

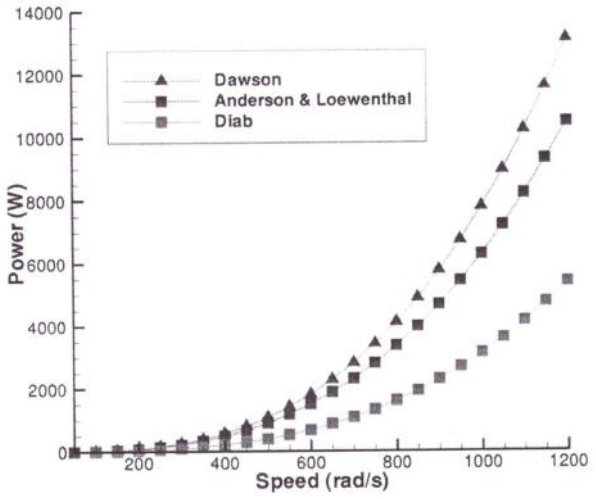


Fig 5: Gear windage loss estimates for a 13-inch pitch diameter spur sear

But even here they did not consider helix angle and module as factors since they use spur gears only usually in cylindrical reduction in helicopter gears.

Dawson developed his own method – well known in windage loss estimates, and often applied by gear design softwares as a function of speed, root diameter D, face width F, module M and without helix applied as:

$$P = N^{2.9}(0.16D^{3.9} + D^{2.9}F^{0.75}M^{1.15}) \times 10^{-20}\Phi\lambda$$

Fig 6

Where C represents the shape of the gear, just as an example, as a large diameter, longer face width, and smaller module, more number of teeth scenario.

Such gears are common in high-speed turbine gear where the windage loss is very critical for accounting the power loss. There is a point mentioned here that even in estimating power loss factors - one of the methods identified as Niemann's method reference of factor K on the line of action as a location from the pitch point is found well-placed in Niemman's method.

For such type of FRICTION LOSS APPLICATIONS in high speed Gear , my understanding is KISSsoft software must be referring to this method.

Well known Diab method estimates even more closely using a factor CT in evaluating windage loss in watts.

$$P = \frac{1}{2} C_t \rho \omega^3 R^5$$

Fig 7

Where he finds Ct as a function of:

$$C_t = \alpha \mathrm{Re}^{\beta} \left(\frac{b}{R}\right)^{\gamma} Z^{\delta} \left\{\left(\frac{h_1}{R}\right)^{\psi} + \left(\frac{h_2}{R}\right)^{\psi}\right\}$$

Fig 8

R,Z,and B are pitch radius, number of teeth, face width respectively and α, β, γ, δ and Ψ are constant coefficients derived by experimentation with chosen fluid medium, and Re being the Reynold's number, h1 and h2 represent a condition whether any flange is present near the teeth.

When no obstacle to the flow of the medium, h1; h2 = 0.5 ^1/ Ψ R. Another detail is a method that uses a split in Ct to fix Cb and Cl.

This explains the physics behind the contribution of face width, and gear tooth module divided into height-wise X profile shift coefficient and along the involute the pressure angle set at pitch point under the tip of the pinion/gear in conjunction with fluid flow under laminal flows.

The subdivisions mentioned here is a critical Reynold's number Re* the form of which can be used a limiting value of 3x10^5 as a reference.

This is to identify the change from laminal flow to turbulent flow.

$$C_f = \frac{2n_1\pi}{5 - 2m_1} \frac{1}{\mathrm{Re}^{*m_1}} \left(\frac{R^*}{R}\right)^5 + \frac{2n_2\pi}{5 - 2m_2} \left[\frac{1}{\mathrm{Re}^{m_2}} - \frac{1}{\mathrm{Re}^{*m_2}} \left(\frac{R^*}{R}\right)^5\right]$$

Fig 9

$$C_l \cong \xi \frac{Z}{4}\left(\frac{b}{R}\right)\left[1+\frac{2(1+X_A)}{Z}\right]^4 (1-cos\phi)(1+cos\phi)^3$$

Fig 10

$$\phi = \pi/Z - 2(\mathrm{inv}(\alpha_P) - \mathrm{inv}(\alpha_A))$$

Fig 11

Where R* is the critical radius of pinion or gear that separates the laminar and turbulent regions. The tooth contribution coefficient is described in fig 10.

$$R^* = \sqrt{\mu \mathrm{Re}^*/\rho\omega}$$

Fig 12

Hence, knowing this value the step to find Cl is shown above.

X is the profile shift coefficient and ϕ is a parameter representing the arc of involute from the pitch diameter to the tip diameter using the pressure angle.

The analysis considers that the fluid is expelled from the active tooth zone and pressure is uniform. (When pressure is changing with the temperature of the fluid, the flow gets into a more complicated zone, and the study goes more towards the effects of any heat transfer and geometry correction on tooth lead).

This change in pressure and temperature under fluid velocity in the teeth gap in the mesh zone and at ends after release from control volume shares the heat generated into the tooth flanks causing a change in temperature to modify the tooth correction.

That may involve Eckert and Prandtl non-dimensional numbers in use to solve partial non- linear differential equations/ Napier Stokes to infer the correction. That bifurcates the method in the route of lead correction topologically.

Compressible Fluid Flow

In multi-phase or in gears under an environment of oil/air - other than simple homogeneous difference.

Yet in the Eulerian approach each phase is treated as a continuum but different velocity/temperature when issuing out of control volume in a mesh environment.

Here the treatment includes mass transfer rate, drag force, non-drag force as one has to encounter different volume fraction, velocity/viscosity.

It can be seen to an extent solid particles/air in place of liquid/air in an explanatory discussion on fine particles/air flow in jet turbine engines for analysis of compressor blade tips getting impact by this very fine particle in aero-engine performance by Professor Tabakoff of the University of Texas using r, θ as polar co-ordinates.

It is a different topic of investigation of impact of solid particles on the tip of the rotor blades inside the turbine engine.

Conclusion

The physical mechanisms contributing to windage loss is the pressure field associated with the diversion and impingement of high-speed fluid flow of the leading tooth surface.

In high-speed gearing applications lubricant is applied to the gears by an oil jet system.

As oil jet is sprayed, it builds up then film thickness on the teeth, which is to machine friction.

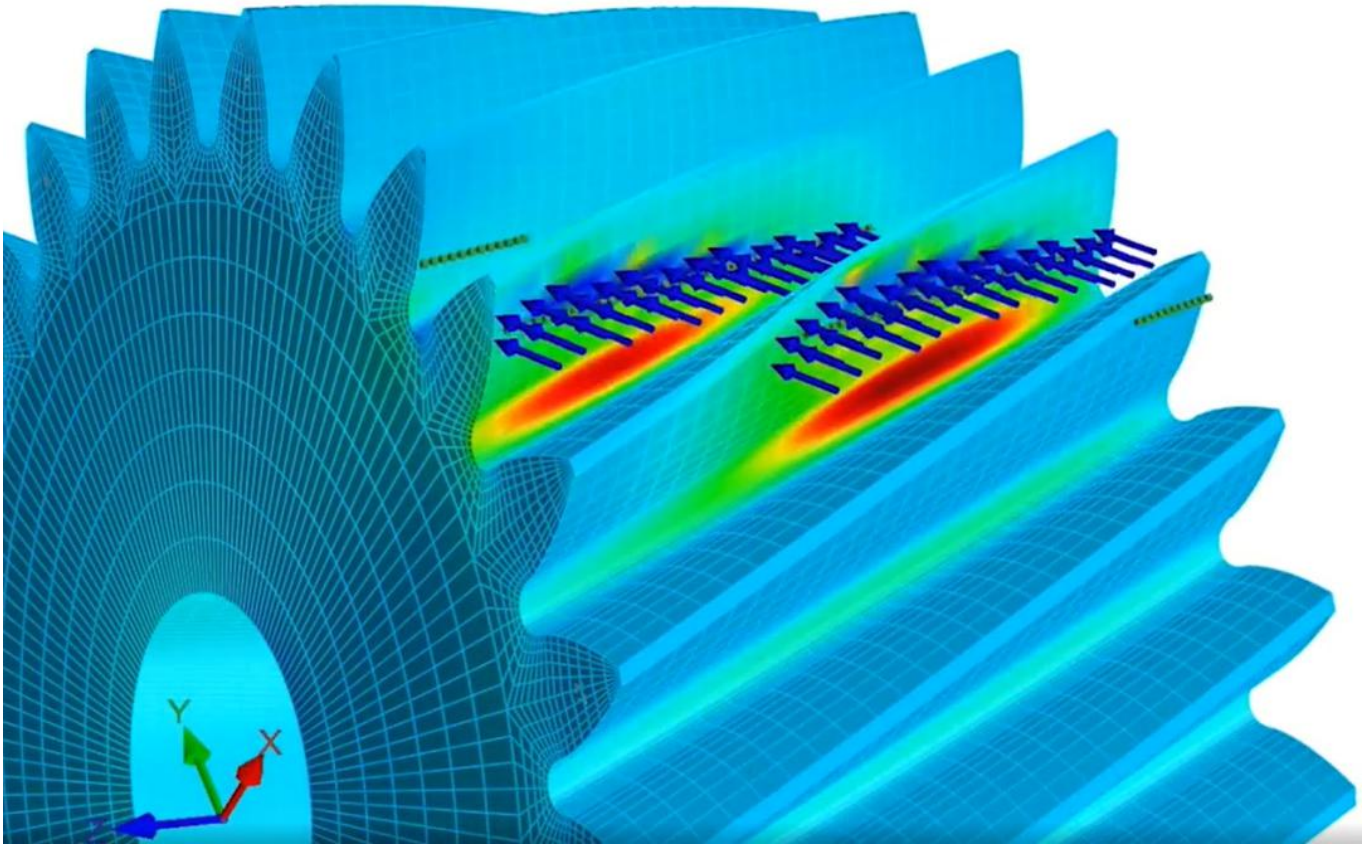
Immediately after meshing the gear teeth that are sprayed again enable dissipate the heat (at least partially) generated during meshing.

The process of windage loss evaluation was worked by many researchers and some of the well known models have been shown.

Reference:

A Computational Investigation of Gear Windage- Matthew J.Hill and Robert F. Kunz of Pennsylvania State University, Philadelphia,/Dec 2012

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



The Role of Virtual Prototyping in Gear System Design and Manufacturing for E-Mobility

By: Aaron Fagan

Apart from what Hollywood's sound engineers have done to bring the vehicles of science fiction to life in film, there isn't a common precedent of what an EV should sound like to us.

There are many roads that can be taken toward that end, which could involve altering the real sounds of an EV into something as familiar as an ICE (not unlike the principle of ICE vehicles equipped with a sound symposer to make them sound even more like an ICE) or something entirely novel that manufacturers may develop into their signature sound of the electrification era.

NVH is a key metric in drive-system development for e-mobility. Careful design and manufacturing of gears are crucial to minimizing NVH, as tolerance variations can result in large differences between nominally identical components. Failure to factor for NVH will force manufacturers to adopt absorbent masking techniques that will add weight or cost or both—and likely reduce energy efficiency. Hexagon is working to address NVH and other drivetrain issues, through a recent collaboration between their Romax toolset and Dontyne Systems, with virtual prototyping (VP) solutions that account for the manufacturing process at the design stage.

Dontyne's manufacturing simulation capabilities are embedded into Romax design products. Romax models interactions between key components (shafts, gears, bearings, housings) and the subsequent impact on shaft deflection, gear contact patterns, misalignment, transmission error, acoustic radiation, etc.

Component measurement processes can be augmented through simulation to gain insight into system performance before sub-system and system testing.

It is obviously far less expensive and far quicker to resolve design issues during the design rather than production stages, but engineers are rarely equipped with comprehensive tools and expertise to consider every aspect of manufacturing variability at the outset.

The combination of Romax's full-system simulation and Dontyne's gear-machining simulation ensures manufacturability. Romax can then export gear sets to Dontyne's Machine Center for detailed tooling design and other manufacturing procedures.

Kristian Kouumdjieff, product manager for Romax, said, "In their efforts to make the transition to e-mobility in a time- and cost-effective way, global manufacturers, OEMs and Tier 1s are investing heavily in new technologies and learning how to overcome new product development challenges."

Since tooling parameters are automatically estimated based on the designed geometry, it is not necessary to have a deep understanding of gear manufacturing to use the software.

However, it is possible to view all the details of the tooling and the gear finishing simulation performed by Dontyne and to have more manual control over the settings.

Gear measurements provide very useful data about the achieved gear profiles, which can be fed directly into full-system simulation models like the ones used for design and analysis earlier in the process.
The designed gear geometry undergoes tooth contact analysis and is considered in the context of the overall drive system for durability, NVH, and micro-geometry-based efficiency analysis.

Kouumdjieff adds, "Gears are highly sensitive to even micron-level deviations in their system performance. The tooth geometry determined by the design engineer often cannot be produced precisely as specified.

Even small adjustments made by the manufacturer due to the limitations or intricacies of the manufacturing method can invalidate the design intent. This is exacerbated by manufacturing variability, which adds further uncertainty."

The software supports prefinish hobbing combined with worm (generation/continuous) grinding or form (profile) grinding simulated using Dontyne's technology. According to Kouumdjieff, "Other processes and features are in development for future versions including skiving, shaving, and honing."

Dr. Michael Fish, cofounder, Dontyne Systems comments, "Dontyne was formed to improve communication along the gear production process to enable greater production efficiency and product performance.

Our software allows better integration of design and manufacture data to quickly assess the influence

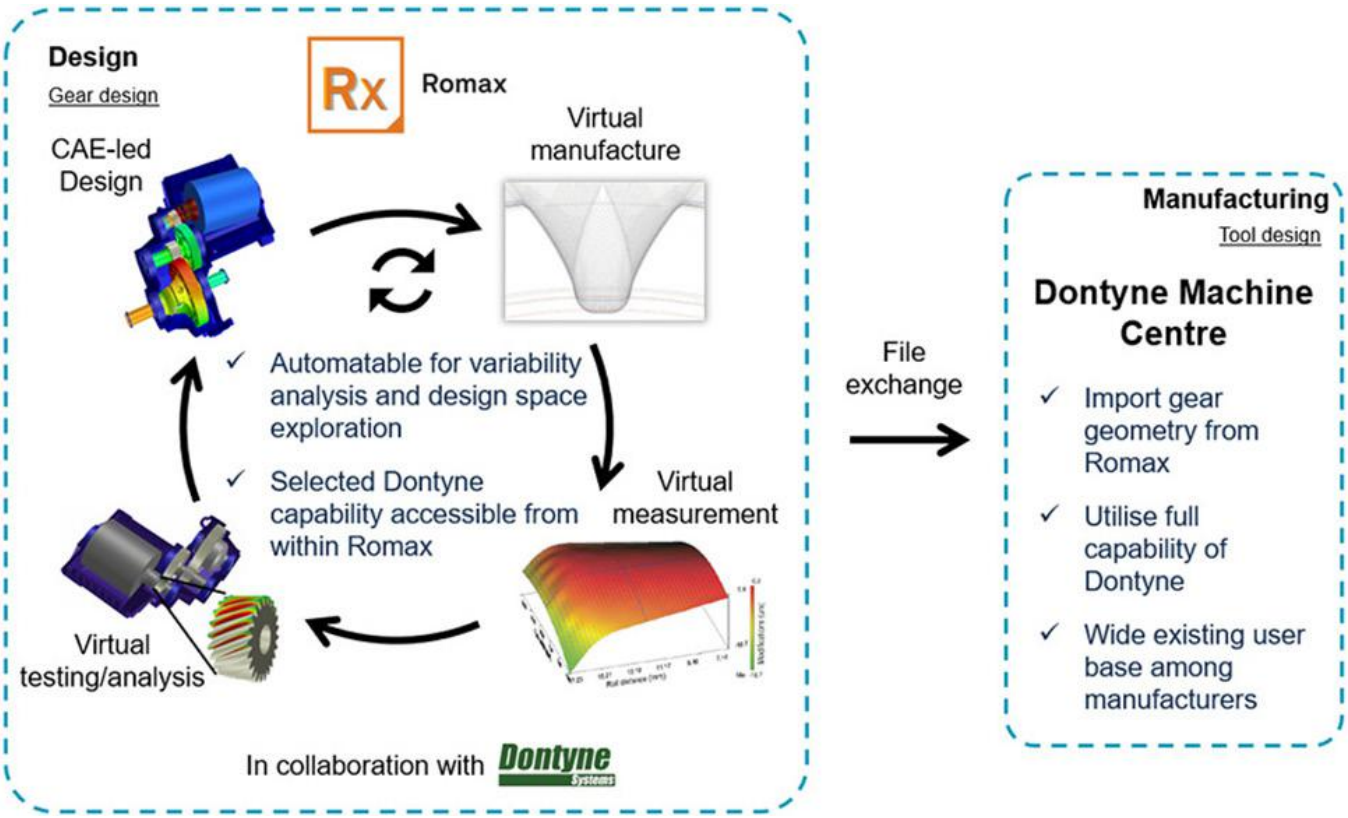


Image Source Hexagon

of each on the other so that problems can be identified, and adjustments made, if required, before commitment to machining.

During the development of our software, we have always kept in mind that it must be flexible enough to integrate with existing systems for maximum utilization and the lowest cost to customers.

Our collaboration with Romax is perfectly suited to this end and will benefit both companies and the industry in general. We are looking forward to expanding the scope of the collaboration in future releases."

As for Romax, Kouumdjieff adds, "We are excited about the possibilities this partnership opens and the technologies we can develop and bring into practice together.

We are looking forward to working with Dontyne and with our customers and partners to improve industry practices for the development and production of geared electro-mechanical drive systems."

VP is an area where huge advances have been made. As gear and transmission systems, and the methods of their production, become more complex and more interdependent, finding ways to use VP across the entire development process—from the initial design, through analysis, right up to manufacturing—ultimately means gaining a better understanding of system performance and efficiency.

Of Custom-Built Gears & Gearbox Manufacturing

Tube Mill Roll Stand Gearbox

By: C. Selvaraj

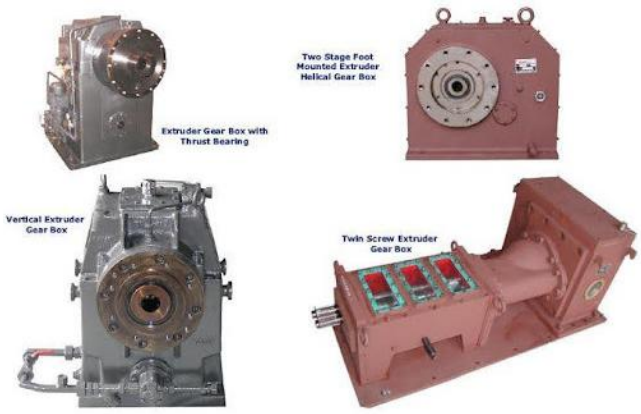
What Does Custom-Built Mean?

Simply put, they are gearboxes that are tailor-made. Typically, they are:

- Manufactured against specific application as per customer design requirements
- Done as per existing gearbox design under operation (Replacement)
- Develop import substitution to reduce dependency and encourage and support local products and industries
- Gears are manufactured as per a given sample or based on customer blueprint
- Gears manufactured as per OEM (Original Equipment Manufacturer) requirement

Specific Applications

Certain customers prefer to develop gearboxes to specific applications like an extruder, agriculture, pharmaceutical, and so on. To take care of these requirements, gearbox manufacturers developed a series of gearboxes for extruders. These ensure that customers select from catalogues based on motor power, reduction ratio, and screw size. There are different types of extruder gearboxes that are developed like the single screw extruder gearbox, and the twin screw extruder gearboxes.



Extruder Gearboxes

Replacement of Gearboxes

In any segment or applications, there are specific gearboxes in operation. These may be supplied by overseas /domestic suppliers. It's important to note that these gearboxes may be in operation for anywhere between 20 to 30 years, therefore customers may find it difficult to get spare parts or a complete replacement for them. In this scenario, customers expect gear manufacturers to give them new gearboxes as per the existing gearbox dimensions. In some cases, the customer would prefer to develop a new gearbox with an enhanced rating without changing the foundational details.

While developing import substitution/replacement gear boxes, manufacturers keep the external dimensions as per the existing one, and accordingly modify tooth parameters as per their standard. To improve the rating, gear manufacturers now design by selecting appropriate materials/tooth parameters.

Sugar Mill Gearbox

Conveyer Gearbox

Some of the steel, cement, power, sugar, paper, mining plants have imported equipment in their operations. These projects may have been commissioned by overseas OEMs. For instance, the majority of power plants have Chinese imported gearboxes, and the customer would prefer to develop the replacement indigenously.

Development of Gears

Often, the customers want to develop spares for imported gearboxes. In this requirement, gearbox manufacturers have to measure complete dimensions as per sample.

Here, manufacturers keep the major dimensions like centre distance, ratio, bearing seating, oil seal seating area and tooth parameters as per their standard, so that during gearbox assembly, they are unlikely to face any issue.

The OEMs want to develop gears for their machines as per their design. For example: machine tool, railway, pharma, printing, extruder, textile, and mining equipment.

Conclusion

In India, there is a huge requirement for replacement gearboxes as well as loose gear components.

End-user segments such as steel, cement, or power often have imported gearboxes in their plants, and this poses a challenge for them as there is a struggle to develop spares/replacement gearboxes.

A solution for this is for gearbox manufacturers to have a dedicated business development team who have an adequate hands-on experience for taking measurements onsite, and to get these to the market.

EIFCO's 'Make in India' Triumph in Gear Hobbing Machine Manufacturing

CNC Gear Hobbing Machine

EIFCO, a legacy of precision and innovation since 1958, has emerged as a key player in the gear machine manufacturing industry. From its humble beginnings, the company's strategic shift in 1976 towards conventional gear hobbing machines laid the foundation for over three decades of excellence.

In 2010, EIFCO embraced CNC technology, marking a paradigm shift and setting new standards in precision engineering.

Beyond its 4-axis and 7-axis configurations, they responded to market dynamics and customer feedback, venturing into automation to offer end-to-end solutions.

Today, EIFCO stands as a global player, with exports to Europe initiated in 2023, showcasing a commitment to delivering world-class products.

Mr. Abishek Ramesh, Managing Director, EIFCO spoke with Sushmita Das and sheds light on EIFCO's 'Make in India' triumph, that emphasizes the advantages of indigenously built CNC gear hobbing machines, and more. They envision a significant role in the ongoing "Make in India" campaign, with joint ventures on the horizon and a customer-centric philosophy at its core.

How has the "Make in India" initiative influenced your gear manufacturing operations and strategies?

The "Make in India" initiative has led to a significant number of foreign companies establishing gear manufacturing units in India, creating substantial demand for locally-produced CNC gear hobbing machines.

What are the key advantages of your indigenously built CNC Gear Hobbing machine?

CNC gear hobbing machines built domestically are cost-effective, leading to a lower cost per component. Service for these machines is readily available, and their lead times are comparatively short.

Could you elaborate on any specific challenges you've encountered in the process of developing this machine?

Manufacturing gear machines is a highly intricate process, and the knowledge required to construct these machines is not easily accessible.

There is a lack of consultants available to provide guidance when encountering challenges. Therefore, individuals must delve deeply into their resources and conduct extensive research to achieve success.

How do you ensure that EIFCO's indigenously built CNC Gear Hobbing machine meets global quality standards while being manufactured in India?

We examine our German and Japanese counterparts for the features they offer in their gear hobbing machines.

To attain comparable performance levels and incorporate those features, extensive in-house research and development efforts are undertaken.

What type of control system does the CNC gear hobbing machine use, and what programming languages are supported for creating machining programs?

Any controller providing flexible synchronous control is suitable. Our primary choices include Fanuc, Siemens, or Mitsubishi.

We've designed proprietary software for executing macros. It takes only four hours to train a machine operator with minimal skills.

Can you provide details on the spindle speed range and the corresponding feed rates achievable with the CNC gear hobbing machine for different materials?

This is highly dependent on various factors. The speed and selection criteria rely on:

- The hardness of the component
- The module being cut
- The hob material and its coating
- Whether dry or wet, hobbing is used
- Considerations for chip thickness
- The number of gashes on the hob
- The number of starts of the hob
- The desired quality after gear hobbing

Without addressing these aspects, it is not possible to pinpoint specific speed and feed selections.

How does the machine handle different module sizes and pitch diameters in gear hobbing? Are there any considerations for specific gear configurations?

Typically, we categorize modules into micro, small, medium, and large, and we have a dedicated machine for each of these categories.

How do you envision the future of gear manufacturing in India under the ongoing "Make in India" campaign?

There is a significant occurrence of joint ventures taking place.

Abishek Ramesh,
Managing Director, EIFCO

Fig. 1: External cycloid machining on the KAPP NILES Gear Centre KX 300 P © KAPP NILES

Grinding with Galvanically Bonded CBN Tools

By: Klaus Bauer and Ulrich Uebel

There's life in the old dog yet - this could be a summary of the last decade in terms of gear and profile grinding with non-dressable galvanically bonded tools using CBN (cubic crystalline boron nitride) as a cutting material.

When considering dressable grinding processes, there are of course advantages in correcting profile errors quickly, as well as reconditioning the cutting performance of the grinding wheel. In addition, it is of course also possible to carry out a profile optimization there and then.

These are all clear advantages compared to galvanically bonded non-dressable CBN wheels. But still, the CBN wheel maintains its place in day-to-day gearbox manufacture.

Especially where there is only a limited amount of space for the grinding wheel for reasons of geometry or where special profile modifications are required, where changing the tool diameter by dressing is not an option due to collision-related or component-specific reasons, where it is absolutely necessary that quality remains high and constant and where it is important that grinding burn is avoided, the galvanically bonded CBN wheel is still the undisputed leader.

The basis of non-dressable CBN wheels is a high-precision hardened steel base body, into which the active grinding profile of the tool is incorporated.

This means that in addition to the grain equidistance, the required gearing modifications such as profile corrections and tooth root form must be taken into account in the steel base body.

Galvanic processes are now used to coat this base body with a single CBN layer, which provides a highly accurate reproduction (µm range) of the required profile in the subsequent machining process.

This coating is non-dressable. This means that the tool diameter remains constant during machining for the entire operating life of the wheel, as it is not reduced by wear. Once the grinding process has been set up with such a wheel, it remains dimensionally

stable throughout the entire service life. As a result, CBN grinding wheels meet industry demands for a constant and traceable machining process of the highest quality.

Since 1980, KAPP has been an absolute trailblazer on the market with the development and manufacture of profile grinding wheels with the CBN cutting material.

For 40 years now, the KAPP NILES tool specialists have routinely dealt with the most complex components, a wide range of profiles and the highest quality requirements.

In the meantime, simpler CBN grinding task have been replaced by more cost-efficient dressable solutions, in particular in the automotive industry.

Nevertheless, there are a wide range of application areas where non- dressable CBN solutions are indispensable. An example of this is the robotics industry and specially the cycloidal drive used there, which is being machined in Figure 1 on the KX 300 P Gear Centre.

Here, the relevant criteria are above all the high positioning accuracy, the static and dynamic robustness of the drive and the low wear behaviour under high load.

These special requirements for cycloidal drives can only be guaranteed if the rotating components are ground with extremely high precision. The corresponding profiles of the cycloidal internal and external gears must precisely follow the decisive pin diameter during rotation.

The smallest deviations in the rolling behaviour can ultimately result in important angle positions not being reached precisely during operation, increasing wear in the drive and thereby reducing its service life.

The decisive criterion for the component quality is the precisely ground profile curve of the cycloidal external and radius-shaped internal profiles.

For high-quality end products, shape deviations over the entire profile curve are expected to be significantly less than 5 µm in series production, as can be seen in Figure 2.

And of course, this is not only required for the first ground part, but also over the entire course of the guaranteed tool life of the grinding wheel, which can reach well over 1,000 workpieces depending on component geometry.

A time-consuming dressing process for sharpening and profiling the grinding wheel is no longer necessary. As a tool manufacturer, KAPP NILES guarantees the quality of the profile through the precisely manufactured profile shape of the

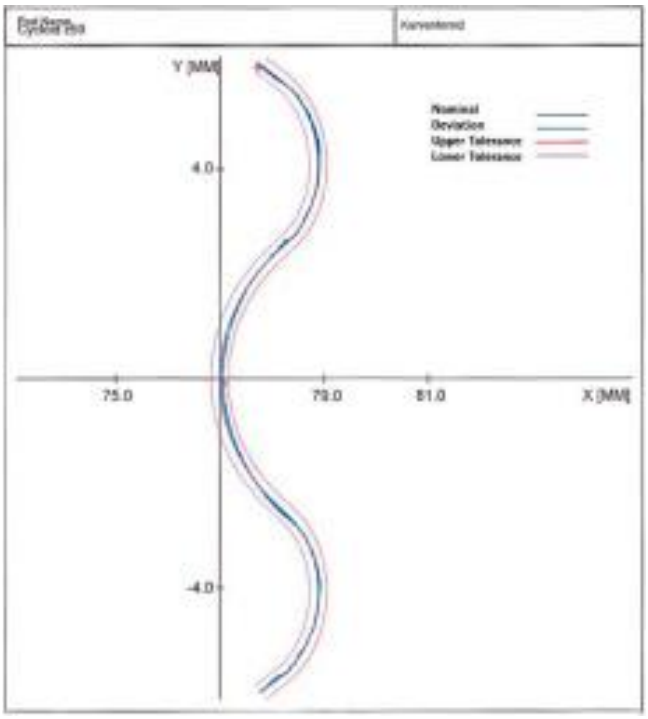


Fig. 2: Profile curve of a cycloidal external gear with a tolerance band of 5 µm © KAPP NILES

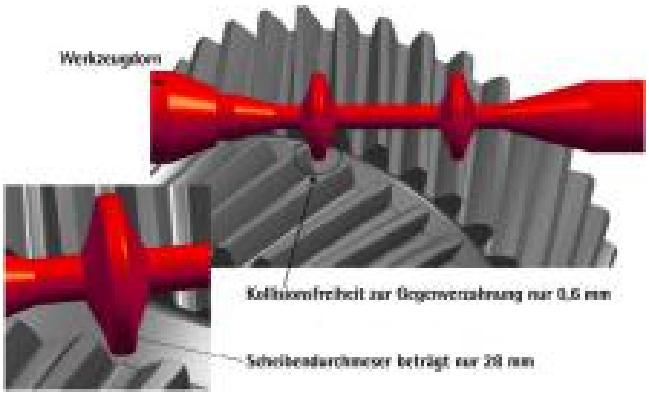


Fig. 3: Machining of a double helical cut planetary gear © KAPP NILES

galvanically bonded CBN wheels. Additional examples of application areas for CBN tools include grinding tasks in the aviation industry:

▪The machining of the gears for double helical cut planetary stages which are located between the slowly rotating main rotor and the quickly rotating turbine, ensuring improved efficiency and thus higher performance.

As shown in Figure 3, the distance between the two gears is only a few millimeters for so-called herringbone gearing of the planetary transmission, leaving little room during machining for the overrun of the grinding wheels. As a result, the maximum possible external diameter of the tools is significantly limited, to prevent them from grinding into the second gearing during grinding strokes.

▪ With internal gearings, the maximum external diameter of the CBN wheels is limited by the available clearance in the component. This can range from sufficiently large, as is the case with ring gears of the planetary transmission, to very small in case of splines. Figure 4 shows the comparison of the different external wheel diameters.

▪ The landing flaps on the wings of a plane are used to increase lift during take-off and landing.

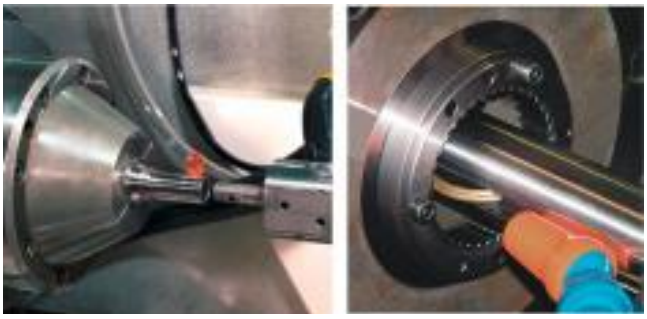


Fig. 4: Comparison of the different external wheel diameters © KAPP NILES

When they are retracted and extended, the flaps are controlled using so-called actuators, which are driven via a joint central gearbox using tandem motors. This also involves the use of triple pinions in the gearbox.

The left and right gearings on the pinion are identical. The gearing in the center differs from both in terms of gearing data, e.g. the number of teeth.

Figure 5 shows that here too, only grinding wheels with a very small external diameter can be used, due to the small size and the interfering contours from the respective adjacent gearing.

Fig. 5: Machining of a triple pinion © KAPP NILES

The high dimensional stability of the CBN wheels ensures excellent grinding quality throughout the entire tool life despite the small tool diameter.

Depending on the required precision as well as the quality of the upstream production chain in relation to profile errors, line errors and especially runout errors, the CBN grinding process can either be carried out in a single stage or in several stages.

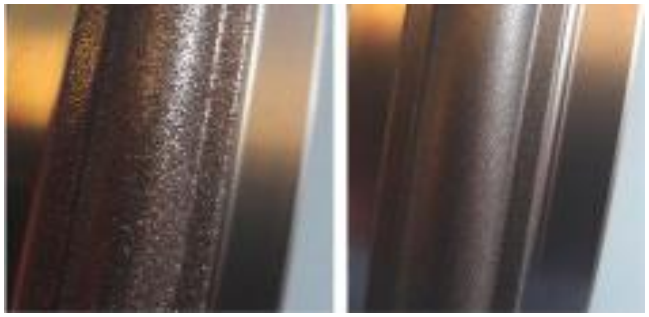


Fig. 6: Galvanically bonded CBN wheels in roughing and finishing version © KAPP NILES

Two-stage processes are typically used today, using coarsely coated roughing and finely coated finishing wheels. Their sequential use makes it possible to achieve both a high material removal rate and a high final quality of the ground gearing (See Figure 6).

Experience in recent years has shown that a high quality, yet economical production process is only possible if all parameters are taken into account. In addition to high-quality galvanically bonded CBN wheel, this also includes the corresponding grinding technology.

This is the only way to realise the actual performance of the galvanically bonded CBN wheels to the benefit of the user, not only in relation to profile quality and tool life behaviour, but also significantly shorter machining time when compared to dressable profile grinding.

KAPP NILES takes up this challenge anew with every application of non-dressable CBN grinding tools and as a system supplier of machine, tool and technology, also assumes overall responsibility for the performance and cost-effectiveness of your machining tasks.

The authors are Dipl.-Ing. (FH) Klaus Bauer and Dipl.-Ing. (FH) Ulrich Uebel; both are responsible for customer support and application engineering of tools at KAPP NILES.

Proper Hob Setting Importance in Gear Hobbing Machines

By: Vishwajit Kothari

Hobs can come in broadly two types: the bore type which is mounted on the arbor; and the other shank type which is clamped between spindle and the counter bearing. The shank type hobs were introduced to get better runout on the hob when mounted, and it can be set quickly thereby reducing the setup time.

Errors in manufacturing the hob, and in mounting it onto the machine are very important in terms of accuracy that is attainable on the work piece.

In particular, hob runout during manufacturing directly influences the quality of the profile.

New machines come with an attachment for setting up the hob on the arbor outside the machine. The base could be suitable for SK40 or SK50 or HSK63A taper identical to what is available on the machine spindle. At the other end, there is tailstock center.

However, it is necessary when in use, to timely verify and validate the co-axiality of its base with respect to the top center. Otherwise, it is likely to develop error on the trueness of the hob when checked on the gear hobbing machine.

It is unlikely at times that the hob found true in arbor on attachment outside the machine will also be true to the same extent on the machine. This is because the center line of hob, the spindle, and the counter bearing may not be co-axial as it should be.

The most trusted measurement of trueness can be obtained by checking the hob arbor assembly on bench center for trueness of hob on the hubs.

Moreover, the measurement readings of trueness must tally on the machine at the same points on the hubs. When you achieve this, you be rest assured for expected profile quality.

Hob arbors are manufactured with an accuracy assured by machining it with reference to the centers at the end. All geometrical accuracies can be found within 0.004 mm when checked on good quality bench center.

Usually, spacers of appropriate sizes are used adjoining the hob, the bore type, on hob arbor. These spacers must have parallelism within 0.002 mm. Its bore size slightly larger by ~ 0.030 mm. Spacers must have outer diameters equal to hub diameters or less by 1 mm. This will help to check the hub trueness by dial indicator. The dial indicator, with least count of 0.001mm, must be used and have stylus type pointer. If planned properly on CAD, there can be one spacer on each of hob of required width.

An important common observation to mention here is that the machine operator or setter ignores to check the hub trueness on the other side, that is supposedly unreachable i.e. on the spindle side.

Hob runout may be due to errors in construction of the hob itself. More often than not, they are the result of the hob being incorrectly mounted on the machine.

Most hobs have ground proof diameters, or hubs, on both ends. All hob geometric characteristics are referenced to proof diameters.

These diameters help operators mount and true a hob on the hobbing machine precisely. Excessive hub runout causes gear profile error.

Types of Hob Mounting Errors

There are three different types of error:

Uniform runout on the whole hob: This is when the hob axis and the axis of rotation are parallel, but they do not coincide.

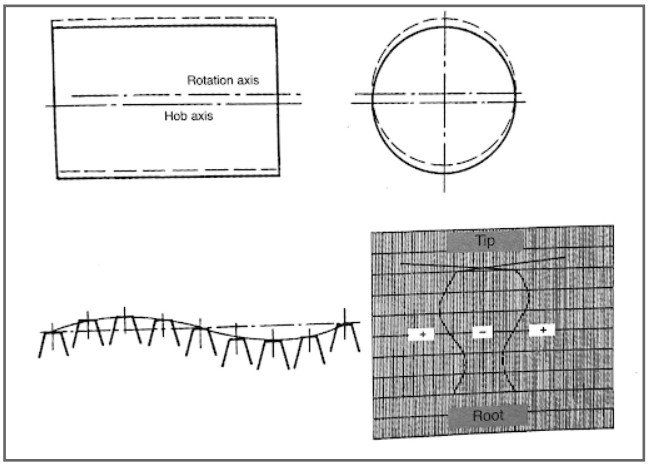
Runout at the two extremities of the hob: This occurs when the two axes (of the hob and of rotation) are not parallel, and they intersect half the way up the hob.

Runout at just one of the extremities of the hob: This is generated by two non-parallel axes which intersect at an extremity of the hob.

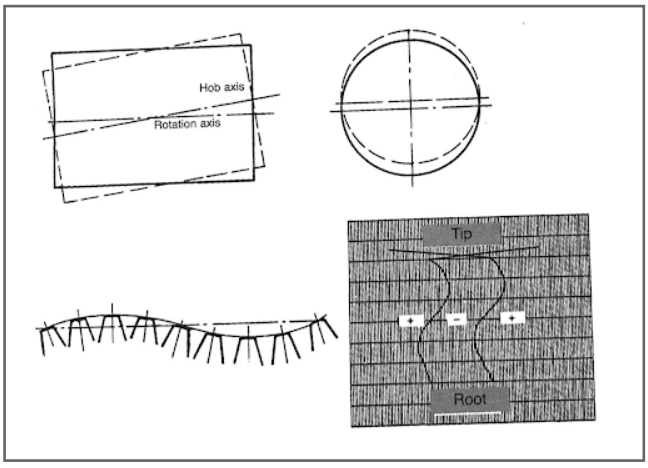
In the case of a), the tooth tips are parallel to the hob axis. The gear tooth which is generated has larger or smaller chordal tooth thickness in its different sections in relation to the theoretical measurements. Thus, the profile generated has a sinusoidal shaper and the two sinusoids are offset by 180˚ as shown in the figure given below.

In cases b) and c), the inclination of the hob teeth continuously varies since their axes follows the sinusoidal form. Thus, while in rotation, the pressure angle varies, like it increases on one flank and decreases on another.

With this mounted condition of hob, a profile error is generated but there are two sinusoids phased together. This means that the tooth thickness is correct in all sections but it is as if the tooth were distorted.



Case A



Case B & C

Mounting the Hob

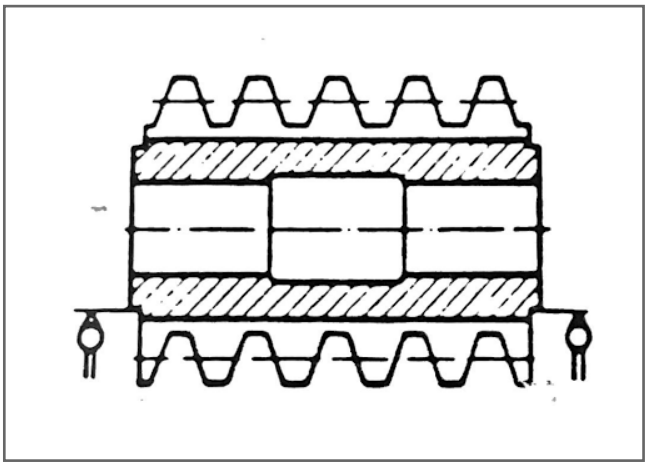
The hob must be positioned correctly in the machine if it is to properly function, i.e. completely, exploited.

Often, hobs may be found in workshops which have teeth at the extremities that have not worked. This means that there have been losses in terms of overall hob performance and the cost of the gear produced increases.

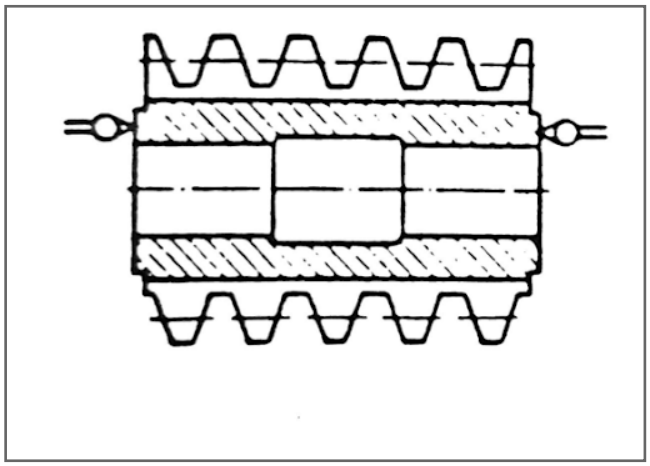
This happens when the hob is not located in the machine with its active face width positioned correctly within the shifting range available in the machine.

It is mandatory to position the hob with the help of hob centering device within the limits of hob shifting stroke available in the machine.

Furthermore, it is better to verify that the coordinates of end extremities fall within the Y axis stroke that is the shifting range of the machine.



Hub OD Truing



Hub Face Truing

Conclusion

The procedure below shows how to true the hob, bore type, and ensure it on the machine.
With this, productivity improves by saving the hob setup change time on the machine.

- Check the runout on the hob arbor in free condition. This can be done on a bench center or on a good accessory meant for this purpose.
- Assemble the hob with spacers on the arbor and clamp it. Before this, check and confirm the parallelism of spacers.
- Confirm the position of the hob on the arbor within the hob shifting range.
- Check the hob for axial and radial runouts of hubs on either side.

- The radial runout must be within 0.006 mm on either side.
- The high points of both these run out readings must lie within 30˚
- Now, mount the whole assembly on the machine.
- Check the hub runouts on both hubs. You should get the same value of runout and their high point as seen on the bench center. With this, you will be assured of good profile quality.

Ultimately, we have to ensure that the requisite trueness of hob is obtained and retained through the production cycle. Periodic inspection of part profile quality in a long production run will give confidence on rigidity of setup of hob on the machine.

Vishwajit Kothari, CEO, Cyber Gears.

www.cybergears.in

Former Head, Sales & Marketing, Premier Ltd. He has 32 years of experience and knowledge in Machine Tools, Machining Processes, Application Engineering, Tooling and Workholding fixtures.

Dressing Tools — Experts Behind the Scenes

By: Martin Witzsch

In recent years, ceramically bonded tools have conquered applications that require highest precision. As such, they increasingly put other technologies in their shadow in terms of accuracy as well as efficiency, such as in gear manufacturing.

With ample time, any accuracy is possible. But the old saying “time is money” is more relevant than ever.

Large series manufacturing are often challenged to produce accurate, fast and cost efficient, all at the same time.

The best examples are automotive transmissions which have the highest demands on weight, noise and performance. The required precision, however, must not drive up production costs – a challenge for the machine tool industry.

The leading player for gear and profile grinding Kapp Niles, headquartered in Coburg, offers several solutions.

The Kapp Niles portfolio includes diamond dressing rolls suitable for various dressing processes.

Ceramics Instead of Galvanic?

Traditional grinding tools of the gear grinding industry are often galvanic tools. These tools consist of a high-precision ground, hardened steel body plated with a layer of CBN (Carbon Boron Nitride) or diamond — CBN is the second hardest material known, next to diamond.

A ceramic grinding body consists of a homogeneous structure which simplifies its manufacturing and reduces the cost. Contrary to the galvanically bonded tools, ceramically bonded alternatives are dressable — the end user is able to re-profile and sharpen them.

For years, Kapp Niles has had dressable, i.e. ceramic based tools and the corresponding high-precision diamond dressing tools in its product portfolio; their customer base continues to grow.

The advantages of this technology are significant. Non-dressable, galvancially bonded generating CBN tools can process 5,000 – 20,000 workpieces, depending on workpiece geometry and requirements, before they need to be sent in for replate.

Ceramic tools have to be dressed after only 20 – 100 workpieces, again, depending on the workpiece. But, these grinding tools do not need to be sent off-premises for refurbishing. Instead, this can be done inside the machine with appropriate diamond dressing tools (Image 1).

Image 1: A generating grinding worm during the grinding process (left) and while it is dressed (right).

That presents two challenges in one: the machine functionality is more complex and production has to be repeatedly interrupted for the dressing process; yet, the process is quite economical.

Even though, ceramically bonded, dressable tools do wear faster than non-dressable they can be

repeatedly re-profiled using the appropriate diamond dressing tools. Depending on the application, a dressing tool can be used for many hundreds of dressing cycles.

One additional advantage is the consistent quality, despite the higher wear — a paradox? Ulrich Uebel, responsible for process development and product management of tools, solves the puzzle: “Over time, non-dressable tools show profile form errors and the cutting capacity decreases.

The more precise the manufacturing task, the sooner the tool needs to be replaced.
During the dressable grinding process, the profile of the ceramically bonded tool is repeatedly re-profiled and sharpened by a diamond-plated dressing tool. Sensors monitor the dressing process.

The quality of the ground workpieces is therefore very consistent, and remains so throughout the entire life cycle of the dressing tool.”

The time factor deserves close consideration also. For large size lots, ceramic tools allow for higher feed speeds and infeed, so the extra time expended for dressing is at least partially compensated for. Nevertheless, the dressing time cannot be reasoned away, but it is possible to minimize it.

Kapp Niles developed a series of diamond dressing tools that, depending on the grinding process, can also be used on non-Kapp Niles machines.
They include profile rolls, form rolls, and diamond dressing gears.

Dressing of Grinding Worms

Grinding worms for traditional generating grinding allow for a continual production of workpieces with natural bias, which in large series production must be manufactured under strict time constraints.

Generating grinding can also be used to produce workpieces with targeted bias. This is called topological generating grinding.

In either case, the dressing time should be kept as short as possible even with complex form requirements for the grinding tool. Image 2 shows the portfolio.

Multi-ribbed, full form profile rolls are the newest and fastest member of the family and deserve special mentioning — they are the sprinters amongst the dressing tools.

Depending on the number of ribs, the dressing time can be reduced up to 2/3 compared to traditional diamond profile rolls.

These dressing rolls are workpiece specific, i.e. they are specifically developed for a unique workpiece with pre-defined geometry. These rolls are plated using a reverse galvanic plating process.

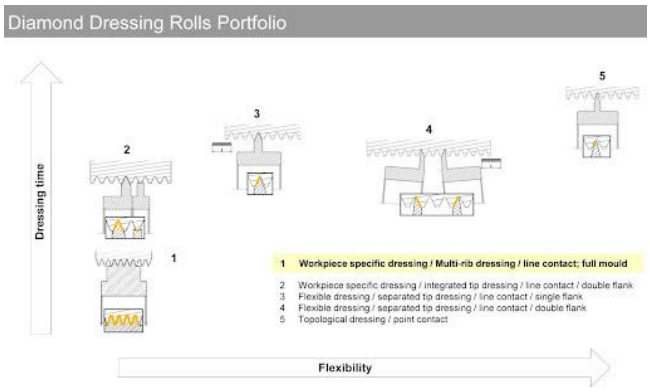


Image 2: Balancing dressing time and flexibility From large series manufacturing to prototype grinding there is a suitable dressing tool for each application.

Further time savers are dressing rolls with integrated tip dresser, which in addition to dressing the ceramically bonded generating grinding worm to the workpiece profile also dress the tip of the worm at the same time.

This saves one extra step, as long one can do without the flexibility that separate dressing of the grinding tool outside diameter offers.

The illustration demonstrates the various levels of flexibility depending on the tool selection.

Topological dressing offers the highest flexibility: the dressing tool has single-point contact with the ceramic tool to generate just about any form. A typical application for such tool is prototype production.

Quality Characteristics of Dressing Rolls for Generating Grinding

Kapp Niles dressing rolls can be produced using either synthetic or natural diamond. Dressing rolls with small radii are reinforced with CVD inserts which are extremely wear resistant.
The profile accuracy is 2 µm, the module can be smaller than 1.0 mm.

Generating simulations calculate and determine the dressing tool geometries and allow for the manipulation of typical gear parameters such as profile modifications, root form and bias.
Depending on the extent of wear, the dressing rolls can be relapped or completely reprofiled.

Dressing of Grinding Wheels for Profile Grinding

The dressing of grinding wheels requires a so-called diamond form roll (Image 3).

Image 3: Kapp Niles diamond form rolls for dressing of grinding wheels.

The geometry of such tool consists mainly of a high-precision radius and is not as complex as that of a dressing roll for the generating grinding process.

The variety of tools is smaller, accordingly. There are two main types: rolls with single and rolls with double radius (Image 4).

Image 4: Diamond form rolls are available with single radius (left) and double radius (right). The latter offers small radii for high-precision profile grinding with high stability.

The latter are used for reasons of stability: the tool has less of a chance to lose its form through contact with the grinding wheel to be dressed, especially for tools with small radii.

Diamond form rolls are available with a radius ranging from 0.1 – 3 mm and a tool outside diameter from 50 – 230 mm.

Quality Characteristics of Diamond Form Rolls

Diamond form rolls allow for a profile accuracy of 2 µm (Image 5), same as dressing rolls.

There are two different types of plating of dressing tools. One type is CVD (Chemical Vapor Deposition) inserts which reinforce the profile.

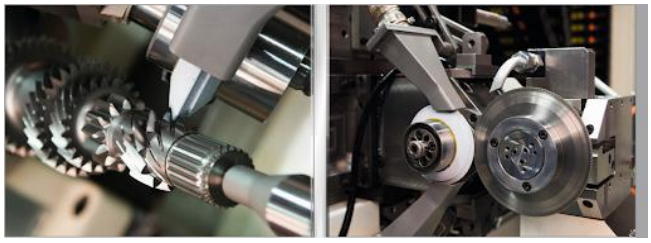


Image 5: A grinding wheel in a transmission plant (left); the dressing is done by a diamond form roll (right)

Depending on the wear, CVD-reinforced dressers can be relapped 5 – 6 times and still guarantee the same profile quality. The alternative to CVD-reinforcements is sintered natural diamond.

This type is approx. 20 % less prone to wear compared to synthetic diamond. Diamond sintered form rolls, however, can rarely be relapped.

Dressing of Honing Rings

To round off its product palette, Kapp Niles also offers diamond dressing gears for honing rings. Due to process related reasons, these tools are plated with synthetic diamond. The profile accuracy is in the range of 2 µm depending on application. The module can be less than 1 mm.

What Does the Future Have in Store?

Non-dressable CBN tools, by all means, are still warranted. Certain grinding applications require that ceramically bonded tools be reprofiled quite frequently.

In a worst case scenario, this could be so time-consuming that dressing becomes unattractive. Or the customer prefers the easier handling of non-dressable tools which is indeed an advantage. The trend, however, leans towards dressable tools.

Kapp Niles has positioned itself in this highly specialized market to be a supplier of machines, tools and processes. Uebel: “We can offer a customer an individually specified gear grinding process for just about any feasible workpiece. We are a turnkey systems partner and customers do not have to engage different suppliers.”

The author, Martin Witzsch, is a freelance journalist for Kapp Niles (www.witzsch.com)

Next Level IIoT

Cost-Effective Solutions to Bring Your Factory Floor into the Future

By: Matthew Jaster

Training and employee development can seem daunting to manufacturers still playing catch-up post-COVID and trying to move product out the door. Management wants to implement new IIoT and smart manufacturing strategies to increase manufacturing productivity, but a lack of time, money and available resources can complicate these goals.

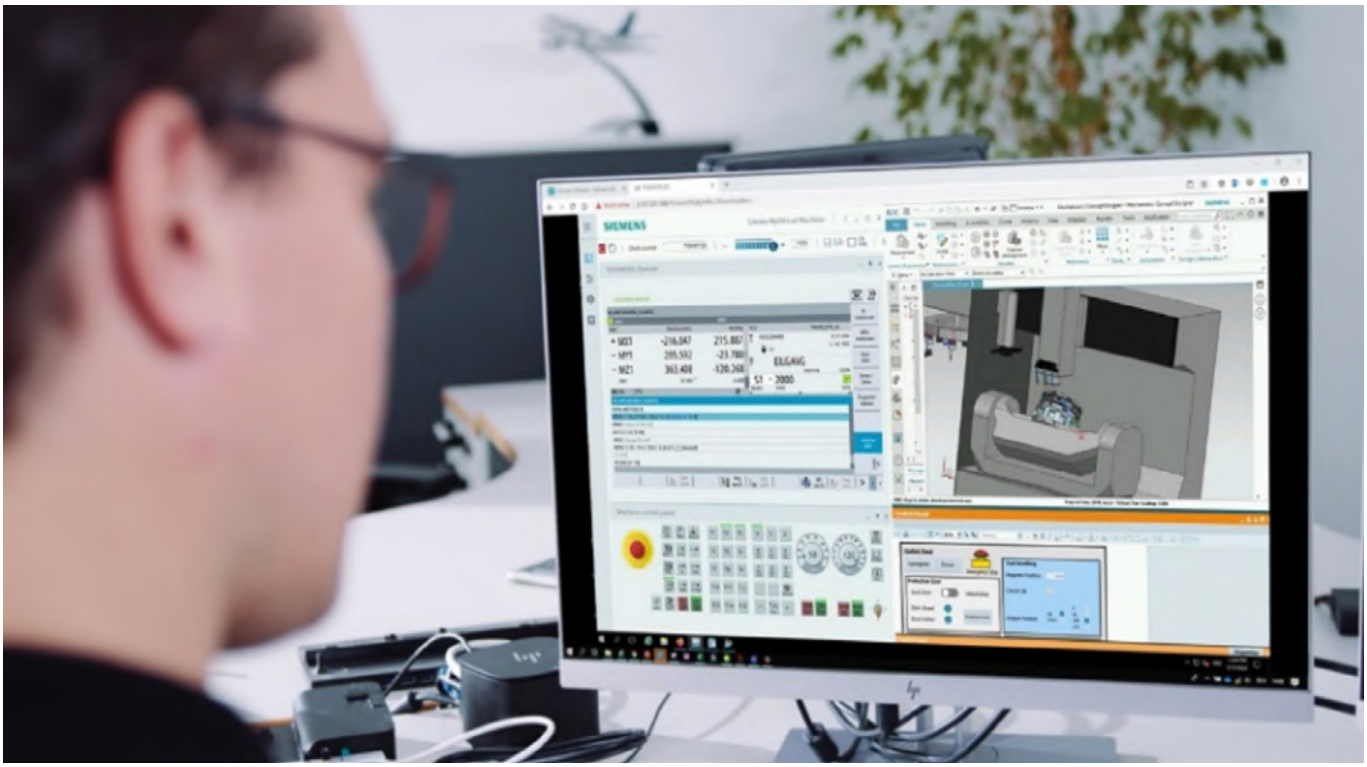
"You can collect all this data, but what are you really doing with it? How can this data help you better under- stand your processes? Companies are going to be looking for information like this. How can robotics and automation help? What can artificial intelligence do for me?" said Jeff Burnstein, president of the Association for Advancing Automation (A3). "Smart manufacturing/IIoT solutions are certainly of inter- est to small or medium-sized companies moving forward."

In 2022, manufacturers are looking for shortcuts to develop cost-effective IIoT solutions. Companies like Siemens, CC-Link, KUKA, and Yasakawa are sup- plying robotics, automation, controls and data collection in order to improve areas like shipping, material handling, machining cells, lights-out manufacturing and applications like hobbing, grinding and skiving.

Siemens Integrates Automation/ Robotics with Digital-Native CNC

With Sinumerik One, the first digital native CNC for machine tools, Siemens works with software to create the machine controller and the associated digital twin from one engineering system seamlessly. The latest iteration of the CNC system was on display recently at Automate 2022 where machine tool builders and CNC users were able to see the product, production, and performance benefits on the show floor.

“Sinumerik One can be used for a variety of machining applications including milling, grinding and gear hobbing,” said Russell Rumschlag, senior applications engineer at Siemens Industry, Inc. “Here at the Automate Show, we’re displaying its capabilities as a robot control.” In the factory of the future, robots and machine tools will work closely



Siemens My Virtual Machine for Machine Builders allows users the opportunity to deploy a "digital first" strategy.

together on workpiece handling, set-up, rework, and parallel machining. Sinumerik Run MyRobot makes it easier to integrate one or more robots into Sinumerik-controlled machine tools.
For high-end and premium controls, this includes complete system integration of the robot kinematics into the CNC system — including drives, motion control, safety technology, maintenance, and commissioning functions—up to PC-supported simulation and optimization with digital twin. But Run MyRobot also offers the option of integrating robots into mid- range CNC systems.

"There are different packages avail- able for Run MyRobot, including a handling package, a machining package, or we simply take our motors and drives and connect them to a robotic arm," Rumschlag said. "Since it's a CNC-based control system and not a robot-based system, you can take advantage of the tool management, for example. There's a significant difference between the processing power of a CNC versus the power of a robotic control."

According to Rumschlag, Run MyRobot allows a machine operator to seamlessly utilize a robot in a manufacturing cell without additional training or certification. "If the operator is familiar with G-Code, he or she can run these programs. It offers a much more versatile robotic work envelope versus a stan- dard machine tool," he added. "This is particularly useful for 3D-printing/additive manufacturing applications."

Using Create MyVirtual Machine, machine tool builders can virtually map their entire development processes—significantly reducing the product development phase and time-to-market for new machines.

The virtual preparation of machine commissioning can also reduce the duration of actual commissioning considerably. Machine users can also benefit from a "digital first" strategy for their central processes during production when they use Run MyVirtual Machine.

Programming, production planning and process optimization can be simulated instead of performing them directly at the machine and non-productive times are eliminated. Even training can be conducted using the digital twin instead of training on the actual machine, Rumschlag said.

At its core, mechatronics brings together software and hardware solutions to create a more intuitive and user-friendly experience. Sinumerik One perfectly fits into the Totally Integrated Automation (TIA) Portal and makes a highly efficient engineering framework available for machine tool builders.

With additional integrated features, the control system supports safety standards, cybersecurity protocols and other engineering concepts.

new.siemens.com/global/en/ products/automation/ systems/cnc- sinumerik/automation-systems/ sinumerik-one.html

Time Sensitive Networking with CC-Link

The convergence of real-time control streams used in automotive and industrial applications involves a set of standards known as Time Sensitive Networking (TSN).

"When it comes to discussions around connected industries, several buzzwords are generally included, making it seem like an endless number of high-tech devices are required to make factories smart. However, at the core of most digital transformation journeys lies an open high-speed industrial network architecture. In effect, future-oriented operations need a suitable data flow to connect various parts and players within an enterprise to generate data-driven, actionable insights and offer advanced control," said Mariana Alvarado, marketing specialist at CC-Link Partner Association.

CC-Link is an open-technology fieldbus network supplying absolute deterministic behavior and cost effectiveness, flexibility, and ease of use. Using CC-Link IE TSN technology for Ethernet bandwidth has made it possible to build flexible IIoT systems.

"Having every single asset communicating with the enterprise is the goal, at least in theory. However, in practice this may not seem feasible, because of the time and cost involved as well as company specific cybersecurity protocol," Alvarado said. "In most cases, it is advisable to 'start small', focusing on enhancing the connectivity of a machine or process that can deliver a quick return on investment (ROI)."

An example could be supplying remote access to a machine on the shop floor, enabling operators to check or control different elements. For example, cameras and other internal sensors, not just the controller, can be installed and connected to receive notifications in case of anomalies as well as interact with assets to maximize uptime, productivity, and efficiency. Once this project is successfully completed, then it is possible to move on to the next area, identifying where more value could be added to a process.

This approach is therefore ideal for small to medium enterprises, as it offers a sustainable pathway to drive continuous improvement and competitiveness in a fast-paced marketplace.

When implementing a stepwise strategy, it is fundamental to select suit- able solutions that

support it by offering the level of flexibility and scalability required. More precisely, specifying a network technology for future machines that can support interoper- ability and interconnectivity on small and large scale is key.

“TSN is highly recommended when embarking on a digital transformation journey and modernizing the architecture of your machines.

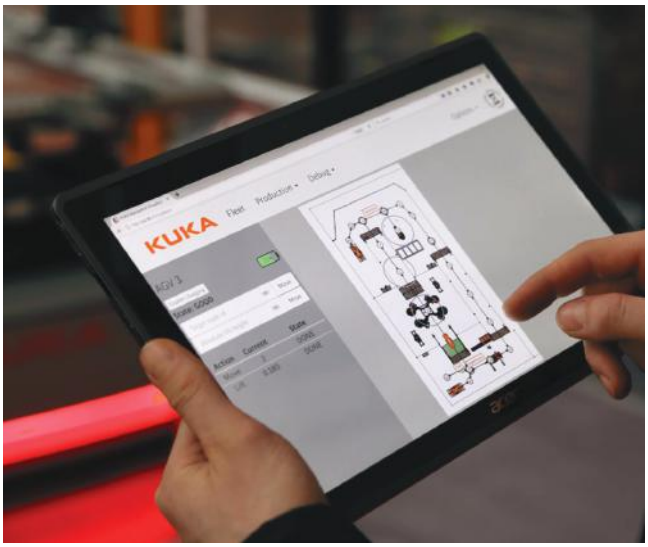
By doing so, companies can make sure they will be able to support both information technology (IT) and operational technology (OT) communications on the same network while delivering reliable, unmatched performance in data sharing. This means that they will be able to smoothly integrate any asset they want at any stage of their digitalization,” Alvarado said.

This solution is a future-oriented platform for industrial communications that can help companies cre- ate Connected Factories. As an open technology, it offers maximum compatibility and interoperability, so that devices, machines, or lines can be connected to each other, regardless of their vendor.

This capability further optimizes flexibility and costs for small to medium businesses. By specifying CC-Link IE TSN to futureproof operations, companies can make sure they are using the most suit- able backbone to support any application related to the connected industries, such as remote control, IIoT, and digital twins.

“In effect, they can benefit from a con- siderable leap forward in realizing smart operations where data-driven insights are used to improve productivity, efficiency, flexibility, and responsiveness.
Even more, businesses can do this in a stepwise approach making targeted investments in terms of cost, time and resources while considerably enhancing their competitiveness,” Alvarado added.

cc-link.org



Performing a robotic system today can be conducted in minutes without prior programming knowledge thanks to IIoT solutions

Robotic Simulation in Minutes with KUKA

KUKA instructs that robots must be integrated into complex production systems on standardized technologies

KUKA’s advanced automation planning software, KUKA.Sim allows manufacturers to accurately plan their automation solutions before the system has even been put into operation.

Robot motion sequences are programmed offline, depicted in real time, analyzed, and perfected to ensure that processes and work cell layouts can be implemented as planned.

KUKA.Sim creates a digital twin and identical image of the proposed produc- tion process that becomes the basis for virtual commissioning of production lines. The offline commissioning capability saves time, improves planning reliability and verification, and increases sales. KUKA’s simulation of a robot system with KUKA.Sim is conducted in just a few minutes without deep programming knowledge.

KUKA.Sim is based on a modular software architecture—with an efficient, flexible and durable toolbox principle.

The basic package can be expanded with three add-ons: for powerful modelling of an individual component library, for virtual commissioning and for simulation of welding applications.

This means customers only pay for the functional expansions they need. If their requirements change, users can easily add further add-ons in the future. The modular system stands out for its flexibility and durability.

VR hardware can offer a virtual demonstration of your system concepts and machining cells. These simulation results can be viewed on a mobile device— smartphone or tablet—through an app.

Additionally, KUKA has been actively promoting its intelligent machines and IIoT strategies at recent trade shows.

KUKA recognized the potential of networked and open automation systems back in the 1990s.

Engineers believe that no robot today has any future unless it is capable of being integrated into complex, networked production systems based on standardized mainstream technologies. Intelligent robots—in a variety of forms and configurations—are leading this evolution.

They will not only be tethered within cells as we knew them in the past, but provided with new intelligence, apps that are simple to integrate and give them new capabilities at a click, or cloud-based functions that turn them into active players in the flexible, autonomously operating smart factory.

Machines must accomplish three things: they must carry out their task as efficiently as possible, be able to adapt to new framework conditions, and be capable of sharing this knowledge with processes and systems in an intelligent way.

kuka.com

Upgrading Robotic and Automation Performance with Yasakawa

Featuring multiple improvements and optimization, Yaskawa's Smart Pendant v2.1 software extends capability for quick robotic implementation of basic assembly, injection molding, inspection, machine tending, material handling, and pick and place tasks.

Enabling previously unsupported functions, Smart Pendant v2.1 provides a built-in classic interface view. Ideal for more experienced robot operators, this option enables the end user to reset minor and major alarms or to edit concurrent I/O with reduced programming downtime.

Expanding on the performance improvements and extension app capabilities introduced previously,

Classic view of Smart Pendant from Yaskawa

Smart Pattern from Yaskawa enables the quick development of jobs for repetitive handling tasks

Smart Pendant v2.1 improves configuration and programming of third-party devices, including Yaskawa's Smart Packager software development kit (SDK).

This desktop tool enables third parties to combine multiple components into a single convenient file. Each file, known as a Yaskawa installation package

(YIP), enables easier robot setup by automating processes typically outlined in a manual.

Various advances, such as YRC1000 controller software updates, multi-touch jogging, 3D viewer optimizations, basic concurrent job support, improved HC-series configuration and other INFORM usability improvements are also included. Smart Pendant is available for use with select Yaskawa Motoman YRC- controlled robots. Soft Pendant software—a digital version of the YRC1000 pendant that can run on a Windows operating system—is also included.

Expanding Smart Pendant capability for handling tasks, the easy-to-use Smart Pattern extension enables quick development of jobs for repetitive handling tasks. Ideal for common tasks like stacking, unstacking, case packing, machine loading and unloading, this intuitive interface supplies guided prompts for single part, grid (2D array), 3D grid (3D array) and stack patterns.

Prompts are supplied to create two types of jobs. Pattern jobs define a specific pattern and robot movement for managing each part in the pattern.

Supervisor jobs define which patterns should be used to pick and place parts, as well as the overall flow of the system, including basic I/O signals.

Easily customizable, job editing is available to accommodate specific system requirements.

A wide variety of grippers and end-of-arm tooling can be used.

Compatible with the YRC1000 and YRC1000 micro controllers. Smart Pattern is available as a complimentary download for use with HC-series and GP-series robots.

This technology can increase production and efficiency for shops in areas like arc welding, assembly, machine tending, machining, material removal, packaging, part transfer and more.

motoman.com

Just Scratching the Surface

As IIoT solutions increase in the industrial sector, manufacturers—through the cloud, A.I., augmented reality and other technologies will have easier access to machine data in real-time. This can lead to more automated processes as well as an overall improvement in productivity.

As these systems and suppliers continue to share data—a facility where products, systems, machines, and manage- ment harness advanced analytics can accelerate innovation.

This is the common thread throughout IIoT implementation. These development tools and training will become more readily available to allow management to find faster, more efficient manufacturing solutions in the future.

The Role of Cutting Tools in Gear Manufacturing

By: C. Selvaraj

In gear manufacturing, cutting tools play a crucial role. Tools are used in various processes to establish dimensional accuracy and metal removal.

Generally speaking, the following operations are carried out for gear manufacturing.

They are:
Facing & Centring; Turning; Drilling; Tapping; Gear Cutting (Hobbing / Shaping), Centre Hole Grinding; Cylindrical Grinding; Bore Grinding, Gear Profile Grinding; Gear Shaving, and so on.

Let's take a closer look at some of these processes in this article.

Turning

The turning operation is the first operation in the gear machining process. Before the machining of any gear blanks in CNC turning operation, proof machining is required to ensure proper clamping.
In pinion shafts and output shafts, the centre hole machining is carried out before any turning operation. This is done so that during machining between centres, there won't be any runouts, which helps attain the gear tooth profile without any runouts.

When it comes to the facing and centring process, appropriate centre drills need to be selected to get good accuracy.

Some of the pinions and gears may need to be removed via extra carburising allowance materials. These components may have 58HRC hardness. For machining these areas, carbide tools for better machining must be selected. Similarly, to cut keyways on gears and shafts, carbide end mills are used.

Gear Hobbing / Gear Shaping

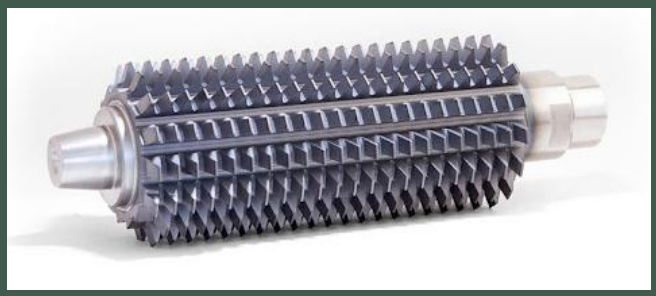
In gear cutting processes, cutting tools play a great role to get high accuracy on tooth parameters. Depending on the design engineer's recommendation, correct hob cutters are to be selected. To ensure protuberance on gears hob, cutter profiles to be ensured accordingly. For hard cutting, carbide cutters are used to remove hardened materials. In the case of gear shaping process, cutter selection is based on component stroke length. Accordingly, a shank type or disc type cutter is chosen.

Hob Cutter Selection

The following parameters to be considered while selecting hob cutter.

- Module of the component.
- Component number of teeth.
- Class of accuracy required for the component.
- If the component is a hobbed cut gear or profile ground gear.
- If the component to be finished in the hobbing process, class AA hob cutters are to be selected.
- For ground gears, class A hob cutters are preferred.
- Number of starts of the cutter to be selected based on the above parameters. For better productivity, it is better to select the multi-start hob cutter as it leads to faster metal removing.
- To improve productivity, hob cutter sharpening must be done periodically
- To get better productivity from hob cutters, various types of coatings can be utilized.
- Popular coatings used presently are the Titanium Aluminium-Nitride (TiN) coating and Aluminium Chromium Nitride (AlCrN) coating to improve productivity.

TiN Coated Hob Cutter



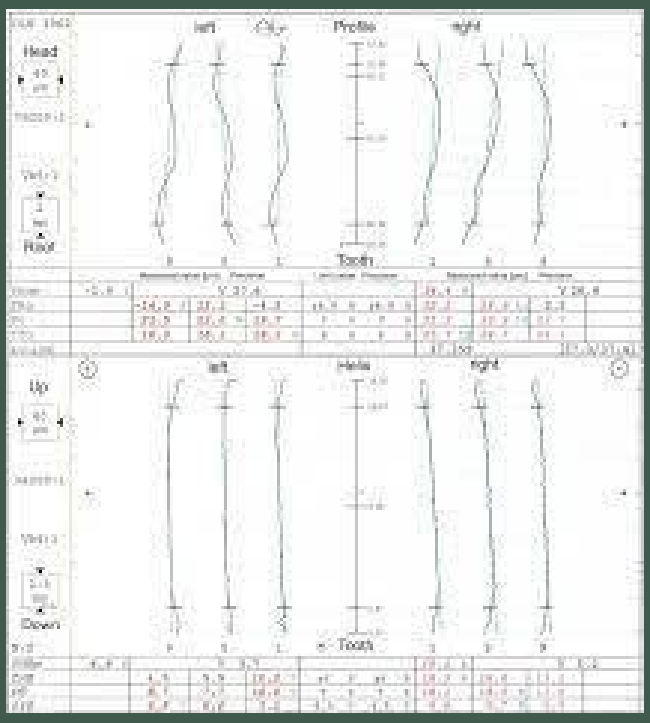
AlCrN Coated Hob Cutter

Cylindrical Grinding/Bore Grinding

In these operations, proper grinding wheels are based on grinding length. Bore size, bore depth, length of the grinding area. Similarly, for hardened surface grinding, the correct grade grinding wheels are

required for use to get recommended surface rough ness. In case of gear tooth profile grinding, wheel dressing is important to get correct profile accuracy.

This accuracy can be measured by profile testers. Periodically grinding wheels need to be dressed to get correct surface finish as well as the correct dimensions.



Gear Profile Graph

Conclusion:

Based on the above details we can understand the importance of cutting tools for the manufacturing of gears.

It is always advisable to select the appropriate cutting tools/grinding wheels depending on the accuracy level required for the components.

We need to take care about maintaining cutting tools accuracy levels by doing proper resharpening of cutters/dressing of grinding wheels.

Only then are we able to get the required accuracy levels in gear components.

The author, C Selvaraj, has four decades of experience in the field of gears and gearbox manufacturing, as well as servicing of gearboxes

Zimmermann's Upcoming Plans for the Indian Gear Manufacturing Market

By: Nishant Kashyap

Frieder Gänzle, CEO, F. Zimmermann GmbH

Frieder Gänzle, CEO of F. Zimmermann GmbH, spoke with Nishant Kashyap on Zimmermann's latest developments, current trends, sustainability initiatives, and future plans at EMO Hannover 2023.

Here's some valuable insights into the company's strategies and its vision for the Indian market.

Zimmermann is known for innovative milling solutions. Could you provide insights into the latest technologies and innovations showcased by Zimmermann at EMO Hannover 2023?

We showcased a groundbreaking thermosymmetric Portal Design with exceptional rigidity for Heavy Cutting Industries at EMO 2023.

This new symmetric portal design not only enhances rigidity but also ensures long-term accuracy through thermal stability, resulting in a more efficient and high-performing machine.

The global machine tool industry is rapidly evolving. In your opinion, what are the key developments and trends currently shaping the machine tool industry on a global scale?

We are observing a distinct trend towards automation and digitization. The surge in inquiries reflects a significant demand for automated and flexible manufacturing systems.

Milling solutions have seen significant technological advancements. Can you elaborate on some of the most noteworthy technological developments in milling solutions that Zimmermann has been involved in?

Over the past few years, we have successfully brought our vision to life—a thermally stable machine system across all weight classes we offer.

Paired with our specially crafted VH10-VH60 milling heads, we now provide the most technologically advanced symbiosis for highly dynamic 5-axis milling.

Looking forward, what do you envision as the future of the machine tool industry, and how does

Zimmermann plan to remain a leader in this evolving landscape?

We are unwaveringly customer-centric, consistently seeking sophisticated solutions to address our customers' challenges. This dedication is especially evident in our after-sales service.

Our commitment extends to ongoing efforts to optimize products and processes, ensuring unparalleled customer satisfaction.

Additionally, we are elevating our digital services and automated processes to provide added value for our customers.

Are there any emerging sectors or industries that you believe will drive the demand for machine tool solutions in the coming years?

We are consistently expanding our presence across various industries. In the upcoming years, we anticipate significant growth in both the aerospace and semiconductor sectors.

Industry 4.0 has been a transformative concept. How is Zimmermann embracing Industry 4.0 principles in its operations and products?

We are continuously advancing the digitization of our products and processes. Notably, we are actively developing a digital twin and exploring virtual commissioning as part of our ongoing initiatives.

India is an emerging market with substantial potential in manufacturing. What are your views on the Indian machine tool market, and do you see specific opportunities or challenges there?

India is undergoing rapid economic and social development. Recognizing India as a strategically crucial growth market in the upcoming years, we are intensifying our connections and actively working to expand our market share.

In coming years, we will be expanding our sales, marketing and service activities in India.

Sustainability is increasingly important in manufacturing. Can you share any specific sustainability initiatives or environmentally friendly solutions that Zimmermann is currently undertaking or planning for the future?

1. Investing in and expanding the PV system
2. Incorporating the latest power feed and regenerative modules across all Zimmermann products
3. Implementing an ECO mode for intelligent shutdown of Zimmermann machines and peripheral units
4. Transitioning the vehicle fleet to EV or hybrid cars, complemented by a PV system and associated fast charging stations
5. Introducing home office policies and implementing measures to increase workplace density, reducing space requirements and energy costs
6. Maximizing the use of online meeting tools (MS-Teams, Webex, etc.) to minimize travel activities
7. Lowering the general room temperature from 21 to 20 degrees for reduced heating costs
8. Adopting digital filing systems to streamline processes and cut down on printer expenses.
9. Investing in energy-efficient server hardware.

In conclusion, what message or insights would you like to convey to our readers about Zimmermann's role in the machine tool industry and your vision for the company's future?

Our family business's compact size and flat hierarchies empower swift decision-making.

We excel in promptly realizing our goals, staying consistently ahead of the competition. Preserving this agility remains a priority even as we anticipate future growth.

Gear Quality Inspection: A New Revolution is in the Making

By: Sudhanva Shevade

The Rising Cost of Quality Inspections

In recent years, the costs associated with gear quality inspections have been on the rise. Several key factors have contributed to this upward trend.

First, the growing complexity of gear designs necessitates more intricate inspection processes and specialized equipment.

Two, stricter industry regulations and customer demands for higher quality standards require additional testing and documentation, and finally the need for skilled personnel to perform these inspections further drives up costs.

Quality Inspection is Key to Profitable Growth

OPPORTUNITIES	HURDLES & CHALLENGES
Increased Global Demand, Export Opportunities	Competitive Pricing, Quality Products, & Reliable Delivery Schedules
Diversification of Products & new Export Markets, New Geographies & Industry Segments	Quickly develop reliable quality inspection systems for new applications, market needs
DIN 4, DIN 3 Class, High-Precision Gears	Investing in Advanced Manufacturing Technologies
Compliance: Obtaining International Certifications such as ISO 9001, ISO/TS 16949, & AS9100, & Adhering to Global Standards such as AGMA, DIN, & ANSI	Near-Zero Internal or Client-Side Rejection, Traceability

It is crucial for manufacturers to address these challenges and ensure cost-effective quality control without compromising on the integrity and reliability of their gear products. But how can this be achieved? We look at a few ways.

The Evolution of Gear Quality Inspection: Embracing CNCtization

The existing quality inspection equipment such as dial gauge-based Manual Gear Roll Tester, DoB or DuB fixtures, or PCD Runout measurement with DROs is primarily attribute-based (DRO is quantified, but human judgment dependent).

Such inspection is prone to errors, provides limited insights into the process and is operator dependent, but without much scope for traceability.

How Long Can We Rely Solely on Analog Measurement Systems?

While analog measurement systems have served us well, they do have limitations in terms of accuracy, efficiency, and data analysis capabilities.

The future of gear quality inspection lies in quantified, digital solutions that leverage advanced technologies, AI-driven algorithms, and real-time data analytics. These systems must offer precision, faster throughput, and comprehensive insights for process optimization.

By transitioning to new measurement systems, manufacturers can unlock new levels of quality control, enhance productivity, and meet the ever-increasing demands of the industry. It's time to embrace the new era and revolutionize gear quality inspection. The answer lies in embracing the transformative power of CNCtizing quality inspection.

Quality Inspection Challenges for Gear Manufacturers

Measuring higher precision with accuracy: Gears are critical components in many mechanical systems, and their performance depends on their precise dimensions and geometries.

Ensuring accurate and precise gear quality inspection requires advanced measuring techniques, such as coordinate measuring machines (CMMs), optical measurement systems, and 3D scanning, which can be challenging to implement and operate correctly.

Reliable quality inspection for complex geometries: Modern gears come in a wide variety of shapes, sizes, and geometries, including spur gears, internal gears, smaller-sized gears, and more. Inspecting these complex geometries for dimensional accuracy, tooth profile, and surface finish can be challenging, as it may require specialized measurement tools and software algorithms to interpret and analyze the data.

Super surface finish inspections: The surface finish of gears is critical for their performance, as it affects factors such as wear, noise, and efficiency.

However, accurate and reliable measuring surface finish can be challenging due to factors such as roughness, waviness, and the complex geometries of gears. Ensuring consistent and reliable surface finish inspection requires specialized equipment, and techniques.

In-process quality inspection in high-speed and large-scale production: Gears are used in various industries including automotive, aerospace, and heavy machinery where high-speed and large-scale production is common.

Conducting gear quality inspection in such production environments can be challenging due to factors such as high throughput rates, automation requirements, and the need for real-time inspection data. Developing and implementing inspection methods that can keep up with the high-speed production pace while maintaining accuracy and repeatability is a challenge.

Data-driven decisions, analysis and interpretation: Modern gear quality inspection generates a large amount of data, including dimensional measurements, surface finish data, and other parameters.Analyzing and interpreting this data can be challenging as it requires advanced data analysis techniques, statistical process control, and data management systems. Extracting meaningful insights from the data and making informed decisions based on it is a key challenge in gear quality inspection.

Eliminating human error and variability: Even with advanced measurement equipment, human error and variability can still be a challenge in gear quality inspection. Factors such as operator skill level, fatigue, and judgment can affect the accuracy and repeatability of gear inspections.

Ensuring proper training, standardization of inspection processes, and implementing robust quality management systems are essential to mitigate human error and variability in gear quality inspection.

Meeting compliance with standards and regulations: Gears are often subject to industry standards and regulations such as ISO, AGMA, and DIN standards, which define the tolerances, specifications, and inspection methods for gears. Ensuring compliance with these standards and regulations can be challenging, as they may be updated or revised periodically, and keeping up with the changes requires continuous monitoring and training of inspection personnel.

Keep, Upgrade, or Buy New?

When it comes to gear quality inspection equipment, manufacturers are stuck with three choices. First, continue as is as long as possible with the limitations of existing equipment.

This means arresting the scope for improving quality control which can be detrimental to overall growth of the company.

Second, upgrade existing equipment for digital output. The advantage here is that the existing equipment can be utilized to improve the accuracy of measurement. While this option helps to quantify the measurements, it leaves a wide gap when it comes to traceability, reducing operator dependency and process analysis.

The third option is to scrap the existing equipment and buy a new one with all the digital frills. This means provisioning for heavy investments, training and risks in case the advanced equipment doesn't suit the process. Plus, it means longer lead time and added complexity on the shop-floor.

The fourth way is to go the CNCtize way.CNCtize is a revolutionary new way to advance your existing quality inspection equipment without significant investments. CNCtize gadget can be fitted on any of your existing fixtures. The gadget includes an LVDT Probe which attaches to the existing equipment.

CNCtize is powered by patented CMGM (Continuous Monitoring and Guide Module) and Artificial Intelligence Software. The gadget when attached to the fixture provides digital, quantified output while giving ok/not-ok decisions and providing complete traceability for the Operator and the process parameters.

CNCtize Benefits

1. Ups the quality with minimal investment
2. Begins immediately
3. Get quantified measurements
4. Take accurate decisions

CNCtize PCD Runout Isometric view Redner

5. Achieve higher throughput
6. Beyond quality - Measure everything from Operator productivity to process throughput
7. Activate traceability - QR, Barcode integration
8. Step-up quality with deep insights – Get SQC, Analytics, trends and patterns
9. Be future-ready - demonstrate your seriousness for quality by showcasing advanced quality inspection with CNCtize to customers
10. Be Industry 4.0 ready

CNCtize Measurement of Any Parameter

- Length/Width/Height
- Distance
- 2D/3D
- ID/OD
- Measure with reference to co-ordinates

CNCtize Advantages

1. 100% quantified inspections
2. Reduced dependency on skilled operator
3. Ensures zero rejection skipping to customer OR to next stage
4. Reduces the load on standard room gear tester as well as machine and operator waiting time
5. Provides remote access & data export for real-time support in improving quality and compliance
6. Eliminates operator errors due to manual recording
7. Gives up to 2 times higher productivity than MRT due to faster rolling
8. Enables traceability by attaching QR/Barcode scanner to store part wise data

As gear manufacturing continues to advance, gear quality inspection has become a crucial step in ensuring that gears meet the highest standards of accuracy, durability, and performance. India has emerged as one of the leading global manufacturers of gears, and gear exports from India have been on the rise in recent years.

CNCtize is helping progressive gear manufacturers to up their quality control game, and improve several benchmarks at once. For gear manufacturers, CNCtize is the one solution that helps to overcome several challenges by transforming their existing quality inspection fixtures to the most advanced levels at a fraction of the investments.

CNCtize is an innovation by CalibroMeasure Equipment Pvt. Ltd. - a specialized new-age solution provider in dimensional quality inspection for gears and transmission components. CalibroMeasure has several disruptive innovations in automating gear quality inspection including auto gear rolling,

DoB/DuB measurement, PCD runouts, as well as other critical parameters along with spline and shaft inspections.

Sudhanva Shevade, Director, Marketing at CalibroMeasure Equipments Pvt. Ltd.

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www.calibromeasure.in

Gear Technology India Proudly Announces Its First Awards for the Indian Gear Manufacturing Industry

By: Divya Sudarsanan

Introduction

Gear Technology India along with AGMA is hosting India's first gear industry business excellence & achievement awards to bring together Indian manufacturers and vendors under one roof to celebrate their impressive achievements and contributions to the Indian gear industry.

The purpose of these awards is multi-fold; not only are these awards a brilliant opportunity to recognize the excellence of the India gear industry, but also to boost and build brand awareness, and cement its credibility among their industry peers.

Here is our website link: https://awardsgeartechnologyindia.com/

Let's break it down, and show you what needs to be done.

How Does This Work?

The awards are home to 9 categories that encompass all aspects of gear manufacturing. These categories are as follows:

- Excellence in Design & Development
- Excellence in Manufacturing Award
- Cutting Tool Innovation Award
- Gear Heat Treatment Excellence Award
- Excellence in Servicing and Testing

- Excellence in Indigenization: Make in India
- Excellence in Social Commitment
- She Drives the Gears
- Innovator of the Year

Each of these categories are home to several criteria-related questions that validate that specific category. Some categories do not have a set of criteria-related questions that need to be answered. Instead, they follow a system of just a question or a category followed by a subcategory that has relevant questions.

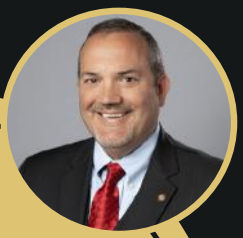
Submission of Documentary Proof

Some categories require documentary proof as evidence. Some of these proofs are specified; while others are self-explanatory.

How Will You Be Judged?

Gear Technology India has six distinguished jury members who are experts in the various fields of gear manufacturing. Our jury members are: Mr. Srikant Manakal, Mr. Selvaraj, Mr. Mahendran, Mr. Soundarajan, Mr. Jacob Thomas, and Mr. Vishwajit Kothari.

A blind review will be conducted wherein your answers will be scored and collated. The top 2 finalists will be expected to make a presentation before the jury members on Jan 30.



> The award recognizing industry excellence is an important signal to the global power transmission industry that India is a leader in world class manufacturing. India is as critical as ever for supply chain partnerships, and AGMA looks forward to a bright future of collaboration with industry leaders from North America and India working together.
> *- Matthew Croson, President, AGMA*

Nomination Submission Guidelines:

Nominees, here are the guidelines to be followed

1. Registration – Fill in all credentials as sought and create your unique ID and password.

2. Sign in with your registered ID and password.

3. Go to the nomination award categories to choose the nomination category appropriate to your company.

4. A Company can seek nomination to multiple categories.

5. Under the respective category, there is an eligibility criterion. Fill in your answers in the text box.

6. Some categories do not have a criteria requirement. In such categories, fill in the details in the given text box.

7. There are no character limits for details in the text box. However, keep it short and meaningful.

8. Some criterion questions will require you to upload supporting documents as proof.

9. Documentary evidence must be in format pdf, jpg, png, zip file against the respective upload button. These files must be correctly named and correlated.

10. If required, multiple documentary evidence files can be uploaded at one go under each criteria-related question.

11. Please ensure only the relevant document/s are uploaded against that specific question.

12. The top 2 shortlisted nominees in each category will make a presentation to the jury members on Feb 8 either virtually or physically.

13. Nominations close on 10 Jan 24 at 11.59pm IST.

14. After the submission deadline, all details provided will be considered as final and no changes are permitted.

15. Nominated Companies will be intimated and such companies (finalists) need to depute a senior management person to the awards show.

16. Selected company(ies) represented are to receive their awards.

17. Juries' decision will be final and dissent will not be entertained.

Award Ceremony Details

The awards will take place on Feb 23,2024, in Pune, on the second day of the IPTEX-GRINDEX expo. The show will start at 4pm and end at 7pm followed by dinner and networking.

SUBMIT YOUR NOMINATIONS

Awards Ceremony will be held on 23 Feb 2024, Pune, India

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Key Basic Conditions in the Gear Shaving Process to Achieve Finish Gear Component Quality

By: Ravi Naik

Material

Input Condition of CNC Blank:

1. The material of the CNC blank with microstructure should be a well separated pearlite & ferrite; no banding is allowed.

2. The CNC Blank Hardness must be 150-180BHN for better shaving quality and better shaving cutter life.

If hardness is less, shaving cutter marks and cutter profile form errors even after a few shaving cycles takes place.

3. Blank Face runout with respect to bore should be less than 25um The direct relation of blank face runout for controlling are: (a) Lead angular error (b) PCD runout.

4. Face Parallelism should be less than 25um.

5. Bore size, ovality and taper must be maintained as per specification.

6. Parts should be free from loose hobbing burrs and metal chips in side flanks and complete parts. Otherwise, the loose burrs will stick between the cutter serrations and material removal will not be effective.

7. Span size stock must not be more than 30-50um. In OPD, it must be between 70-90m maximum, and one must refer to the hob drawing. Similarly, also for span size / OPD, the size must be mentioned in the hob drawing.

8. Shaving stock per flank should be as per the protuberance amount provided on shaving cutter.

Hobbed gear with undercut to avoid the fouling of the cutter with material allowance of maximum 25 microns/flank for shaving operation.

9. Profile angular error (Fha) in hobbing to be maintained similar as per Fha value required in shaving to ensure uniform cutting load.

Example: if Fha require +1 to +5 in shaving then maintain +1 to + 5 in hobbing.

10. For input shaving operation, hobbed gears must be with tip chamfer to avoid dents.

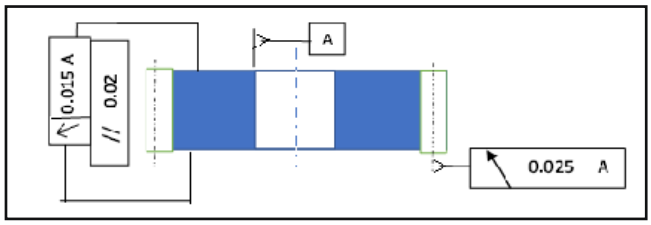


Fig 1: Face runout , Face // & Gear PCD Runout

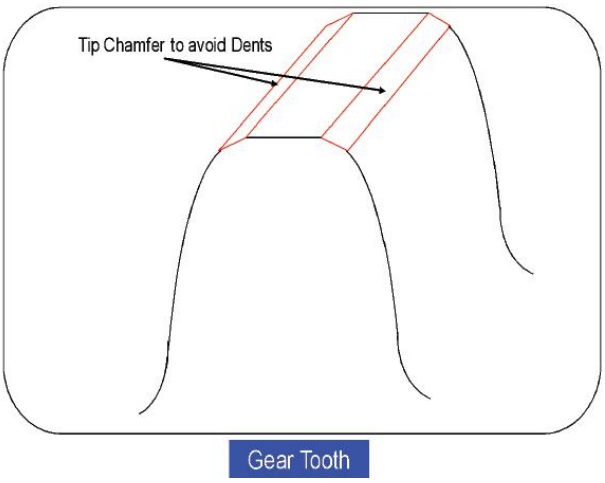


Fig 2: Semi Topping

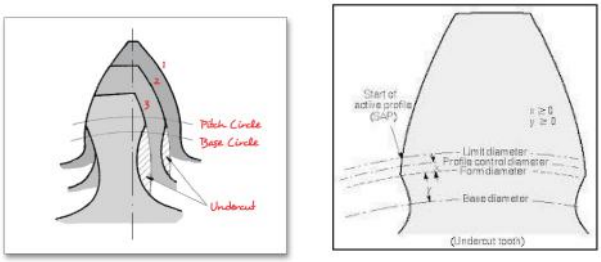


Fig 3: Protuberance pictorial view

Shaving Fixture

1. Collet clamping or hydraulic expansion fixtures for zero clearance between part bore and clamping fixture.

This take cares of controlling PCD runout , Fh-alpa variation and span size variation.

2. Part slippage in fixture needs to be checked during setup, and the clamping force be set accordingly.

3. Part slippage torque should be checked in every shift.

4. Tailstock clamping force need to be fixed as per part configuration.

5. For collet clamping mandrel, collet life to be monitored and replaced as per decided frequency.

6. If mandrel is hydraulic, mandrel OD size to be checked and replaced after wear limit. Don't forget to check part clamping; if clamping is not firm, fill the oil as per standard operation procedures to ensure part clamping.

7. Mandrel resting plate and clamping cap runout need to check every day and maintained as this will take care of lead errors.

8. Runout master component must be checked during setup, and at set frequency.

9. Fixture resting face, tailstock clamping cap, and collet must be cleaned every shift.

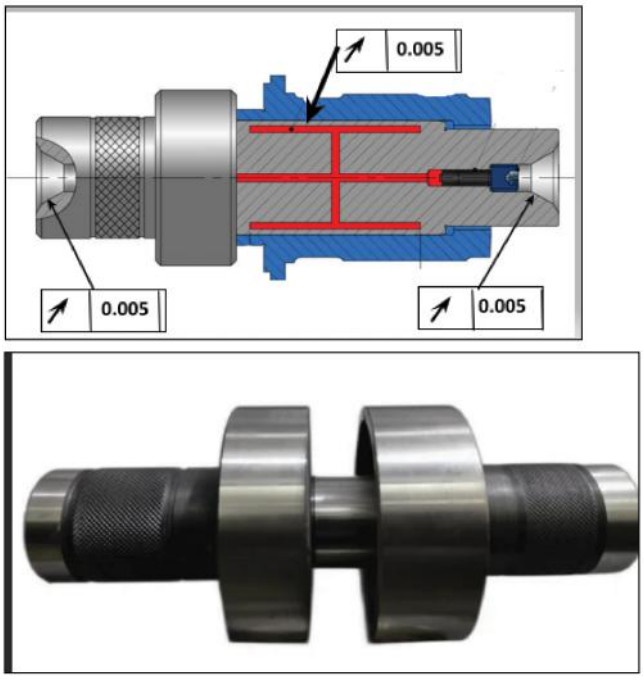


Fig 4: Hydraulic mandrel

Tool Shaving Cutter

1. Shaving cutter with material ASP2023 or higher grade to be used.

2. Shaving cutter with standard bore size 63.50 mm (2 ½") to be used.

3. Shaving cutter profile needs to maintain as per part profile requirement after shaving considering heat treatment distortion pattern.

4. Maintain the cutter profile and crowning as per established profile angular and profile crowning, and lead crowning. If part profile angular error (Fh-alpa) is required to be negative, then the cutter profile angular also needs to maintained in negative only. This again depends on the process cutting parameters (RPM, number of passes, and feed).

In every cutter sharpening, the established profile angular (Fh- alpa) and crowning needs to maintained. This will control Fh- alpa and profile crowning on part.

5. In shaving cutter sharpening, the stock removal in resharpening should not be more than 0.03-0.05mm, and it should follow ROP ROD Chart for Cutter for OD grinding correctly.

6. If cutter is the plunge type, and lead crowning is required, then calculate the crowning required on cutter to obtain crowning on part.

7. Shaving cutter should be demagnetized, and washed every time after removing the cutter from the machine.

8. The cutter should be handled carefully, and kept in a box provided by the tool supplier after every use.

9. The cutter face should be free from dents and damages. Check for flatness of cutter as per frequency.

Method

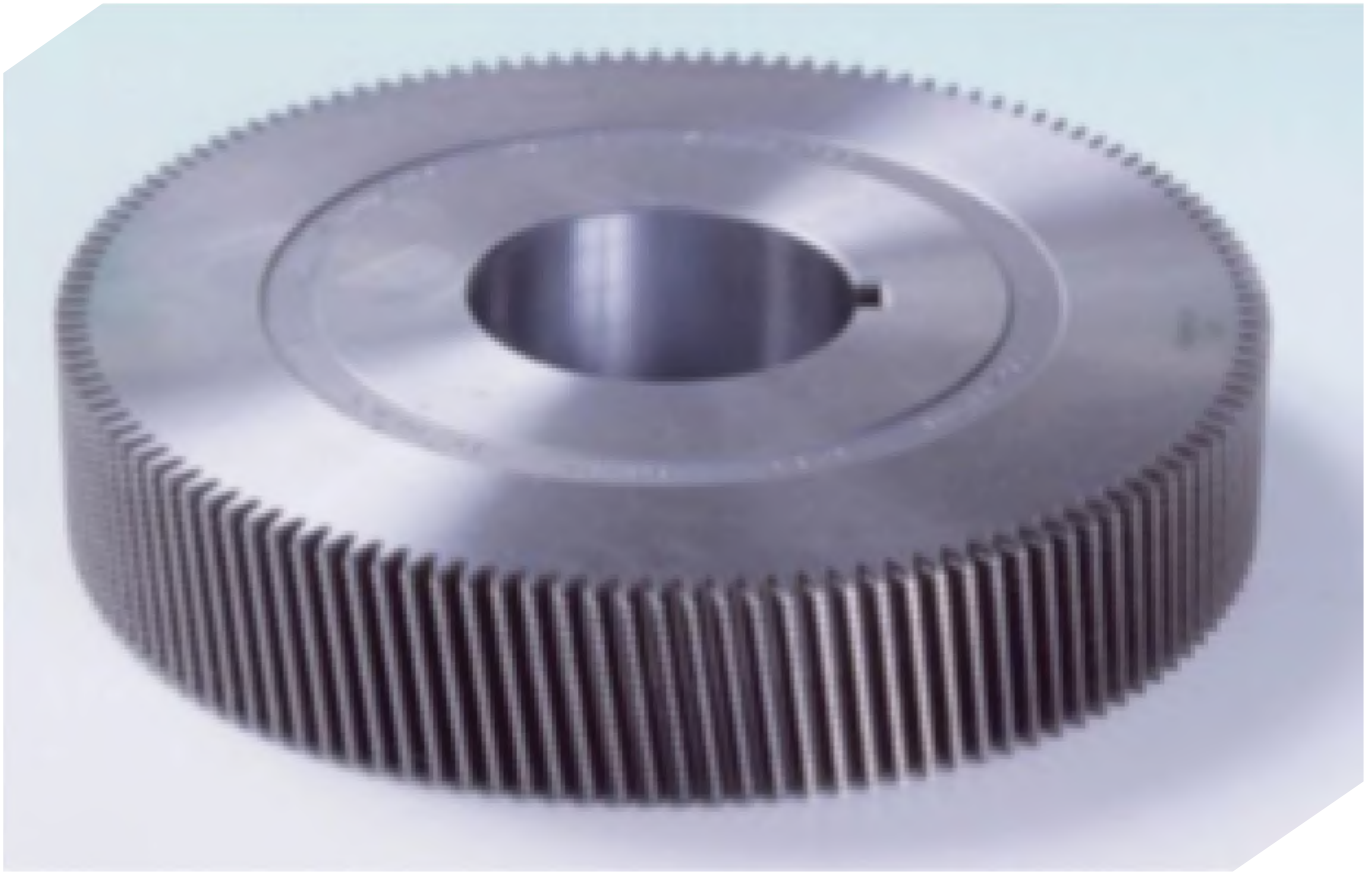
Cutter RPM, feed, number passes and dwell time need to be established as per the gear profile angular error and profile crowning required on part.

Types of Shaving:

a. Plunge shaving is used for lower cycle time, and if the lead crowning part is required, then the cutter should have lead crowning.

b. Diagonal Shaving: If part crowning is higher and part width is higher than cutter width, then diagonal shaving is preferred.

c. Diagonal shaving cycle time is higher compared to Plunge shaving. For diagonal shaving, suitable cutter is needed to be designed and manufactured.



D-Machine

1.Machine conditions –

-Cutter Spindle Runout must be checked and ensure within 0.01mm or as per GA Test chart.

-Alignments of head stock and Tailstock need to maintained within 0.01mm or as per GA test chart.

2. Machine leveling should be ensured, else it leads to profile form error.

3. In conventional shaving, the machine table axis repeatability must be checked. This leads to span size variation.

4. For chip flushing, cutting oil flow rate and direction of flow need to maintained.

5. Machine JH condition monitoring and actions need to be followed for machine basic health condition.

6. Follow the preventive maintenance schedule and critical spare parts planning.

Conclusion

Part shaving quality effects final part quality; therefore, the shaving process basic conditions must be maintained to achieve required finish gear quality.

Extending the Limits of the ChamferCut Process

By: Ramakant Reddy

Introduction

Chamfering and deburring gears by machining processes is increasingly being considered by gear manufacturers. The decision to use machining processes for chamfering and deburring gears in mass production is mainly driven by their qualitative and economic advantages. After all, approximately three to ten percent of production costs are required for deburring processes.

There has been a lot of research on the issue of burr on gears being generated during the machining process. One strategy has been the investigation of burr formation mechanisms to minimize burr by setting the parameters of the machining processes properly.

Another strategy has been to modify the design of the cutting tools. For example, a sharp edge of the cutting tool with a small edge radius reduces the burr size. On the other hand, a sharp edge radius reduces tool life and tool life also plays a key role in terms of production costs.

There are a variety of methods that can be used for deburring or chamfering gears. Each of these processes has its limits, advantages, and disadvantages.

For example, a well-known technology for deburring is brushing, which allows you to round the edges of the gear. However, it is not feasible to produce a geometrically defined chamfer by brushing whereas the machining processes do not have such a disadvantage.

The ChamferCut technology is an established approach to deburr and chamfer gears economically. The resulting geometry of the chamfer is highly reproducible and well-defined.

This article explains the conventional ChamferCut process and introduces two new ChamferCut processes. The first ChamferCut process deals with chamfering geared workpieces with an interference contour. The second one allows chamfering of internal gears.

Conventional ChamferCut Process

Figure 1 shows the principle of the patented ChamferCut process. The ChamferCut process does not differ significantly from conventional gear cutting with a hob. This process can be performed on hobbing machines or machines with the option to perform hobbing processes.

Both ChamferCut and workpiece have to be mounted on rotary spindles. The rotation of these spindles is coupled during the cutting process.

Further, the ChamferCut has a radial feed and is cutting skewed to the gear axis. The ChamferCut has to be set to an exactly calculated starting position.

As shown in figure 1 (A), this starting position is defined by the center distance (As), the distance from the tool axis to the workpiece (h) and the pivoting angle (eta).

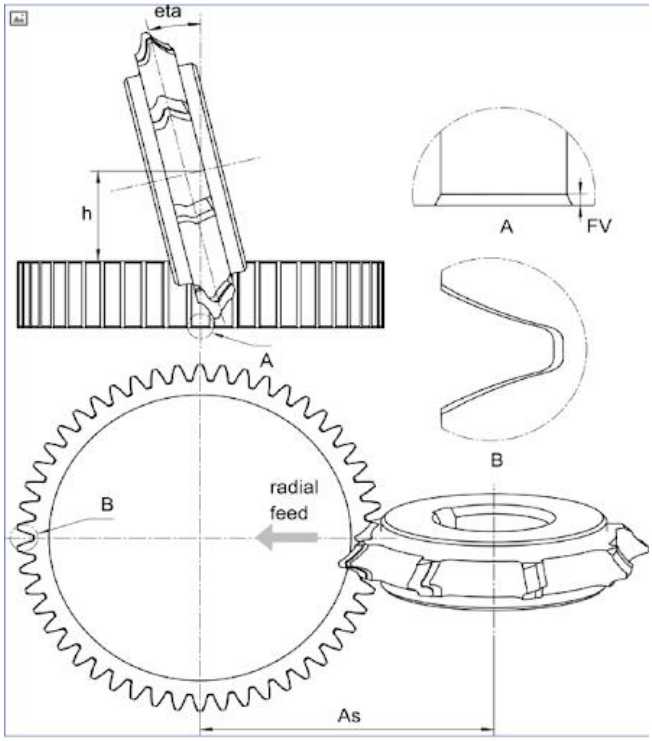


Fig 1: Principle of the ChamferCut process

The profile of the ChamferCut is geometrically bound to the tooth gap profile of the gear. Both flanks and the root of the tooth gap profile can be chamfered at the same time.

The resulting chamfer has a constant chamfer depth (FV) normal to the transverse section of the gear as shown in figure 1. The number of the teeth of a ChamferCut equals the number of starts and is

calculated by evaluating both setting and process parameters.

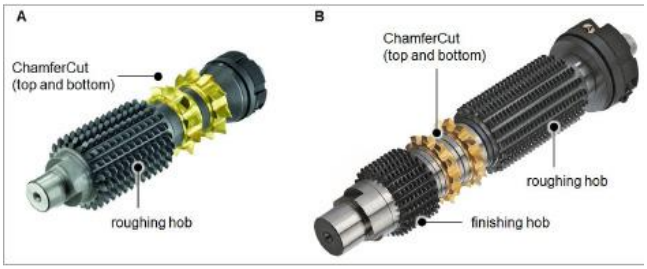


Fig 2: Examples of ChamferCut tool systems

Figure 2 shows examples for ChamferCut systems which can be used for chamfering gears or geared workpieces. The shape of the hobs can be designed as both a shank or bore hob.

These systems can be mounted into hobbing machines. Hobbing and chamfering a workpiece is done in different positions.

The process starts with standard hobbing. Afterwards, the ChamferCut tool system is set to another position in order to chamfer the top side of the geared workpiece.

This is done by considering the calculated setting parameters of the ChamferCut process. The bottom side of the gear is chamfered in a last step. Optionally, it is possible to finish the geared workpiece with a finishing hob (figure 2).

Fig 3: ChamferCut tool system for chamfering on a standalone machine

An additional tool concept to use the ChamferCut is shown in figure 3.

It is possible to perform the ChamferCut process on a standalone machine or on hobbing machines with an integrated ChamferCut unit.

This has the main advantage that the ChamferCut process can be performed during the main time of the hobbing process.

Fig 4: Bevel gear with chamfer produced using the ChamferCut process

In the ChamferCut process, the chipping volume is low which leads to a very long tool life. After a specific amount of chamfered workpieces, the ChamferCut has to be sharpened. The sharpening process is similar to the sharpening process of a conventional hob. A ChamferCut can be sharpened up to 20 times depending on the tooth height and the width of the wear marks.

The ChamferCut process allows chamfering a variety of gears or geared workpieces. It is possible to bring defined chamfers on straight or helical gears. For example, worm gears or bevel gears can be chamfered, too.

Figure 4 shows a bevel gear which has been chamfered with a ChamferCut. Although the edge of the tooth gap is a 3D contour, it is possible to use the ChamferCut process to manufacture a well-defined chamfer.

Geometry of the Chamfer

The geometry of the chamfer is designed by considering the chamfer quality, symmetry of the resulting chamfer. The resulting chamfer has a variable chamfer angle (CA) and a variable chamfer width (CW).

These are the pivoting angle (eta), the center distance (As) and the distance from the tool axis to the workpiece (h). This is illustrated in figure 5 using the example of the pivoting angle (eta) and the distance from the tool axis to the workpiece (h).

For example, a modification of the pivoting angle (eta) without changing the distance from the tool axis to the workpiece (h) leads to an asymmetric chamfer as shown in figure 5 (B). Further, there are critical values for the chamfer width (CW) and the chamfer angle (CA). The chamfer width (CW) and the chamfer angle (CA) may not fall below a certain limit.

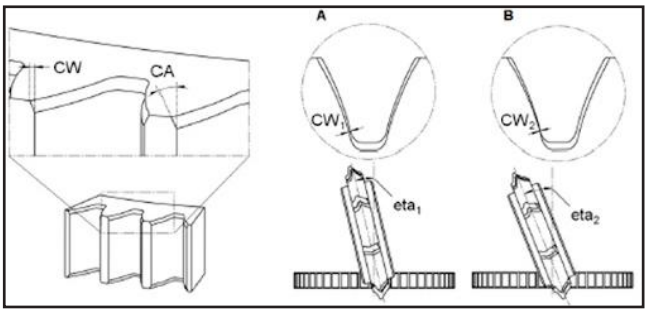


Fig 5: Influence of the setting parameters on the chamfer width (CW)

The ChamferCut Processes

Figure 6 (A) shows an example of a gear with an interference contour. The tool path of the conventional ChamferCut would collide with the shank of the gear. The idea may be to increase the pivoting angle (eta) and decrease the distance from the tool axis to the workpiece (h) to avoid collision. As explained in the previous section, in some cases this is not possible. The chamfer width (CW) and the chamfer angle (CA) could fall below a certain limit and the quality of the chamfer would not be sufficient.

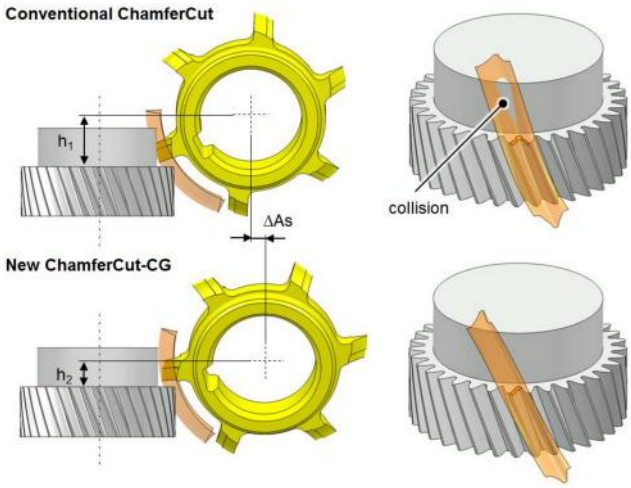


Fig 6: Conventional ChamferCut which would collide with the interference contour (A) and the new ChamferCut-CG with changed setting parameters which does not collide (B)

The solution for this challenge requires a change of boundary conditions.

If the flanks of the tooth gap are chamfered separately with two ChamferCuts, it is possible to change the setting parameters while maintaining a sufficient chamfer width (CW) and an adequate chamfer angle (CA).

A tool system for this new ChamferCut process is shown in figure 7. ChamferCuts, which are cut one-sided to avoid collisions, are called ChamferCut-CG (CG: Collision Gear).

Fig 7: Assembly to perform the new ChamferCut process in a dedicated ChamferCut unit

Further, with this new boundary condition it is possible to manufacture chamfers with a constant angle (CA). Within certain limits, it is even possible to generate chamfers with a constant chamfer depth (FV) and a constant chamfer angle (CA). Figure 8 shows an example of a gear with interference contour which is chamfered with a ChamferCut-CG system.

Fig 8: Examples for gears which are manufactured with the new ChamferCut process

Until now the usage of the ChamferCut process was limited to external gears. Hence, the mathematical model for the ChamferCut process has been extended. A change of both the setting and the process parameters allows the design of ChamferCuts for deburring and chamfering internal gears.

Conclusion

Chamfering gears are considered more by gear manufacturers to reduce production costs as it can be used for producing gears with a well-defined high quality chamfer. The ChamferCut-CG helps them use the ChamferCut process for gears with an interference contour. It is possible to design the chamfer geometry within certain limits. In future, the chamfer might be used as a design element, too.

SKF Improves Bearing Predictability Through R&D Efforts

By: Matthew Jaster

Guillermo Morales-Espejel, principal scientist at SKF Research and Technology Development, examines a bearing. (Photos courtesy of SKF)

The science of bearings continues to improve annually. Research on everything from fatigue behavior and misalignments to mounting errors and tribology has led bearing manufacturers to pinpoint key challenges in rotating machinery and make the necessary adjustments to provide the best possible solution.

In turn, this research provides bearing designers with real-world data that is extremely valuable as new bearings are produced.

It is not efficient to put a bearing with a 20-year lifespan into a machine that's going to last 10 years. There has to be a happy medium, according to Guillermo Morales-Espejel, principal scientist at SKF Research and Technology Development.

"The goal is to provide a bearing for an application that will last the same lifespan as the machine," Morales-Espejel said. It's not a matter of improving the bearing itself, it's more a matter of improving the predictability of the bearing."

SKF has spent many years — particularly the Research and Technology Development department — solving the mysteries of bearing performance.

This research has led to hundreds of custom machine designs for some of the world's most demanding applications.

A Closer Look at Bearing Research

First some design engineering facts presented during SKF's technical press event in late 2020:

90% of the bearings in the field outlive the machine when they are designed properly from the start and maintained.9.5% of the bearings are replaced in the field as part of a preventive maintenance strategy.

For so called critical assets (those machines, for example, that determine the bottle neck in a plant) such a preventive strategy could be more cost effective (even if the bearings are still ok) then accepting the risk of an unplanned failure.

As SKF becomes better and better at predicting bearing failures and remaining life, this will enable customers to switch from a preventive maintenance strategy for these machines to a more predictive maintenance strategy, directly saving the cost of unnecessary maintenance and replacements.

0.5% of the bearings are replaced because of failures. From these, 33% fail because of fatigue which you could say is the 'correct failure mode' as it is simply cause by the number of load cycles that the bearing material was able to handle.

16% of these failures are caused by improper handling, which includes mounting errors, misalignment etc.

"We inform and educate many of our customers, end users and distributors each year to avoid these errors," said Bernie van Leeuwen, director at SKF Research and Technology Development. "51% however, is related to so called 'surface-initiated-failures', which on their turn can be caused by anything that can (start to) damage the raceway surface of the bearings, including contamination and lack of sufficient lubrication."

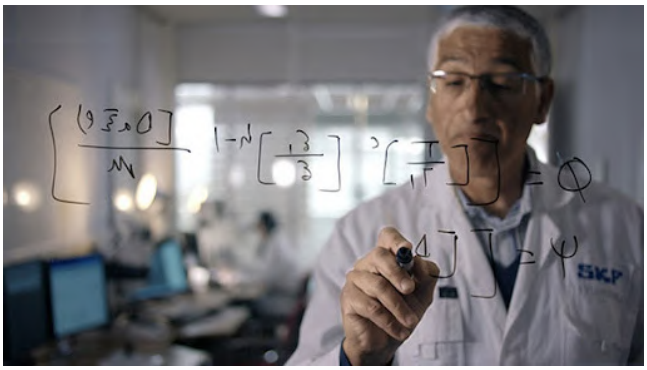
Historically a lot of research and eventually design engineering has been done on the understanding and calculation of the fatigue life.

Through this research, it is clear that a greater understanding of surface-initiated-failures will lead to the increased reliability of rotating machinery, according to van Leeuwen.

GBLM Calculation Tools

SKF unveiled the Generalized Bearing Life Model (GBLM) in 2015 to ensure customers and distributors could select the right bearing for the right application, every time. In the past it was difficult for engineers to predict whether a hybrid bearing could outperform a steel bearing in a given application.

"From 2015 to 2018, we tested hybrid bearings and began implementing and verifying the model,"



The Generalized Bearing Life Model (GBLM) leads to better choices when selecting bearings.

Morales-Espejel said. Through this research Morales-Espejel found great potential for hybrid bearings across many different applications. Hybrid bearings use ceramic silicon nitride rolling elements and steel rings. They have been the preferred choice for high-speed, high-precision equipment such as machine tool spindles.

The Generalized Bearing Life Model (GBLM) leads to better choices when selecting bearings.

Today, the hybrid bearing's combination of low weight, good electrical resistance and good performance under demanding lubrication and contamination conditions is helping it find many new applications, from electric vehicle powertrains to industrial pumps and compressors.

"GBLM enables better choices to be made when selecting bearings for a wide variety of applications," he added. "We built curves in order to describe the behavior of bearings over a wide range of loads and surface conditions. Hundreds of these bearing tests compared steel and ceramic rolling elements and we were able to finalize a new GBLM for hybrid bearings."

When a bearing is heavily loaded, but able to run in a clean, well-lubricated environment, sub-surface fatigue is likely to be the ultimate failure mode, and a steel bearing may perform better than a hybrid. But a lot of bearings operate under lighter loads, but with a greater likelihood of poor lubrication or contamination. The SKF model shows if a hybrid solution would offer a longer life on those applications and will quantify the difference.

In a poorly lubricated pump bearing, for example, the rating life of a hybrid bearing can be up to eight times that of a steel equivalent. For a screw compressor bearing running with contaminated lubricant, meanwhile, the hybrid offers a rating lifetime a hundred times greater than a conventional steel bearing.

From railway and car engines to industrial pumps, hybrid bearings can provide the necessary combination of low energy consumption and high reliability. E-mobility is another area where bearings need to survive high speeds, accelerations, and temperatures with minimal lubrication. These bearings must resist stray electric currents, which can burn away lubricant films and damage rolling surfaces. Combined with their other benefits, the excellent electrical insulation properties of hybrid bearings make them the ideal solution for such applications.

SKF's GBLM calculation tools are being used 260 times a day on average. "When you don't have tough tribological conditions, there is no need to have a hybrid bearing," Morales-Espejel said. "Hybrids will

SKF's GBLM calculation tools are being used 260 times a day on average.

tend to introduce more subsurface fatigue that steel to steel bearings particularly with very high loads." The challenge is comparing the two design types in a variety of different applications and circumstances and compare the results.

"Hybrid bearings don't always emerge as the winner in comparison with conventional designs. The idea is not to replace all steel-steel bearings with hybrid designs, but to do so when it makes economic sense. Our GBLM for hybrid bearings allows customers to make those decisions based on our data," Morales-Espejel said.

SKF's GBLM calculation tools are currently being used 260 times a day on average by the company's application engineers and customers.

From Preventative to Predictive

The move from preventative to predictive maintenance strategies will continue in the coming years. Tougher operating conditions will increase the need for more hybrid bearings in the future, according to Morales-Espejel. And with more effort on predictive maintenance, the bearing industry will see a significant increase in smart manufacturing technologies in the coming years.

"We'll see more sensors on bearings, more field data and intelligent software that will provide additional benefits," Morales-Espejel said. "The bearing industry will evolve as these tools are combined with good calculation methods, predictive measures and lots of sensors sending information to the models." New steel bearings will also receive attention in the coming years.

We currently are using new steels in very extreme applications, but these steels are becoming more mainstream." Morales-Espejel said. "You cannot do some of the things with typical steel bearings in a corrosive environment, you need specialized steel in many of these unique applications. I believe we'll continue to see an increased demand for specialized steel bearings in the future." Data collection continues to improve the overall efficiency of bearings, giving customers the ability to make well-informed decisions regarding their applications.

Late last year it was announced that SKF — founded in 1907 — and Imperial College London, were extending their R&D partnership. The SKF University Technology Centre (UTC) has been housed at Imperial College London since 2010 and has delivered research that helps bearings perform better and longer, whilst also contributing to lower energy consumption in the machines they operate in. This work will continue until 2025.

At the end of our conversation on bearing efficiency, I returned to the statement that 90 percent of the bearings in the field outlive the machines when they are properly maintained. Can this number reach 100 percent in the future?

"Manufacturing bearings that are engineered for specific operating conditions typically come with higher costs," Morales-Espejel said. "The pressure is mounting to provide as much real-time bearing data as possible to help our customers make informed decisions regarding their equipment. Our hope is to use this data to provide more efficient bearings in the future."

Data collection continues to improve the overall efficiency of bearings, giving customers the ability to make well-informed decisions regarding their applications.

The Power and Potential of Digital Twin Technology

By: Nishant Kashyap

Digital twin is a virtual, data-driven replica of a physical object or system. In the context of gear manufacturing, a digital twin encompasses the gear designs, manufacturing equipment, and the entire production process.

This digital representation created using data from sensors, IoT devices, and other sources closely mirrors the real-world counterparts providing an accurate and dynamic reflection of the physical gear manufacturing environment.

A digital twin is not a static model but a dynamic entity that continuously updates in real time, allowing for precise monitoring, analysis, simulation, and optimization of the physical gear manufacturing processes.

It serves as a bridge between the physical and digital realms, facilitating better control, decision-making, and problem-solving.

Digital Twin Applications in Gear Manufacturing

Digital twins have found numerous applications within the gear manufacturing industry. Here's an in-depth look at how digital twins are being used in gear manufacturing processes:

Virtual Gear Design and Prototyping: Digital twins are employed to create virtual models of gear designs. These 3D representations allow manufacturers to simulate and evaluate the performance of different gear designs before they are physically produced. Virtual prototyping reduces the need for physical prototypes, saving time, and resources.

Real-time Monitoring and Control: Sensors attached to machinery collect data on factors such as temperature, vibration, and process parameters.

Thus, digital twins continuously update to reflect the state of equipment enabling operators to monitor and control production processes effectively.

Process Optimization: Digital twins are used to simulate and analyze the entire gear manufacturing process. This includes gear cutting, heat treatment, surface finishing, and more.

Simulation helps identify bottlenecks and inefficiencies, leading to process improvements, reduced waste, and cost savings.

Quality Control: Digital twins compare the characteristics of manufactured gears with the desired specifications.

Deviations from the specifications are immediately identified, allowing for rapid corrective actions and reduced waste.

Predictive Maintenance: By analysing equipment performance data, they can anticipate issues such as wear and tear. This proactive approach reduces

unplanned downtime, increases the lifespan of equipment, and lowers maintenance costs.

Supply Chain Optimization: Digital twins monitor the availability of raw materials and components in real time.

This visibility ensures that there are no production delays due to material shortages, leading to better inventory management.

Remote Collaboration and Support: Experts can access the digital twin remotely, providing guidance and support to on-site personnel.

They can troubleshoot issues and share their expertise, regardless of their physical location.

This capability enhances problem-solving and knowledge sharing within the organisation.

Data Analytics and Machine Learning: The data generated by digital twins is a valuable resource for gear manufacturers. They can apply data analytics and machine learning to derive insights from this data.

Machine learning algorithms can be used to optimize processes, predict maintenance needs, and improve product quality further.

Digital twin technology is not only enhancing the efficiency and quality of gear manufacturing but also driving innovation in the industry.

The ability to simulate, analyze, and optimize processes in real time is invaluable, making gear manufacturing more competitive, adaptive, and capable of meeting the demands of various industries, from automotive to aerospace.

Challenges and Considerations in Implementation of Digital Twin

Implementing digital twins in gear manufacturing holds great promise but is not without its set of potential challenges and limitations.

Firstly, the complexity and cost involved in creating and maintaining digital twins can be a hurdle, particularly for smaller manufacturers.

The investment in sensors, IoT infrastructure, and data management systems can be significant.

Managing the massive amounts of data generated by digital twins is another challenge, requiring the right infrastructure and tools for handling and analysis.

Furthermore, interoperability issues may arise when integrating digital twin technology with existing manufacturing systems, emphasising the importance of ensuring seamless compatibility among equipment and software components.

Another challenge involves expertise and workforce training. Manufacturers need personnel who are well-versed in digital twin technology to effectively manage and utilise the systems.

This often necessitates additional training or hiring of specialised talent.

Scalability, especially for larger manufacturing facilities or complex production processes, can present logistical challenges.

Additionally, the reliability and accuracy of the data collected are paramount. Inaccurate data can lead to incorrect decisions and process inefficiencies, necessitating rigorous data validation and quality control.

Regarding data security and privacy, gear manufacturing often involves sensitive intellectual property and proprietary information.

Protecting this data against cyber threats is crucial, and robust measures such as encryption, access controls, and security audits must be in place.

Clarity on data ownership and rights within the organisation and with third-party partners is essential to maintain control over the data. Compliance with data privacy regulations and industry standards is vital.

In terms of technology integration, ensuring scalable infrastructure is important to accommodate evolving manufacturing needs.

Integration with existing manufacturing systems and legacy equipment is critical, as is standardising data formats and communication protocols to simplify the process.

Careful vendor selection is advised, with a focus on reputation, support, and compatibility.

Finally, equipping the organisation with the necessary data management and analytics tools is crucial to make the most of the data collected by digital twins.

Addressing these challenges and considerations allows manufacturers to reap the benefits of digital twin technology in gear manufacturing while ensuring data security, privacy, and smooth technology integration.

Digital Twin Paving the Road Ahead

The field of digital twin technology is continually evolving, with several emerging trends and technologies that hold the potential to significantly impact the gear manufacturing industry.

Advanced simulation and modelling techniques are becoming more accurate, enabling precise predictions and reduced prototyping costs.

Artificial intelligence (AI) and machine learning are increasingly being integrated into digital twins, offering predictive analytics, anomaly detection, and autonomous decision-making capabilities that can enhance gear manufacturing's quality control and process optimization.

Edge and fog computing reduce latency and enable real-time decision-making, crucial for precision manufacturing.

Generative design algorithms, backed by AI, rapidly generate and optimize gear designs, cutting design time and costs.

Digital thread integration ensures data continuity and traceability, benefiting quality control and compliance.

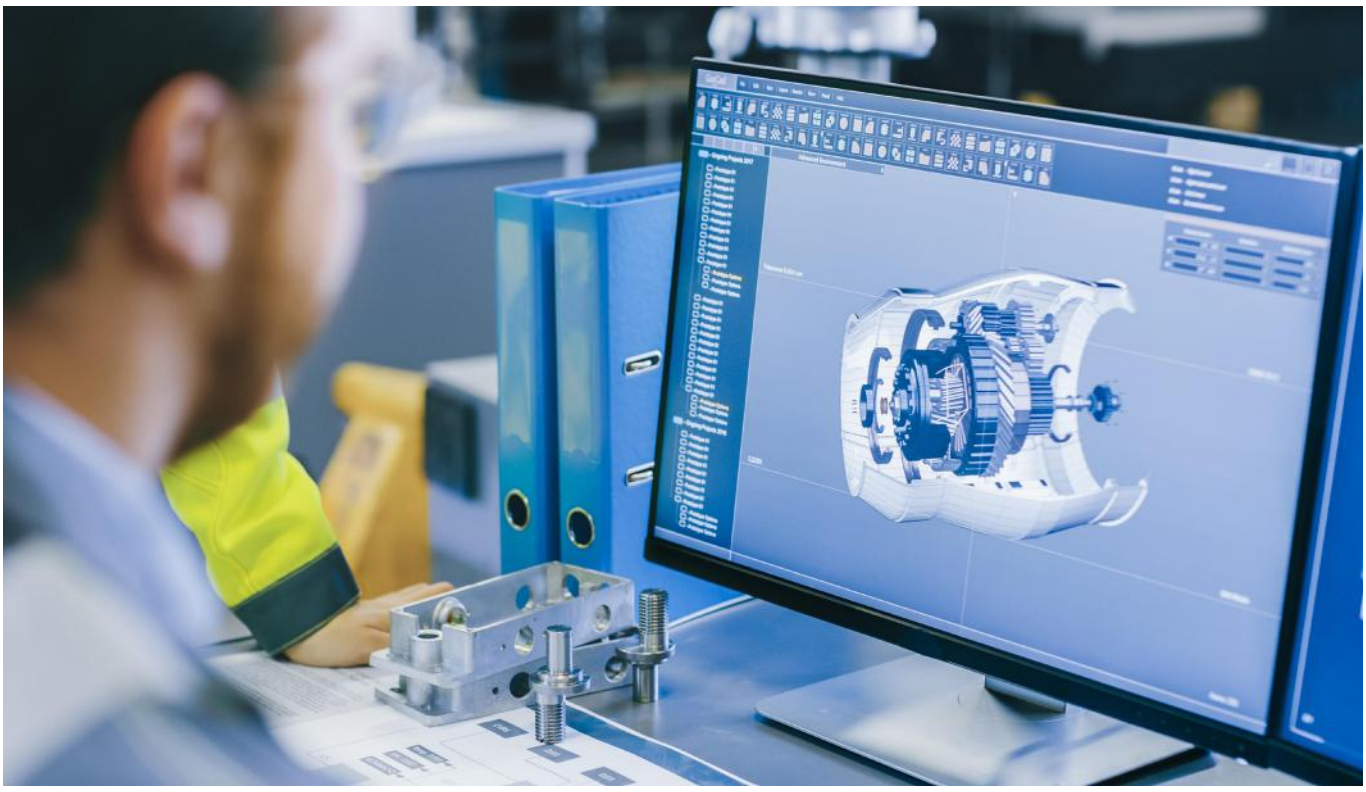
The rapid increase of IoT devices and 5G networks provide faster data transmission and lower latency, further enhancing digital twins' capabilities in gear manufacturing.

Lastly, blockchain technology is explored for securing and verifying data within digital twins, ensuring data integrity and enhancing security.

These trends and technologies collectively empower gear manufacturers to achieve advanced design, real-time monitoring, cost savings, and improved supply chain efficiency, positioning them as competitive leaders in the industry.

HIGHLIGHT

Digital twin technology not only enhances the efficiency and quality of gear manufacturing but also drives innovation in the industry. The ability to simulate, analyze, and optimize processes in real time is invaluable, making gear manufacturing more competitive, adaptive, and capable of meeting the demands of various industries, from automotive to aerospace.



EMO Hannover 2023: Back with a Bang!

By: Nishant Kashyap

After a four-year hiatus, the international trade fair once again scored with high internationality and innovative solutions for the industry's present challenges.
EMO Hannover 2023, which attracted a highly international audience from a wide range of industries, offered a glimpse into the promising possibilities for machine toolmakers.

A spectacular display of innovations, high levels of visitor interest from all over the world, and a great atmosphere in the halls… In the wake of a world transformed by the COVID-19 pandemic, these aspects were proof of why EMO Hannover 2023 was a resounding success.
"After the four-year break, the relaunch has been a huge success for EMO Hannover," affirmed EMO Commissioner General Carl Martin Welcker.

The international trade fair was held at Hannover Fairground in Germany from September 18 to 23, 2023.

Exhibitors and Visitors

The trade fair's strengths included the internationality of the exhibitors and visitors. Around 1,850 exhibitors attended, with roughly 70% coming from 45 different countries, including China, Italy, Taiwan, Switzerland and Japan. Of the approximately 92,000 trade visitors, 54% came from 130 countries.

Here, the five largest visitor countries were Turkey, China, the Netherlands, Italy and Poland.
Around one-third of the trade visitors came from Asia.

More than half of the visitors at EMO were attending for the first time, the exhibition company claimed.

This dovetailed nicely with the exhibitors' goal of attracting new customer business. Dr. Karsten Röttger, CEO at Ecoroll AG of Germany, said: "Many visitors became aware of us for the first time.

They hadn't even considered the possibilities of mechanical surface finishing.

Our tools allow them to meet the increasing product quality requirements, but above all the higher demand for sustainable products."

Around one-fifth of the exhibitors were also at the event for the first time. Representing this group, Jörg Rommelfanger, Head of ABB's Robotics Division, Germany, said: "This year's EMO provided the ideal platform for showcasing our latest technologies and solutions for the industry for the first time.

These included a machine loading cell specially designed for the fast and automated removal of randomly arranged workpieces. There was tremendous interest, and the numerous conversations and demonstrations we conducted were fruitful and inspiring."

Innovations on Display

According to the visitor survey, 30% of visitors gave "obtaining information about innovations and trends" as their top priority. A further goal was finding concrete solutions for their specific problems. And, EMO Hannover 2023 provided a perfect platform for top-class technical innovations. "We saw everything here for the future of production: new solutions for automation, for networking within the factory and for sustainable production.

When digitalization finds its way into the factory, there is no end to the potential for new solutions and increased efficiency. This was impressively demonstrated by the exhibitors. And there was a positive mood at the event, despite the tense economic situation," said Welcker. Dr. Matthias Klein, CSO of the Emag Group, added: "We have seen an overwhelming level of interest in the innovative solutions and machines of the Emag Group.

In particular, our solutions presented for machining electric vehicle powertrain components met with great interest. Overall, we are more than satisfied with the response from the market."

The exhibition showcased a diverse array of technologies, ranging from imposing double-column CNC machines to intricate miniature cutting tools, from IoT-based cutting tool fluids to intelligent design and manufacturing software.

The exhibits also featured tool holders sporting innovative geometries and tool presetters equipped with advanced tool management systems.

Among the plethora of cutting-edge technologies displayed were grinding machines, Coordinate Measuring Machines (CMMs), and collaborative robots (cobots). “Cobots are continuing to enjoy rising popularity in manufacturing, especially in smaller companies that are now struggling to find staff,” explained Nils Tersteegen, Marketing Manager at Japanese vendor Fanuc.

Trade Fair for Decision-Makers

It is important for exhibitors to be seen at EMO Hannover, to showcase their offerings and to demonstrate competence.

EMO is therefore a trade fair for executives and decision-makers from the mechanical engineering, automotive and supplier industries, metal processing, precision mechanics, optics, and the aerospace industry, among others.

Almost 60% of the visitors comprised executives or those from the top management. Just under half have decision-making authority for purchasing and procurement. Indeed, half of the trade visitors actually stated that they came to EMO with concrete investment plans. On average, these visitors planned to invest just under 3 million euros. More than a quarter said they had placed orders at the fair.

Stephan Nell, CEO of the United Grinding Group from Switzerland, said: “The number of leads is currently at the same level as in 2019. Some machine contracts were also signed directly at the trade show booth.” Another quarter of visitors said that they intended to place orders after the trade show, according to the survey.

“EMO Hannover has once again confirmed and consolidated its position as the world’s leading trade fair for production technology,” Welcker concluded. He is looking forward to the next event, which will doubtless attract even more exhibitors in two years’ time once the economy has improved. In 2025, it will be held from September 22 to 27.

Conclusion

EMO Hannover 2023 was an exceptionally well-organised event that not only showcased the latest developments in the machine tool industry but also highlighted the shifting dynamics of global markets. India’s rise as a major player in the industry was a recurring theme, generating hope and enthusiasm among exhibitors and visitors alike.

The organisers put together a truly remarkable show that left an indelible mark on the industry’s future. EMO Hannover 2023 was not just an exhibition, it was a glimpse into the exciting possibilities that lie ahead for the world of machine tools.

HIGHLIGHTS

EMO Hannover 2023

Opportunities in India: The excitement surrounding India was palpable, as global companies looked to this emerging powerhouse with newfound optimism. The Indian presence had significantly increased, with twice the number of exhibitors compared to the previous edition, and they occupied double the exhibition space. For instance, ACE Micromatic Group, India’s largest machine tool conglomerate, had an impressive presence with four booths at the show. It was a testament to India’s growing influence in the industry.

Industry 4.0: An interesting shift towards Industry 4.0 concepts was seen as companies proudly showcased innovative solutions and machines integrated with cutting-edge technology. Conversations buzzed about the potential for Industry 5.0, hinting at the ongoing evolution and transformation within the industry itself.

Integration of AR and VR: The integration of Augmented Reality (AR) and Virtual Reality (VR) was another intriguing aspect. Many CAD/CAM companies incorporated these technologies into their offerings, providing a glimpse into the future of design, prototyping, and production.

Sustainability: A striking trend that pervaded the event was a heightened focus on sustainability and carbon neutrality. Numerous companies unveiled innovative green solutions designed to reduce their carbon footprint, underscoring the industry’s commitment to environmental responsibility. The Future of Sustainability in Production was high on the agenda for 68% of visitors.

Connectivity: Another focus was on connectivity. The main emphasis here was on the open exchange of data – based on OPC UA, for example. This is the basis for the Companion Specification OPC UA for Machine Tools under the UMATI umbrella. Retrieving large amounts of data from digital controls without affecting the process was a key factor here.

UMATI (Universal Machine Technology Interface): Introduced in 2019, this initiative has come a long way, with numerous world-leading companies embracing the concept. It showcased the collaborative spirit of the industry, as organisations worked together to pave the way for a more interconnected and efficient future.

Start-up pavilion: A plethora of innovative solutions and concepts held the promise of reshaping the industry. It was a testament to the entrepreneurial spirit and forward-thinking mindset that thrives within the machine tool community. Many young engineers from the machine tool industry showcased their innovative products and concepts. Interestingly, there were special subsidies for start-ups at EMO.

Generating and Profile Grinding in Gear Manufacture

KAPP NILES Generating Grinding Machine KX 260 DYNAMIC with pick-up axis © Martin Witzsch

Generating grinding with dressable tools is an established technology in gear production. ZF Steyr Präzisionstechnik GmbH uses this process for a wide variety of applications, from series production to prototyping.

Flexible machines manufactured by KAPP NILES can master all applications at the shortest set-up time and fully integrated into automatic production. They can be easily used for profile grinding in special productions or prototyping which cannot be realized with generating grinding.

ZF is a world-leading technology group in driveline and chassis technology with around 230 sites in nearly 40 countries. One of these is ZF Steyr Präzisionstechnik GmbH in Upper Austria.

Around 500 employees produce components and gears for agricultural machines such as tractors, combine harvesters, forklift trucks, construction and special machines as well as steering gear components for the automotive industry.

The company rarely produces a large series for this portfolio, but rather focuses on small to medium series with high part variance.

Typical batch sizes are 200-500 pieces; but for some products it can also be as large as 5,000-6,000. Capacity utilization is high.
Usually 17 shifts are scheduled per week,i.e. three from Monday to Friday and two on Saturdays. Up to 20 shifts may be used for large orders.

Precision Technology for Large Series Production and Prototyping

Requirements resulting from the portfolio are diverse and very demanding.

There are seasonal fluctuations for the parts of agricultural machinery — a significant peak in the spring — compared to car manufacturing. However, the major issue is the extraordinarily high precision.

It is no wonder that "Precision Technology" is already included in the name of the company: Steyr. The noise emission requirements require immense accuracy for some components.

The steering gears, which are located near the passenger compartment, are a typical example. The small gears are also ground from the rod.
A similar level of precision is required for E-lift trucks which mainly operate in production halls.

There, the noise level generated by the production noise should not be increased even more by the industrial trucks.

Along with the day-to-day business, prototypes must also be produced from time to time. ZF Steyr relies entirely on the products of KAPP NILES for

grinding purposes. Fifteen different machines are in production; some are brand new while others are from the 80s.

Otmar Schlachter, authorised signatory and Head of the Production Process and Tools Management at ZF Steyr, explains the long-standing cooperation: "With KAPP NILES, the combination of tool and machine works perfectly; the machines are always running and in the shortest time.

You do not always find this interaction between machine and tool with manufacturers from whom you only buy one part." Lukas Aigner, Deputy Head of the Profit Centre Räder, adds: "The user interfaces are mostly the same. This is an advantage for us in production. An employee who is trained on one machine can also operate the others. In addition, many components are interchangeable. This facilitates the maintenance work."

In general, KAPP NILES tries only to use as many new parts in a machine as necessary in order to simplify the spare parts maintenance of various machines for the customer.

The service also includes remote diagnosis which allows a technician from KAPP NILES to get an impression of the machine in question before travelling to the site.

At times, this might even completely save a journey to the customer. Even service works such as installing new software updates can be done online.

"DYNAMIC" Machine Concept

The latest acquisition at ZF Steyr is the KX 260 DYNAMIC generating grinding machine (Fig. 1).

A smaller version, the KX 100 DYNAMIC, has already been in use for a while. Both are further developments of the multi-spindle design already realised with the KX 160 TWIN. As a pick-up machine with integrated automation, it is characterised by very short set-up and process times as well as a low surface requirement. The optional automated clamping device makes these machines equally suitable for series production with large and small batches.

Fig. 1: Group picture with generating grinding machine: Eldin Zuban, Otmar Schlachter, Karl Schlachter, Lukas Aigner (from left to right) in front of KAPP NILES KX 260 DYNAMIC © Martin Witzsch

The KX 100 DYNAMIC has two separate, rotatable mounted columns, whereas the KX 260 DYNAMIC has only one. These are fitted with vertically moveable pick-up axis, each equipped with a workpiece spindle. While a workpiece is being ground, the other pick-up axis removes the finished workpiece and loads a blank part on the workpiece spindle (Fig. 2).

Fig. 2: The pick-up unit removes a finished workpiece and loads a blank part on the workpiece spindle © Martin Witzsch

The workpiece is aligned outside the working space, so that the workpiece spindle can be swivelled to the processing speed and synchronised into the work space.

This reduces the non-productive times. For the KX 260, this can be reduced to 3.8 seconds. The multifunctional axis is used for discharging measurement and test parts (Fig. 3).

Only continuous generating grinding with adjustable grinding tools is used as the processing method. Depending on the application, both dressing tools with integrated head dresser and flexible tools with independent head dresser can be used on the dressing unit.

The “Topological generating grinding“ option makes it possible to produce gear grinding with or without targeted entanglement.

The advantage of the machine concept is the full integration of automation functions, since the parts can be loaded and unloaded from a belt without further handling devices.

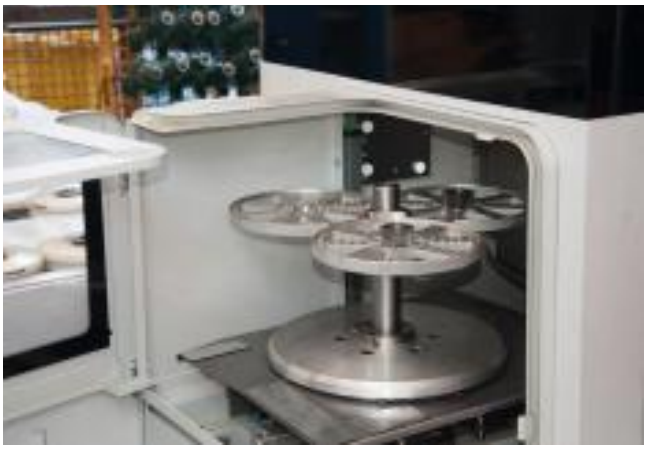


Fig. 3: The multifunctional axis allows the extraction of mea suring and test parts © Martin Witzsch

Optionally, a measuring unit is available for measuring and evaluating all relevant gearing features.

Automation Even During the Set-Up Process

The DYNAMIC machines do not only save time during the manufacturing process through automation. The set-up operations are also partially automated, such as the automatic screw change.

For this purpose, only the interchangeable prism is manually swivelled out of the park position (Fig. 4).

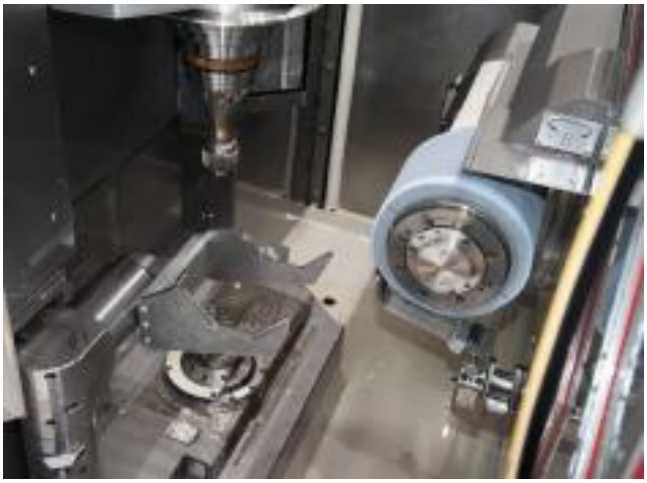


Fig. 4: Here, the interchangeable prism (left below) swivels out of the park position and ready to receive the screw © Martin Witzsch

The machine then places the tool securely at the push of a button. The operator swivels the tool into an ergonomic position and changes the screw manually or with a hoist.

The operator should neither loosen the screw nor climb into the machine. Lukas Aigner says: "The change can also be easily managed by new employees, as the machine shows the set-up sequence on the display and provides point-by-point instructions on what to do. In addition, the employee must acknowledge every step so that no mistakes occur."

Machinery for All Tasks

Even if the performance characteristics of a single machine are good, this alone is not sufficient for ZF Steyr's production.

Otmar Schlachter says: "Of course quick machining times are important, especially for small components in large quantities. The pick-up procedure is a valuable tool for this purpose. For us, however, the fact that the diamond dressing rolls are interchangeable on all machines is also very important. When a machine is occupied, we can move to another machine for an order. It is only thanks to this flexibility that we can manage our portfolio." (Fig. 5).

Fig. 5: The diamond dressing roll on the left in the picture can be used on all machines © Martin Witzsch

Of course, support is also important when producing a new product. Otmar Schlachter adds: "Sometimes, we need a suitable dressing roll for a new gearing at short notice. KAPP NILES offers a very good and quick service for this purpose."

Lukas Aigner addresses another application: "For some components, the generating grinding reaches its limits, e.g. in cases of several gearings on one component, double wheels, etc. which can no longer be machined with large tools. We have equipment on which we grind up to 70% with CBN wheels in sub-processes (profile grinding). Although the grinding process takes longer, a component, e.g. a lateral ring, can be produced in one clamping. This saves on overall throughput time."

Prototyping: Batch Size 1 Integrated Into Day-to-Day Business

Small and medium batch sizes are the core business in Steyr. From time to time, however, prototypes are also required. There are only a few ZF sites that can take over this. In the case of large series production of passenger cars, it is very difficult to organize such special orders.

Nevertheless, the corporate group relies on these components. Otmar Schlachter explains: "Gear manufacturers want new features every 3-4 years. In the case of upper class vehicles, the demands on performance and gearing keeps increasing while the installation space remains the same. One has to produce prototypes quickly during operation. Companies gladly send us such orders." For this purpose, the production with adjustable discs is unbeatably fast.

Lukas Aigner describes it vividly: "You take a grinding wheel, pull the profile on it and you can grind within one day. You would have to wait 8-10 weeks for a new tool. It is then ground out of the full material. In case of a prototype it is irrelevant if the machine runs for two hours." Ulrich Roos, Regional Sales Manager for Automotive Sales at KAPP NILES, describes how the KAPP NILES machines support this process: "Some machines must be programmed block by block. Our controls can independently generate programs. First, you simply enter the gearing and technology data. The latter can even be left to the machine. It then makes suggestions for the number of cuts and strokes, speed, infeed depth, etc. Therefore, you do not need to know all the complex interrelationships. If needed, you can of course make corrections based on your own experience. Once the input is complete, the machine generates the program at the push of a button."

Integration Into the Overall Process

The described, varied tasks require individual solutions. Ulrich Roos says: "Our advantage is the broad product range: We are proficient in profile and generating grinding, combined with single-spindle, double-spindle and pick-up machines. Moreover, our machines are universal. We can also perform, for example, internal grinding on the large KX 500 FLEX. Hardly any other manufacturer has this wide range of processes and machine configurations in its portfolio."

One of the specialties of KAPP NILES are small grinding discs for workpieces with interfering contours.

The Coburg company has a lot of experience with these components, which are typical for ZF Steyr. It manufactures its own tools and has developed machines with above-average speed for workpiece and tool spindles.

This makes it possible to achieve high cutting speeds even with small tools. This has another advantage for integration into automated production:
The workpiece is immediately degreased in the machine through centrifuging.

Thus, an oil discharge in the transfer station and carry-over onto the conveyor belt is avoided without a separate handling. ZF Steyr uses this option for the steering gear production on the KX 100 DYNAMIC.

In addition to the main features, precision and speed, these features help to integrate the machines perfectly into a highly flexible production.
"The machines feature high technical availability. In addition, the service is excellent," says Otmar Schlachter, summarizing the experience with KAPP NILES. A statement confirmed by the excellent cooperation and the large machinery.

The author, Martin Witzsch, is a freelance journalist for Kapp Niles (www.witzsch.com)

R 300: Are You Still Hearing It, Or Are You Already Measuring It?

By: Dr.-Ing. Alexander Landvogt, and Thomas Serafin

The measuring technology on the Höfler R 300 Cylindrical Gear Roll Testing Machine provides a reliable way to determine the root causes of gearbox noise. Due to the short measuring time, it can be easily integrated into any manufacturing process.

The more precisely a gear is manufactured, the better its running behavior will be. This is true for the working load limit of a gear, but not to a gear's noise emissions.

Thus, gears with almost identical results in pitch, profile and tooth flank measurements can differ significantly in terms of noise behavior in the gearbox.

The result can be heard right away – but finding the root cause is not so easy.

There seem to be many causes for gear noise, but it actually always boils down to vibration of the gear elements under load. The noise behavior is mainly determined by vibrations resulting from tooth contact.

Starting from the tooth contact, these vibrations are transmitted to the gearbox housing surface as structure-borne noise and radiated from there as audible airborne noise.

From Hearing...

The "sore point" in production is not the running behavior resulting from the design, but the fluctuations in noise results on the end-of-line (EOL) test rig. If unacceptable noise behavior occurs here, a very complex root cause analysis of all components is required.

Often the unpleasant noise can then only be "miraculously" eliminated by replacing individual components. This accounts for the increasing need to predict noise for each individual gear even before assembly.

... to Measuring

Because there are many variables influencing the transition from vibrations to airborne noise, a simple geometric consideration of the gear deviation is not sufficient for noise analysis. Here, suitable measurement methods and special evaluation procedures are required to get to the bottom of the noise.

When it comes to improving noise behavior, a general distinction is made between primary and secondary measures.

Primary measures minimize the excitation behavior, while secondary measures improve the transmission path from excitation to the generation of airborne noise. The rest of this article will focus on the primary measures.

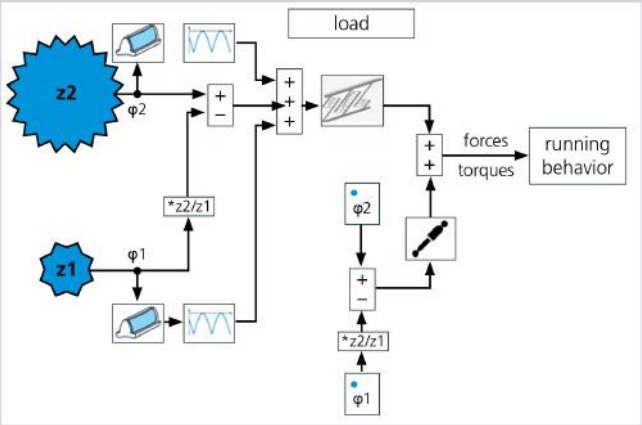


Fig. 1: Interaction between tooth flank geometry, load influences and attenuation

Figure 1 shows how manufactured tooth flank form, load influences and attenuation interact.

So where can we start to get a clear picture of a gear's noise behavior in series production? Keeping in mind the reality of manufacturing, variations in material characteristics and variations in attenuation behavior in the gearbox can be ruled out.

Consequently, the tooth flank is the only thing remaining that is allowed to change within the tolerance specifications for manufacturing.

And that's the good news: With a load-free examination of the tooth flanks, almost all effects on gear noise caused by tooth contact can be detected.

Roll Testing

The single-flank test is a method that has been used for decades to evaluate the quality of the rotary transmission or running behavior of two gears.

To test the running behavior, the gear is generated with a precisely manufactured master gear.

Due to the low test speed, the single-flank test is highly reproducible, but it involves a longer measuring time.

The structure-borne noise measurement very closely approximates the noise behavior in the gearbox.

Instead of measuring the transmission error between the test gear and the master gear with high-resolution angular encoders, an acceleration sensor is used here to record the dynamic excitation from the tooth contact on the structure of the test rig.

Since this is done at much higher speeds compared to the single-flank test, the measuring time is relatively short.

In addition, there is also the rotational acceleration measurement, which instead of measuring the vibration excitation in all spatial directions, only measures those that act on the rotation of the test gear and master gear.

In purely mathematical terms, this is the second derivative of the single-flank test. All roll testing methods are characterized by the fact that all tooth flanks of the test gear undergo a function-oriented measurement.

Compared to 3D coordinate measurement, the effect of the geometry deviation on the function is evaluated and not the deviation compared to the nominal geometry.

However, only the areas of the tooth flanks that are in rolling contact with the master gear are evaluated.

By suitably designing the tooth flank geometry of the master gear, the area to be examined can be optimized to achieve an adequate correlation with the end-of-line (EOL) test rig.

Although the characteristic values of the gear geometry deviations are of secondary importance in roll testing, the results reflect the running behavior as closely as possible.

Instead of analyzing the transmission error or acceleration signals in the time domain, they are represented as an order spectrum using a Fourier transformation. In simple terms, an order spectrum indicates how often an irregularity occurs per gear revolution.

Fig. 2: Roll Testing

The magnitude of such an irregularity is expressed in the amplitude of the respective order (see Figure 2).

Runouts can always be found in the low orders. If eccentricity is the only irregularity on the gear, only the first order is present.

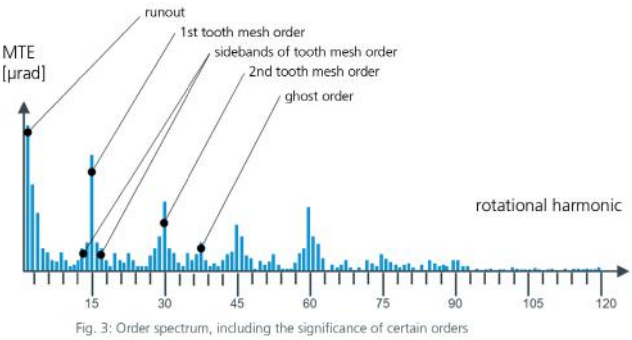


Fig. 3: Order spectrum, including the significance of certain orders

Fig. 3: Order spectrum, including the significance of certain orders

For example, in a gear with 15 teeth (see Figure 3), tooth contact occurs 15 times per revolution.

This is the reason for the 15th order. The amplitude of this order depends on the size of the tooth flank modifications defined in the design.The orders in the immediate vicinity of a tooth-mesh order originate from single pitch deviations and runout.

The prominent 38th order is a gost order.
Gost orders are orders that do not correspond to any multiple of the number of teeth. They are caused by manufacturing deviations that are not equally present on all teeth.

An order spectrum therefore offers deep insight into the quality of a gear's transmission error, which is ultimately the cause of vibrations and the resulting noise.

Gear Measurement Technique

In contrast to roll testing, the focus here is on the geometry of the gear. The gear measurement

technique is used to detect the production-related geometric deviation of the pitch, the tooth flank in profile and lead direction, and to minimize it by means of corrections on the processing machine.

Although the gear measurement technique is called a function-oriented test, its validity is limited.

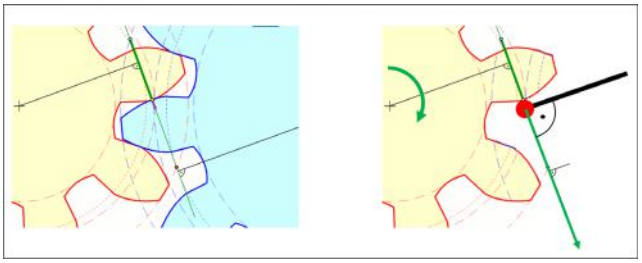


Fig. 4: Length of path of contact and profile measurement

The functional orientation is based on the distinctive characteristic of involute gears, whose contact points of the tooth flanks run along the so-called straight length of path of contact. (see Figure 4).

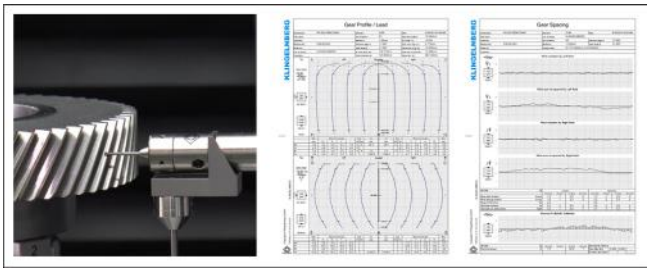


Fig. 5: Profile and flank line measurement on four teeth as well as pitch measurement

The key difference in comparison to roll testing is that line measurements in the profile and lead direction are used to draw a conclusion about the geometry of the gear (see Figure 5).

This assumes that when three or four teeth are measured on the perimeter, all teeth are essentially identical.

The indisputable advantage of the gear measuring technique is that it can be used to conclusively pinpoint manufacturing deviations, which in turn opens up possibilities for corrections.

In the design phase, tolerance widths for pitch, profile and lead are defined such that the theoretical running behavior will fall into the acceptable range. Thus, the running behavior is not explicitly tested.

Rather, it is assumed that the 3D surface tooth flank resulting from extrapolation of the measured profile and lead will exhibit precisely this behavior. But the conventional gear measuring technique reaches its limits in noise-critical applications. Profile and lead measurements are inadequate when it comes to identifying flank defects that are relevant to noise.

In addition to selective point and line measurement, limiting the measurement to three or four teeth on the perimeter introduces additional measurement uncertainty.

Gear Deviation Analysis (GDA/ Waviness Analysis)

Nevertheless, geometry-based detection of noise excitation has not reached ist end. Measurable waviness that leads to vibrations when the tooth flanks are generated can be identified by a graphical comparison of measurement results on loud and quiet gears.

Quantitative analysis of waviness requires an evaluation method that allows the amplitude and frequency of the waviness to be reliably determined.

Since the waviness amplitudes are often in the nanometer range, measuring point acquisition requires high resolution and, in particular, an extremely accurate measuring instrument.

Surface waviness is a periodically recurring geometric deviation.
The dominant waviness method according to VDA 2007 is suitable for evaluating surface waviness.

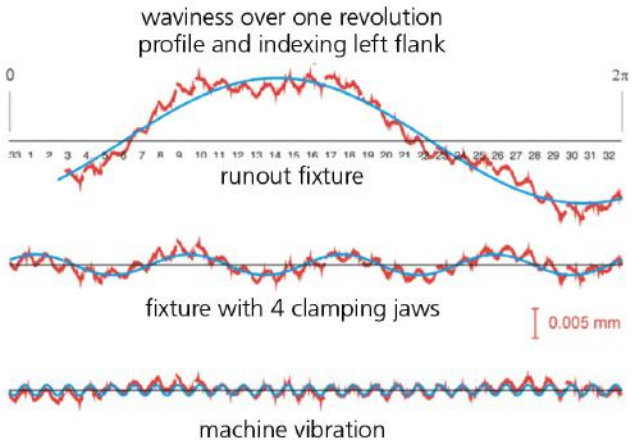


Fig. 6: Result of a GDA/waviness analysis

This method makes it possible to identify a periodic deviation even at small wavelengths of just a few micrometers (µm).

Figure 6 shows the results of a profile and pitch measurement on a gear with 33 teeth. This diagram should not be confused with the results diagram of roll testing. The curve segments shown in red at the top are the results of the profile measurement of each gear tooth.

Each of these profile measurements is vertically shifted by the result of the pitch measurement.

The analysis shows three prominent waviness instances. The waviness shown at the top has a wavelength that corresponds to the entire reference circle perimeter of the gear.

This first order can always be attributed to runout. The first order is subtracted in the center section of Figure 6. Now, a fourth order is evident. It was caused by the collet of the fixture, which holds the workpiece in four locations and undergoes elastic deformation during the hard finishing.

The first and fourth orders are subtracted in the bottom segment. Now, a 28th order can be seen.

Since the component has 33 teeth, this cannot be the tooth mesh order. Rather, it is a machine vibration that is occurring 28 times per workpiece revolution.

Assuming that waviness does not only occur singularly on one gear tooth, but can be found on all teeth, a sufficiently reliable conclusion can be drawn as to whether or not noise-relevant orders are present by evaluating four profile and flank line measurements as well as the pitch measurement.

Since the evaluation is generated as part of the usual gear measurement without any additional effort, the waviness analysis of the gear measurement offers the potential to detect noise-critical gears at a very early stage.

For troubleshooting purposes and to precisely identify what critical orders are occurring, an all-teeth measurement is essential.
This is the only way to detect noise-relevant deviations that do not occur periodically with tooth contact, but do occur periodically with rotation.

Roll Testing Versus GDA

Both roll testing and the waviness analysis generate an order spectrum that provides quantitative insight into the running behavior of a gear. But what potential does each offer – and where are their limits? (See also Table 1.)

	Roll Testing SFT, SBN, TAT	GDA Software
Inline Integration	↑	↓
Isolated results of the gear to be checked	↗ depending on master gear quality	↑
Investment	↓ additional machine	mandatory, GDA on 4 teeth without additional operation
Tooth mesh orders	↑	↗ 4 teeth measurement → all teeth measurement
Sidebands and ghost orders		↓ 4 teeth measurement ↗ all teeth measurement
Single flank test (SFT)	↑	X
Structure-borne noise test (SBN)	↑↑	X
Torsional acceleration test (TAT)	↑↑	X
Correlation to EOL results	↑	↗
Closed Loop manufacturing feedback	↓	↓

Tab. 1: Differences between roll testing and Gear Deviation Analysis processes

Tab. 1: Differences between roll testing and Gear Deviation Analysis processes

The GDA/waviness analysis generates an order spectrum that originates solely in the gear undergoing testing, whereas in roll testing, the master gear influences the result.

This places considerable demands on the tooth flanks of the master gear. But roll testing does include a large part of the tooth flank in the measurement – and not just the lines in the profile and flank line direction.

Another difference is the structure of the order spectra. The more teeth are measured, the more closely the structure of a GDA spectrum will match that of roll testing.

Low orders or orders that only periodically match the gear rotation, but not the tooth contact, are only detected by the GDA software if all teeth are measured. An even better match can be achieved if the orders resulting from the profile and pitch measurement are superposed on those from the flank line and pitch measurement during the GDA.

The amplitudes in the order spectra must differ due to the process. During roll testing, a wave is only detected in the tooth contact if the flank of the master gear can follow the wave trough of the test gear and does not bridge it.

A similar effect is known from roughness measurement when using different radii of the test needle. With the GDA software, this ball diameter effect plays a significantly smaller role. Thus, the amplitudes of the two order spectra will differ.

Examples from the Field

A look at specific example gears (z = 63, mn = 1.52 mm) illustrates the possibilities of the GDA software and the single-flank test (SFT) on the Höfler R 300 Cylindrical Gear Roll Testing Machine for identifying noise excitation-relevant geometry deviations.

The GDA is based on all-teeth measurements of pitch, profile and lead that were taken on a P 40 precision measuring center using a stylus with a 1 mm ball diameter. For the SFT measurement series, a z = 32 master gear (MSTR) was used. The profile radius of curvature on the MSTR reference circle is 9.627 mm.

Reference Gear ...

The measurement results show that the reference gear essentially has a sinusoidal accumulated pitch error and a flank topography without waviness (see Figure 7). Accordingly, the order spectrum of the single-flank test at the top of the figure shows a prominent 1st order (O63) and a precipitous drop

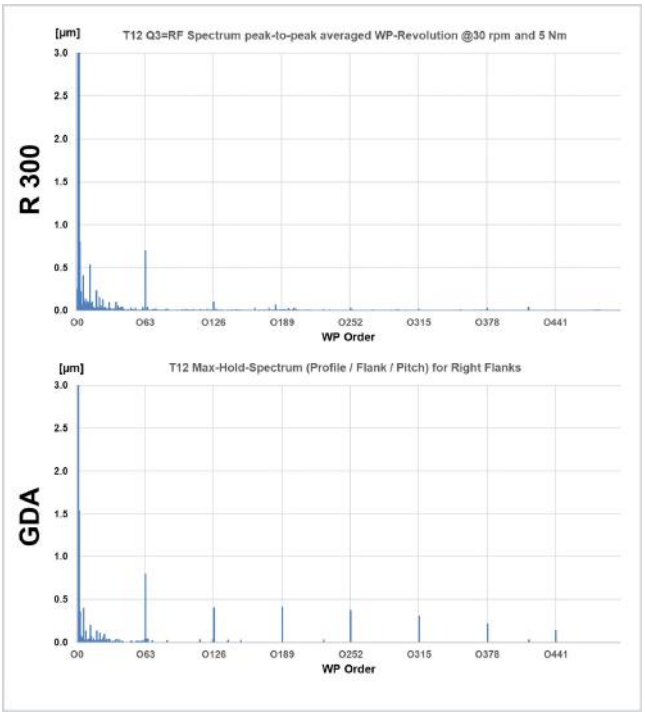


Fig. 7: Comparison of SFT versus GDA using the example of a gear with sinusoidal accumulated pitch error and a flank topography without waviness

in the amplitudes of the higher-harmonic of fz. Similarly, in the GDA order spectrum, the 1st order is prominent, but the amplitudes of the higher harmonic of fz are significantly larger in the GDA order spectrum than in the spectrum of the single-flank test. This is due, among other things, to the different stylus radius and profile radius of curvature sizes. Between the orders of the 1st fz and its higher harmonic, no extremely significant intermediate orders, or sidebands, can be identified in either the SFT or the GDA spectrum.

... Versus SFT and GDA Order Spectra

Compared with the reference gear in Figure 7, Figure 8 shows a side-by-side comparison of the SFT and GDA order spectra for a gear that was ground with a defective, three-thread grinding worm.

Due to the whole-number transmission ratio between the number of workpiece teeth (z = 63) and the three-thread grinding worm, both the SFT spectrum and the GDA spectrum show prominent amplitudes for the 21st workpiece order and its multiples, in addition to the harmonics of the tooth-mesh order.

When Gears are not Smoothly Ground

Figures 9 to 11 show what gears can look like if they have not been smoothly ground.
Some tooth flanks show shading produced by a lack of grinding (see Figure 9). Accordingly, there are two significantly different areas in the averaged workpiece rotation of the single-flank test (see Figure 10). In

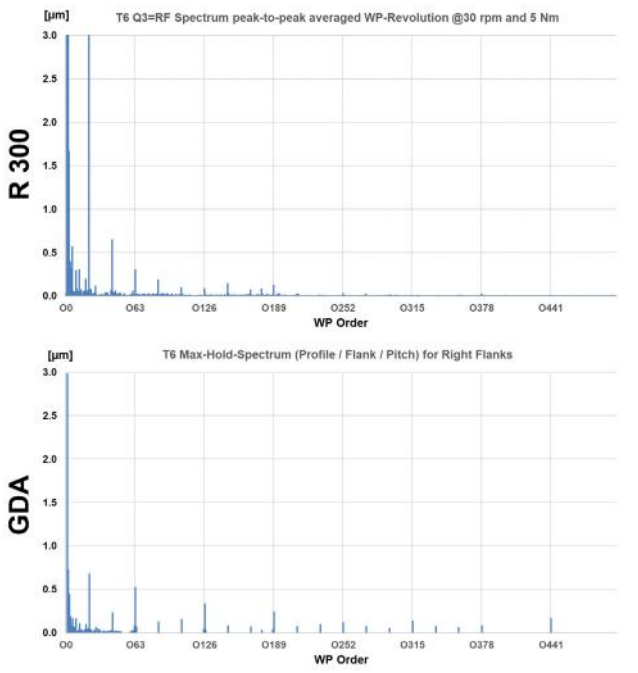


Fig. 8: Comparison of SFT versus GDA using a continuously generative-ground gear machined with a three-thread grinding worm as an example

the corresponding order spectra of the SFT and the GDA (see Figure 11), in addition to the amplitudes of the 21st workpiece order and its multiples already known from the previous example (see Figure 8),

Fig. 9: Tooth flanks of a continuously generative-ground gear that has not been smoothly ground in certain areas

other prominent amplitudes can also be recognized as sidebands to these orders and the tooth mesh harmonics.

The examples here show a good correlation between the results of the SFT and the GDA. Thus, both methods are suitable for identifying noise-relevant geometry deviations. Each has different advantages, however. Due to its significantly shorter measuring

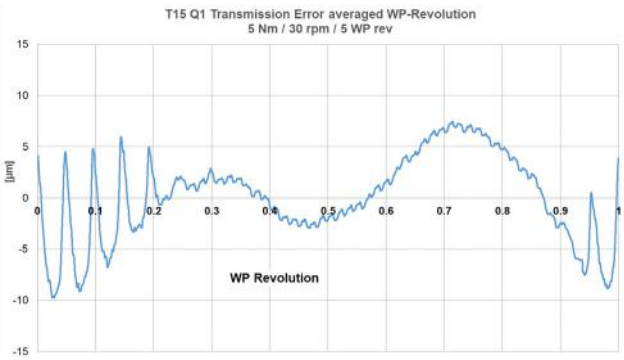


Fig. 10: SFT averaged workpiece rotation of a continuously generative-ground gear that has not been smoothly ground in certain areas

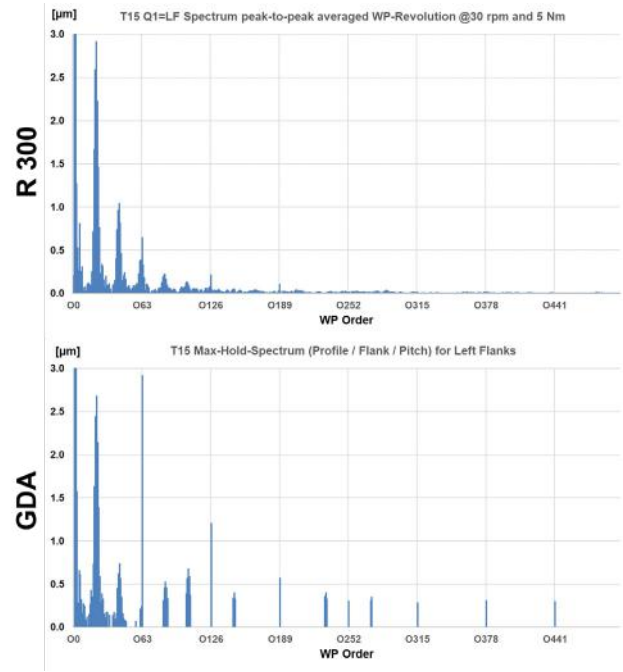


Fig. 11: Comparison of SFT versus GDA using a continuously generative-ground gear that has not been smoothly ground in certain areas as an example

time, the single-flank test is well-suited to complete inline monitoring of the production process.

The GDA, on the other hand, is better suited to laboratory analyses due to its all-teeth measurement.

Conclusion: Informative Value of Order Spectra

Both roll testing and the waviness analysis are suitable for detecting gears that are critical from a noise perspective.

The informative value of an order spectrum goes far beyond the evaluation of a conventional gear measuring technique.

The appeal of the GDA software lies in the fact that it can be integrated into the process chain without any additional effort. Klingelnberg's P-series Precision Measuring Centers provide clear indications of expected noise problems for each gear measured.

It must be mentioned that the structure of the order spectrum only attains its full informative value when an all-teeth measurement is performed. This is where the orders classified as critical by the EOL test appear, because they convert vibrations in the gearbox into airborne noise. Due to its short measuring time, the R 300 can be easily integrated into the production process. This permanently prevents quality slippage.

Thus gearbox noise is best determined with roll testing on the R 300. A Klingelnberg Precision Measuring Center then provides the critical geometric information for measures to remedy the noise excitation.

The authors are Dr.-Ing. Alexander Landvogt, Head of the Roll Testing Competence Center, and Thomas Serafin, Application Developer at Klingelnberg

Precision Redefined: The VAJRA 130 CNC High Speed Gear Hobbing Machine

By: Sai Sagar

In an era where precision and speed define manufacturing excellence, Nimble Machines (a strategic business vertical of UCAM Pvt. Ltd.) proudly introduced the VAJRA 130 CNC Gear Hobbing Machine at the IMTEX 2023 Exhibition.

The VAJRA 130 CNC Gear Hobbing Machine, the latest addition to our product range alongside VAJRA 250 and VAJRA 400, meets the contemporary demand for high-speed hobbing. It features a module capacity of up to 3 and handles diameters of 130mm, positioning it as a leading choice in precision gear manufacturing.

Advanced Features for Unparalleled Precision

Dry hobbing capabilities: Eliminates the need for coolant during the machining process. This not only enhances environmental sustainability but also reduces operational costs for end-users.

Servo tailstock: Ensures precise and automated positioning of the workpiece, reducing the cycle time and contributing to the overall efficiency of gear manufacturing.

Smaller footprint: Minimizes floor space, ensuring an ergonomic layout for seamless operation

Gearbox Technology: Implements Electronic GearBox (EGB) for enhanced efficiency

Precision Casting: Utilizes Epoxy Filling Casting for improved stability and durability

Automated Loading System: Includes an Indexing type ringloader for component loading/unloading and Component magazine for continuous component feeding.

Unveiling Unprecedented Speed for Peak Performance

Central to the VAJRA 130's superiority is its remarkable speed, driven by advanced features such as direct-driven high-speed spindles. With a spindle speed reaching an impressive 4500 rpm and a table capable of up to 450 rpm, this machine surpasses traditional counterparts, translating to faster production cycles without compromising precision. The direct-driven high-speed spindles contribute to excellent performance in both wet and dry hobbing processes. The implications of such speed extend to a broad range of applications, with a special emphasis on precision components like steering pinions among other automotive gears.

Conclusion: Elevating Manufacturing Excellence

The VAJRA 130 CNC Gear Hobbing Machine is not merely an addition to our product line; it represents our commitment to the gear manufacturing technology. Its compact design, innovative features, and unparalleled speed collectively position it as an industry game-changer. Whether you are a seasoned industry player seeking efficiency enhancements or a newcomer aiming to set new standards, the VAJRA 130 promises to elevate your gear manufacturing processes.

A Pre-Event Report on IPTEX-GRINDEX 2024

By: Divya Sudarsanan

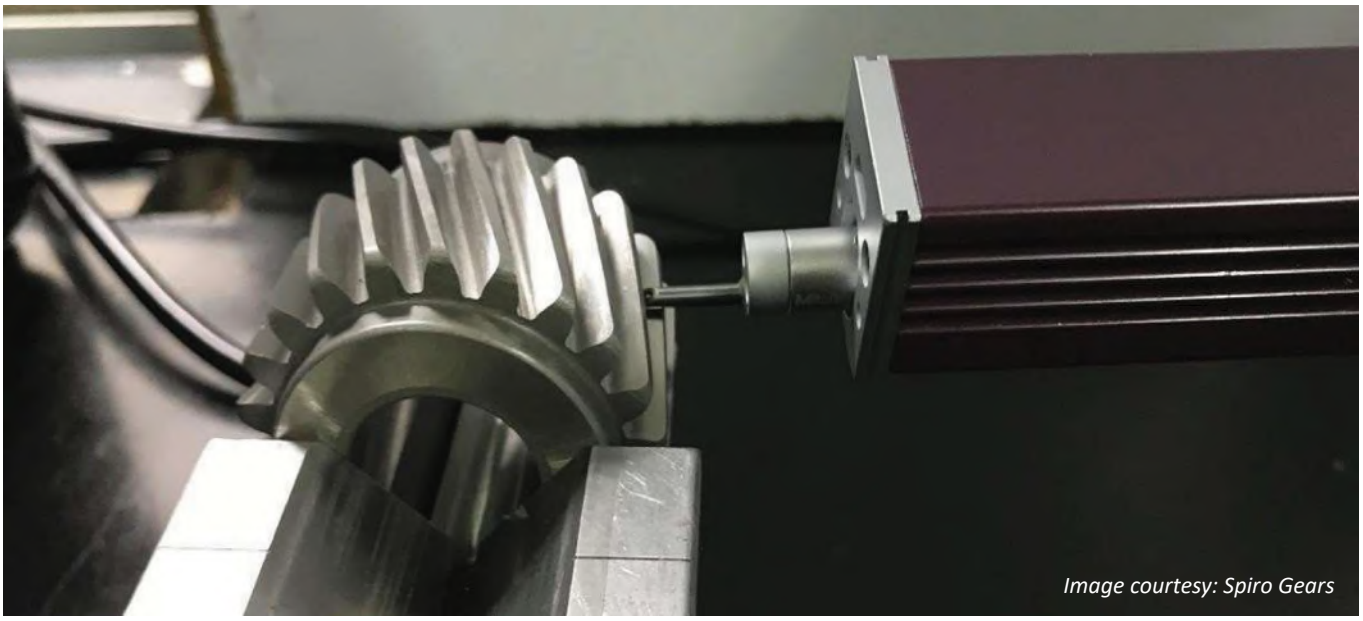


Image courtesy: Spiro Gears

2024 is off to a big start! Virgo Communication and Exhibitions are proud to organize two power packed events catering to the gear manufacturing market.

Its 8th edition of the International Power Transmission Expo (IPTEX), and the 6th edition of the International Expo on the Grinding and Finishing Process (GRINDEX) will take place in Pune.

This explosive IPTEX-GRINDEX exhibition brings together two massive events for both exhibitors and visitors under one roof on this amazing platform.

The benefits are enormous – from showcasing the latest innovations and trends to networking with important stakeholders in the industry, and live demonstrations to seminars, and even a first-of-its-kind award show, this exhibition promises to be unlike any other exhibition that you've either as an exhibitor or a visitor has ever witnessed.

Co-founder of Virgo Communications and Exhibitions, Raghunath G, had this to say: "We are delighted to be organising the 8th edition of IPTEX and the 6th edition of GRINDEX.

Over a period of years, we have worked closely with the gears & grinding industry and it is great to see the industry grow by leaps and bounds and to create a platform that further encourages the growth of the industry. The gear industry is the backbone of many other sectors and an integral part of our day to day lives and if there is one industry that can accomplish the "Make in India" vision, it will be this one."

The three-day IPTEX-GRINDEX event will take place on Feb 22-24 at the Auto Cluster Centre in Pune. On the second day of the expo, India's First Gear Industry Business Excellence and Achievement Award Ceremony will take place.

For more information on these awards,

click here

Gear Technology India spoke to prior exhibitors who are participating in the upcoming exhibition, and this is what they had to say:

What Exhbitors' Say

Sachin Mahajan,
Marketing Head, India,
Quaker Houghton.

"We've been partnering with the expo from the first edition which started in Mumbai. This is an exclusive expo for gear and transmission, and we have a product line for this reason.
The IPTEX-GRINDEX expo is an apt platform to interact with the customers. We will be introducing new product lines for gears and transmission at the upcoming expo."

Amit Kumar Singh, Molemab India

“We’ve been participating in the IPTEX-GRINDEX expo for over three years now, before Covid hit. We feel this is one of the best platforms; Pune is an automotive haven. We have a complete range of products that we manufacture, and is a great opportunity to meet customers – new and old. We are looking forward to catering to new customers to your list, we have new range of griding products to showcase. Indian manufacturing plant in Bangalore introduce and look for building new relationships for Make in India products.”

Madhu Devarajan, Export Marketing Engineer, Ghishnu Gear

“IPTEX - Grindex is one of the established platforms to connect customers with the gear people all around the world. We have been part of the expo for 6 years. We get opportunities to meet new customers and traders, and we try to build a connection. We are newly getting into Planetary gear segment, and our USP is that we have the capacity to cut internal helical gears in our facility.”

Sriharsha M. B, REISHAUER AG (Proteck Machinery Pvt. Ltd)

“We've been part of the IPTEX-GRINDEX show from the first edition. The expo is more focussed on gears and transmissions, and this is what makes us return. This time during the 3-day event, we will be looking at showcasing tooling and technologies. There will be no machines on display at the upcoming event.”

Mr. Kansara, Partner, Supreme Gears Industries

“We've been part of the expo from the first edition itself. This is an apt platform for us to attract new customers, and connect with old customers. We will be showcasing our products like spur helical worm shaft, spiral bevel, rack pinion and so on at the upcoming expo.”

Mr. Naveen Patel, Executive Vice President, Business Development, Empire Machine Tools

“Empire Machine Tools is associated from inception of IPTEX. The expo is a niche and focused segment, and thus we get the opportunity to meet existing customer and potential customers. At this expo we will be showcasing a Profilator Germany make advanced generation scudding (skiving) solutions, Profilator Gear Center - Producing all key gear features in one machine. Kanzaki Japan make new generation high speed gear Grinding and Gear profile Honing solutions, Spline Rolling solutions for EV Transmission shafts, Rotary Transfer solutions for high production volume and a one source to complete GearTech solution.”

Manoj Agarwal, CEO, Spiro Gears

“We've been a part of the IPTEX-GRINDEX expo since 2016. It's because of the visitors that come here for the expo, as they are very focused and genuine inquiries. Besides this, Pune is a great hub for meeting such visitors who are very supportive of the gear manufacturers. We have developed new and different gears for the American and European market for the upcoming expo.”

Aroop Kumar, Owner, TASA MICRO

"We’ve been with IPTEX-GRINDEX from the beginning. As a gear machine builder, we don’t get the recognition at other expos unlike at IPTEX-GRINDEX because it caters to our specific needs, and offers that space. For the upcoming expo, we will be exhibiting something new for our customers.”

Precision Engineering Excellence: A Deep Dive into RDMC's Gear Manufacturing Legacy with Tarun Nahata

By: Sushmita Das

Founded in August 1972, Research Development & Manufacturing Corporation (RDMC) has evolved into a global leader in high-precision gear manufacturing. Specialized in crafting tailored components for the engineering sector with over 50 years of experience, *Gear Technology India* caught up with Tarun Nahata about his company's role in custom gear manufacturing, and more.

Can you provide an overview of your company's background and activities?

Established in August 1972 in Bangalore, Research Development & Manufacturing Corporation (RDMC) embarked on a journey with the ambitious vision of serving the engineering sector and establishing a global footprint. With over five decades of experience, RDMC has emerged as a premier manufacturer of High Precision Gears, specializing in the precision machining of components tailored to meet our customers' exact specifications.

As an ISO 9001:2015 certified company, we uphold quality standards that rival the best in the industry.

RDMC looks forward to new ventures, with its parts encompassing higher precision and driven by innovation.

Ring gear

What is your manufacturing capacity for different types of gears (spur, helical, bevel)? Can you share details about the largest gears you've produced and their applications?

Over five decades, RDMC has meticulously developed a cutting-edge machine shop that seamlessly integrates both CNC and Conventional machines.

Our unwavering commitment to excellence is evident in our strategic investment in the latest technology, aligning our capabilities with the dynamic demands of today's market. RDMC proudly boasts a collection of top-tier machines sourced from industry leaders.

Within our state-of-the-art facility, our robust machines stand ready to manufacture External Gears with precision finish cuts in both Spur and Helical configurations. These machines excel in handling a wide range of diameters, spanning from 10mm to an impressive 1800mm, with Module specifications ranging from 0.75M to 24M.

The versatility of our operations extends to Internal Gears, where finish cuts are achieved with diameters ranging from 50mm to 1000mm and Module specifications from 0.5 to 12 Modules.

Moreover, our capabilities extend to external ground gears, offering a range from a minimum diameter of 10mm to a maximum diameter of 1100mm, and supporting a maximum module of up to 25M, all while maintaining a gear quality standard of DIN 5. Internal Grinding processes cover a diameter spectrum from a minimum of 230mm to a maximum of 1000mm, also adhering to a gear quality standard of DIN 5.

Complementing our comprehensive gear shop is our sophisticated machining setup, featuring a battery of CNC Turning & CNC VTL (with a turning capacity of up to 1800mm), VMC, HMC, and a range of other allied machines.

RDMC proudly houses an impressive Inspection Facility, equipped with a Klingelnberg P100 Gear Tester and a CMM capable of measuring parts up to 1500mm x 1200mm x 1000mm. This underscores our commitment to ensuring the highest standards of quality and precision in every aspect of our operations.

At RDMC, our dedication to staying at the forefront of technology and quality assurance positions us as a reliable and versatile solution provider in the ever-evolving manufacturing landscape. The largest gear manufactured at RDMC was Dia 1800mm x 16 module (Cut Gear) for a Tyre Machine Manufacturer. In the past, we have also manufactured tailor-made precision large-size gears for Dams, Paper, Sugar, Cement and Steel Mills.

What's the largest custom-built gearbox you've supplied, and who was the recipient? Additionally, could you share the applications for which this gearbox was used?

In the year 1989 RDMC exported gearboxes for industrial application to the then-Soviet Union of Russia and has since pioneered the capability of manufacturing gearboxes of all sizes and applications. RDMC also emphasizes on having its manufacturing skills in Planetary gearboxes for applications like windmills, marine engines, industrial gearboxes, and so on.

Gearbox 2

Have you supplied any gears or gearboxes to the aerospace industry?

RDMC has not only supplied gears but has also machined and supplied complex components for the aerospace industry namely HAL, AERDC, GTTC, NAL, ISRO, ISTRAC etc. RDMC has had the privilege to be a part of projects like Agni & Prithvi, Cheetah Chetak helicopter, ALH, LCA, KAVERI Engine Project and more, for which we have been appreciated by both Ministry of Defence & Hindustan Aeronautics Limited (HAL).

Kaveri Engine

What is the highest level of accuracy that you have achieved in gear production?

At RDMC, we always strive to give the best of quality to our customers, and we take pride in saying that we have been consistent in our gear quality while maintaining DIN class 5. In exceptional cases, we have also achieved DIN class 4 for projects from ISRO, HAL, & AREDC.

Have you developed gears or gearboxes as alternatives to imported products? If so, what applications do they serve?

RDMC is one of the preferred suppliers across the gear manufacturing industry when it comes to indigenization or alternative to imported products. We have been associated with the industry's best in gearbox manufacturing like Flender, Renk, and Bonfiglioli to name a few.

Gearbox 1

Could you describe the key high-precision machinery in your facility used for manufacturing high-accuracy gears?

High Accuracy Gear Manufacturing not only requires high-precision machinery but also requires a robust process & tooling. The key machines to get accurate gears are gear hobbing, gear grinding and most importantly the right gear testing machine. It is the feedback from the gear tester that helps generate the desired high-accuracy gear.

We have the state-of-the-art Liebherr gear hobbing machine, which is complimented with the industry's best Hofler (now Klingelnberg) gear grinding machine that is further validated by the Klingelnberg gear tester.

KLP 100 gear tester

Please explain RDMC's design and development capabilities.

We have a team of highly trained, dedicated, innovative, and passionate individuals specializing in CAD (Computer-Aided Design), CAM (Computer-Aided Manufacturing), and CNC programming across a spectrum of machines. Our adept CNC programmers are well-versed in operating gear hobbing, gear shaping, gear grinding, CNC turning, VMCs, and HMCs. They possess the capability to seamlessly guide the production process, from manufacturing to self-inspection, ensuring that stringent quality requirements are met at every stage.

What sets your products apart? What is your unique selling proposition (USP)?

RDMC's key USP is the rich experience we have garnered over five decades, which is one of the main contributing factors that gives us an edge over our competitors. At RDMC, we not only supply parts but also partner with our customers and provide solutions. One of the most gratifying compliments that our customers give us is "If no one in the industry can do it, then go to RDMC," and this is the most assuring accolade that we have earned in the past five decades.

Can you please mention a specific sector to which RDMC has uniquely contributed?

RDMC has been mainly into earth moving and off-highway equipment, and we are one of the leading suppliers to all the big brands in this field. Currently, we are involved in a very prestigious defence project under the Make in India scheme by indigenising the transmission for T-72 tanks.

Tarun Nahata, Partner, RDMC

Bonded Abrasives in Gear Industries: Perfecting Surface Grinding

By: Sushmita Das

Bonded abrasives play an important role in the precision-driven world of gear manufacturing. Gear industries rely on these abrasive tools to achieve the desired surface finish and dimensional accuracy in their products. Here, we look at the crucial role of bonded abrasives in gear manufacturing, and how they facilitate the process of surface grinding.

The Importance of Surface Grinding in Gear Industries

Gear manufacturing demands an unparalleled level of precision. Whether it's in the automotive, aerospace, or industrial sectors, gears are vital components in countless machinery and vehicles.

To ensure optimal performance and longevity, gears must have smooth, precise surfaces that minimize friction, noise, and wear. This is where surface grinding comes into play.

Surface grinding is a machining process that involves removing material from the gear's surface using abrasive particles. The primary goal is to create a high-quality surface finish, ensure dimensional accuracy, and produce gears that meet stringent industry standards. Achieving these objectives relies heavily on the choice of abrasive tools, and this is where bonded abrasives come to the forefront.

Bonded Abrasives: The Gear Manufacturer's Best Friend

Bonded abrasives are abrasive tools made by mixing abrasive grains with bonding agents (usually resin, ceramic, or vitrified materials) and shaping them into grinding wheels, stones, or segments. These tools are tailored to specific applications and are ideal for precision grinding in gear manufacturing. Here's why they're indispensable:

Material Versatility: Bonded abrasives can be formulated to work effectively on a wide range of materials, including steel, aluminium, and hardened materials, commonly used in gear manufacturing.

Precision and Control: The abrasive grains in bonded abrasives are precisely oriented and held

together firmly by the bonding agent. This ensures a consistent, controlled material removal process, crucial for creating gear surfaces with minimal deviations.

Cool Grinding: Many bonded abrasives are designed to generate less heat during grinding, preventing workpiece distortion and maintaining the integrity of heat-treated gears.

Longevity and Efficiency: The durability and longevity of bonded abrasives result in fewer tool changes and downtime, optimizing the grinding process in gear manufacturing.

Tailored Solutions: Manufacturers can choose the specific type of bonded abrasive based on their unique gear production needs, ensuring a perfect match for the job at hand.

Conclusion

Bonded abrasives are invaluable tools for surface grinding. They contribute significantly to achieving the desired surface finish, dimensional accuracy, and overall gear quality.

As gear industries continue to advance, the innovative development and application of bonded abrasives will play a critical role in perfecting the art of surface grinding and ensuring the reliable operation of machinery across various sectors.

Research & Development Role in Driving Innovation in Gear Manufacturing

By: Nishant Kashyap

Research and Development (R&D) plays a pivotal role in the world of gear manufacturing, serving as the catalyst for innovation and progress in this critical industry. The importance of R&D lies in its ability to drive advancements in gear design, materials, and manufacturing processes.

Through continuous research efforts, manufacturers can develop gears with enhanced performance, durability, and efficiency, ensuring they meet the ever-evolving demands of diverse applications. R&D also contributes to cost reduction, improved competitiveness, and the ability to adapt to changing market dynamics.

Moreover, it facilitates the customization of gears for specific applications, addresses environmental considerations, and fosters global collaboration, ultimately positioning companies at the forefront of technological excellence and sustaining the growth of the gear manufacturing sector. In essence, the commitment to R&D is not merely an investment in the present but a strategic move to secure the future success and relevance of gear manufacturing in an increasingly dynamic industrial landscape.

R&D's Importance in the Gear Manufacturing World

Research and Development plays a crucial role in every stage of gear manufacturing right from its design and material selection to its impact on the environment. Here are several key reasons highlighting the significance of R&D in gear manufacturing:

Innovation in Design: R&D teams conceptualize novel designs, iteratively refining prototypes through rigorous testing. Integrating advanced materials like high-strength alloys, R&D enhances gear strength and wear resistance.

Leveraging Computer-Aided Design (CAD) tools optimizes gear geometry, considering tooth profiles

and pitch. It tailors designs for specific industry needs, from automotive to aerospace.

Exploring non-traditional manufacturing methods, such as additive manufacturing, allows for intricate gear designs. By continuously enhancing efficiency metrics and incorporating real-world performance data for feedback, R&D ensures gears stay at the forefront of innovation, setting new benchmarks in efficiency and reliability.

Material Selection and Development:
R&D identifies and explores materials, optimizing performance by tailoring them to specific applications. This includes developing innovative materials and evaluating their durability under diverse conditions.

It also addresses critical factors like weight reduction, cost-effectiveness, and environmental considerations, integrating emerging technologies for enhanced gear performance.

It also ensures manufacturers have access to advanced, customized, and environmentally conscious materials, elevating the competitiveness of gears in an evolving industrial landscape.

Efficiency and Environmental Considerations:
R&D initiatives focus on optimizing manufacturing processes, adopting energy-efficient technologies, and identifying sustainable materials to reduce the overall environmental impact.

By exploring digital technologies, waste reduction strategies, and life cycle assessments, R&D contributes to minimizing material waste, energy consumption, and the carbon footprint associated with gear production. In essence, R&D plays a pivotal role in ensuring that gear manufacturing remains both operationally efficient and environmentally sustainable.

Customization and Tailored Solutions:
By delving into specific industry needs, R&D allows manufacturers to innovate in design, select optimal materials for distinct applications, and create prototypes that undergo rigorous testing. This iterative process ensures continuous improvement in performance and reliability.

Efficiency optimization, adherence to industry standards, and the ability to meet niche market demands are all outcomes of R&D efforts.

Through a customer-centric approach, manufacturers establish feedback loops to adapt customized solutions to evolving market trends and client expectations.

R&D serves as the key driver behind the development of gears that precisely align with the unique requirements of diverse applications, ensuring optimal performance and adaptability in a rapidly changing industrial landscape.

Failure Analysis and Reliability Improvement:
R&D teams systematically identify and analyze failure modes, conducting root cause analyses to address weaknesses in designs and manufacturing processes.

By exploring advanced materials, optimizing heat treatments, and developing coatings, researchers aim to enhance wear resistance and fatigue characteristics, contributing to overall reliability.

Advanced simulation tools predict stress and fatigue life, while physical prototypes undergo rigorous testing, providing valuable insights for iterative design improvements.

R&D fosters a culture of continuous enhancement, ensuring gears not only meet current standards but also withstand diverse operating conditions, ultimately bolstering the reliability of gear systems.

Digitalization and Simulation:
R&D is pivotal in driving the gear manufacturing industry toward digitalization and simulation, ushering in technological advancements and heightened efficiency.

R&D initiatives create digital twins, virtual replicas streamlining analysis and optimization processes, minimizing the need for extensive physical prototyping.

Sophisticated computer-aided design tools, a product of R&D, optimize gear designs for specific applications. Simulation, a cornerstone of R&D, analyzes gear performance, predicting maintenance needs and enhancing reliability. R&D also integrates the Internet of Things (IoT) and data analytics for a data-driven approach to process control.

Virtual prototyping, an R&D outcome, accelerates product development cycles. R&D's digitalization and simulation capabilities not only optimize manufacturing but also enhance the agility, efficiency, and competitiveness of the gear manufacturing industry.

Adoption of Industry 4.0 Technologies:
By actively assessing and integrating emerging technologies such as the Internet of Things (IoT) and data analytics, R&D facilitates the development of smart manufacturing systems. These systems leverage connectivity, sensors, and digital twin technologies to optimize gear production processes.

R&D plays a key role in implementing predictive maintenance through data analytics, ensuring machinery reliability.

Moreover, it addresses cybersecurity concerns in interconnected manufacturing environments

and supports the creation of adaptive, flexible manufacturing systems. By fostering human-machine collaboration and utilizing data-driven insights, R&D propels the adoption of Industry 4.0, enhancing efficiency, quality, and agility in gear manufacturing.

In summary, R&D in gear manufacturing is essential for driving progress, ensuring product quality and safety, and positioning companies as leaders in the rapidly evolving landscape of industrial technologies. It is a key factor in the long-term success and sustainability of the gear manufacturing industry.

Challenges in Gear Manufacturing R&D

R&D in gear manufacturing faces several challenges that impact the pace of innovation and development. One primary challenge is the need for substantial financial investments in research initiatives, especially when exploring advanced materials, precision manufacturing technologies, and Industry 4.0 integration.

Another challenge involves the complexities of interdisciplinary collaboration between engineers, material scientists, and data analysts, as successful innovation often requires a convergence of diverse expertise.

Additionally, navigating stringent regulatory requirements and ensuring intellectual property protection can pose challenges.

The inherently iterative nature of R&D, with the potential for failures and setbacks, demands perseverance and long-term commitment.

Future Trends in Gear Manufacturing R&D

Looking ahead, several trends are shaping the future of R&D in gear manufacturing. Advanced materials, such as nanomaterials and smart alloys, are gaining prominence for their potential to enhance gear performance.

The integration of artificial intelligence (AI) and machine learning (ML) in gear design and manufacturing processes is becoming a key focus, enabling predictive modelling and optimization.

Digital twinning and virtual reality are expected to play an increasingly important role, allowing for comprehensive simulation and testing before physical prototypes are produced.

The trend towards sustainable manufacturing practices is pushing R&D efforts to explore eco-friendly materials and energy-efficient processes.

Collaborative research initiatives and partnerships between industry and academia are anticipated to grow, fostering a collective approach to solving complex challenges and accelerating innovation in gear manufacturing.

Lastly, the continuous evolution of robotics and automation is poised to revolutionize production lines, enhancing precision and efficiency in gear manufacturing processes.

Overall, the future of gear manufacturing R&D is characterized by a dynamic interplay of advanced technologies and collaborative approaches to address the industry's evolving needs.

Conclusion

Research and Development (R&D) is pivotal in driving innovation in gear manufacturing, focusing on design, materials, and processes to meet diverse application demands.

It ensures gears achieve enhanced performance, durability, and efficiency, contributing to cost reduction and global competitiveness.

Despite challenges such as financial investments and interdisciplinary collaboration complexities, R&D plays a key role in areas like customization, failure analysis, and adopting Industry 4.0 technologies.

Looking forward, trends include advanced materials, AI, and ML integration, digital twinning, and sustainable manufacturing practices. Challenges involve financial investments, interdisciplinary collaboration, regulatory navigation, and intellectual property protection.

Despite these, the future of gear manufacturing R&D is characterized by a dynamic interplay of advanced technologies and collaborative approaches to address evolving industry needs.

Environmental Concerns and Minimizing Hazards in Gear Manufacturing

By: Sushmita Das

It is essential for gear manufacturers to be socially accountable throughout the process of manufacturing gear.

This can be done by curbing the looming menace of industrial waste in the environment. This calls for responsible gear manufacturers to carry out a regular environmental assessment for a sustainable future.

According to the Brundtland Report-1987 of the United Nations World Commission on Environment and Development, the term sustainability can be defined as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Maintaining sustainability in the gear manufacturing industry is challenging for the engineering team involved in the process. There are various reasons that contribute to environmental pollution, therefore mitigating them can lead the gear industry towards sustainable manufacturing. The rising environmental concerns have necessitated the manufacturing industries to venture through all the possible sustainable methods of developing gears.

The article explores the best possible ways through which industries can rely upon sustainable techniques of manufacturing gears to avoid unprecedented environmental hazards.

Additionally, one becomes aware of the harmful impacts of the gear manufacturing processes on the environment, and the subsequent advancement in the gear industries that includes sustainable gear designs.

Let’s dive into learning the sustainable methods of gear manufacturing.

Paving the Way Through Sustainable Machine Tool Manufacturing

Exploring sustainable practices in machine tool manufacturing can significantly contribute to reducing the industry's carbon footprint and fostering innovation.

The following are a few inspiring examples of sustainability in the machine tool manufacturing within the gear industry.

Energy-Efficient Manufacturing Techniques

The gear industry is embracing energy-efficient manufacturing techniques by using advanced CNC machines and lean manufacturing practices.

These methods optimize resource utilization, reduce energy consumption, and minimize waste production during production.

Precision Engineering for Longer Life Cycles

Precision engineering ensures gears are manufactured with high accuracy, reducing the chances of premature wear and tear.

This results in longer-lasting gears, leading to less frequent replacements and a reduction in overall material consumption.

Material Innovation

Research into sustainable materials for gear manufacturing such as high-strength composites and recyclable alloys is gaining traction. These materials offer improved durability and reduced environmental impact compared to traditional options.

Lubrication Efficiency

Developing eco-friendly lubricants with longer lifespans not only enhances gear performance but also decreases the frequency of maintenance, lowering the consumption of lubricants and reducing waste.

Closed-Loop Manufacturing

Closed-loop manufacturing systems monitor and optimize processes in real time, minimizing errors and scrap production.

This approach not only enhances the quality of gears but also conserves resources and energy.

Digital Twin Technology

Digital twin technology creates virtual replicas of physical gears, enabling manufacturers to simulate performance under various conditions. This reduces the need for physical prototypes and iterations, saving resources and cutting down on waste. Take alternate pic used for digital twin for earlier article

Lean Supply Chain Management

Efficient supply chain management reduces the carbon footprint by optimizing transportation routes, minimizing material waste, and streamlining logistics operations.

Remanufacturing and Recycling

The gear industry is increasingly adopting practices such as remanufacturing and recycling, allowing worn-out gears to be refurbished and repurposed rather than discarded. This extends the lifecycle of products and reduces the demand for new resources.

Renewable Energy Integration

Machine tool manufacturing processes are integrating renewable energy sources, such as solar panels and wind turbines, to power production facilities. This transition to clean energy reduces the carbon emissions associated with manufacturing.

Collaborative Industry Initiatives

Industry collaborations and partnerships are promoting knowledge sharing and research into sustainable practices. These initiatives foster innovation, as experts from various fields work together to develop more eco-friendly manufacturing methods.

Sustainable Gears—Design of Gear Body Modified Powder Metal (PM) Gears

Powder metallurgy has long been a favored technique for producing intricate components with high precision. In gear manufacturing, Powder Metal (PM) technology involves compressing fine metal powders into the desired shape and then sintering them at high temperatures to form solid parts.

Modified PM Gears take this process a step further by introducing innovations in design and material composition, resulting in a new generation of sustainable gear solutions.

Benefits of Modified PM Gears

Resource Efficiency: The Powder Metal process allows for near-net shape production, minimizing material wastage and reducing the need for extensive machining. This resource-efficient method aligns with sustainable manufacturing principles.

Weight Reduction: Modified PM Gears can be designed to have complex internal geometries, allowing for intricate designs that optimize strength-to-weight ratios.

This feature is particularly crucial in industries like automotive and aerospace, where weight reduction directly translates to fuel efficiency and reduced emissions.

Enhanced Durability: Through careful material selection and precision engineering, Modified PM Gears offer exceptional durability, reducing the frequency of replacements and extending the life cycle of machinery.

Reduced Carbon Footprint: The efficient production process of Modified PM Gears requires less energy compared to traditional manufacturing methods, contributing to a lower carbon footprint.

Additionally, the extended lifespan of these gears leads to a reduction in waste generation.

Customization and Innovation: The Powder Metal process allows for intricate designs and customization, enabling engineers to create gears tailored to specific applications. This flexibility drives innovation and promotes efficient gear usage.

Design Innovations in Modified PM Gears

Complex Geometries: The Powder Metal process facilitates the creation of complex gear geometries that optimize load distribution and enhance performance, all while maintaining the required precision.

> It's vital that gear manufacturing industry funds & encourages research in "Alternative Gear Finishing Technologies" like "Hard Gear Shaving". These new values-for-money technologies will avoid end-of-line scrap generation & directly ensure sustainability & save capital investment in gear grinding, not only correct distortions from material handling & heat treatment but stop noise in gearbox assemblies.
> *- Abhay Deshmukh, Managing Director, Shilpin Machine Tools Pvt. Ltd.*

Material Composition: Engineers can modify the material composition of PM gears to enhance properties such as wear resistance, corrosion resistance, and strength, ensuring that gears are well-suited to the demands of their applications.

Noise Reduction: By strategically designing gear profiles and tooth shapes, Modified PM Gears can reduce noise during operation, contributing to a quieter and more sustainable working environment.

Heat Treatment and Surface Coatings: These gears can undergo heat treatment and receive surface coatings to further enhance their performance characteristics, resulting in gears that are both resilient and efficient.

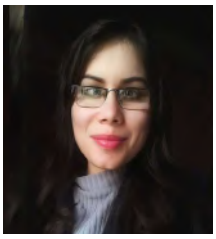
The design of Modified Powder Metal (PM) Gears signifies a significant leap forward in sustainable gear manufacturing.

Conclusion

In an era where environmental concerns and resource conservation are paramount, industries across the globe are redefining their operations to prioritize sustainability.
The gear manufacturing industry, a cornerstone of modern engineering and production processes, is no exception. As the heart of various mechanical systems, gears play a vital role in industries ranging from automotive to aerospace.

Through these efforts, the industry is not only reducing its environmental impacts but also, setting a precedent for other manufacturing sectors to follow.

By keeping the gear industry at the center of the sustainability discussion, we can pave the way for a more environmentally-conscious and innovative future.



Sushmita Das is an accomplished technical writer. Holding a degree in Electrical Instrumentation and Control System Engineering, she brings a wealth of technical expertise to her writing

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