gear TECHNOLOGY INDIA

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Get an insight into some of the lubrication trends and issues pertaining to the gear industry

GEAR TECHNOLOGY EVOLUTION & THE POWER SECTOR

Find out the recent advancements, and what it holds in the future

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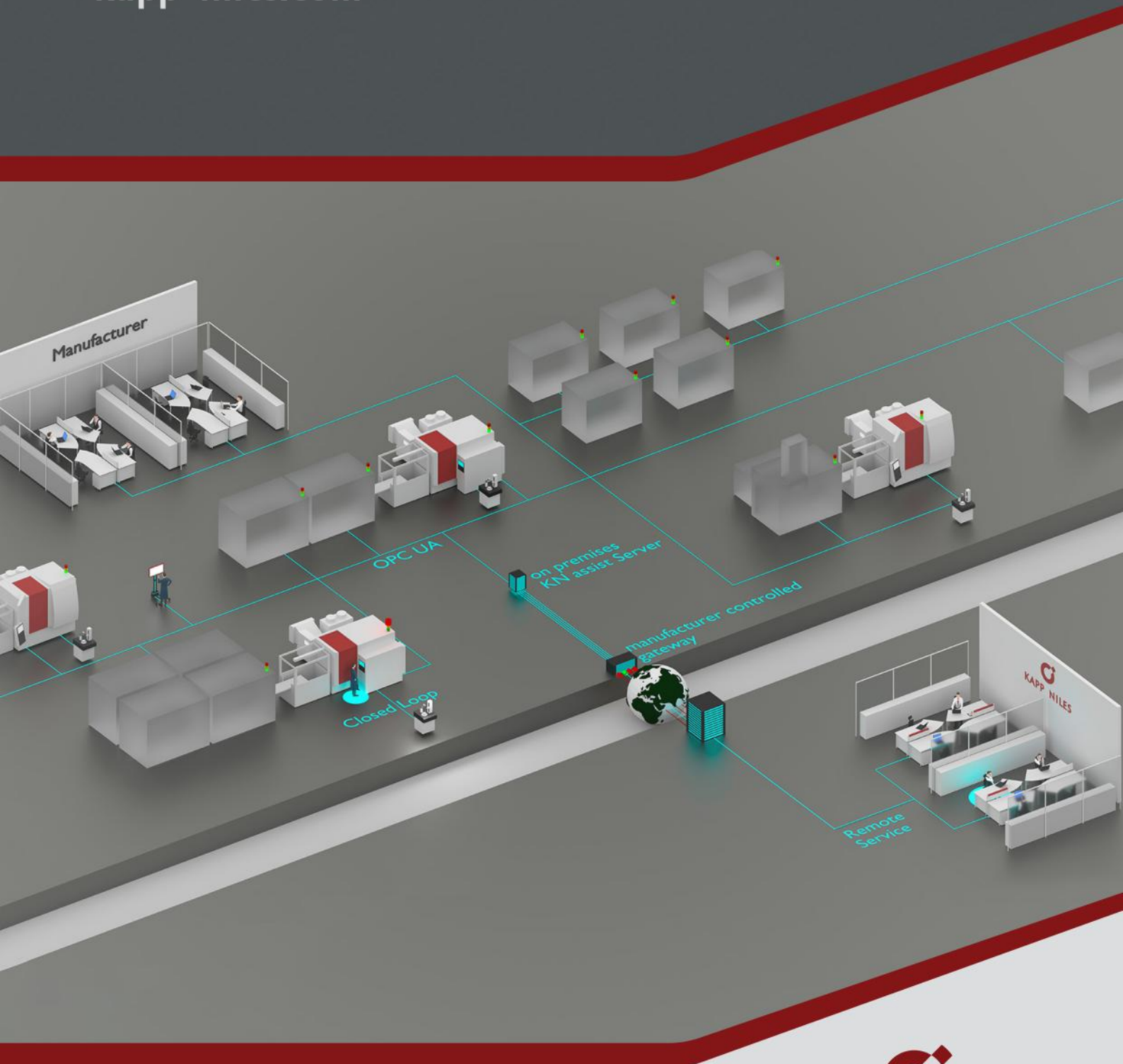

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Anitha Raghunath
Director
Virgo Communications and Exhibitions Pvt.Ltd

Dear Reader,

We are happy with the response we got from our inaugural issue, and we thank you all for the immense support you have shown us.

Taking our journey forward, our second issue looks at a host of technical and non-technical articles as well as interviews with the head honchos of the gear manufacturing companies. To whet your appetite, here is what you can look forward to in our digital magazine.

Read about the challenges and trends faced by the gear industry vis-à-vis lubricants, find out what the optimized solutions for gear grinding are, understand the impact of 3D manufacturing in the gear industry, and get a comprehensive view on the fractal geometry characteristics in gear tooth surface wear evaluation and many more. Besides this, hear from the founder of Gear Technology, Michael Goldstein, on his illustrious journey to what RDMC's Tarun Nahata has to say about the Indian gear industry, and much more informative reading to broaden your perspective.

That's not all, our commitment to building a community for the Indian gear industry only gets better. Now, we are expanding our services by offering webinars, and holding customised training sessions to enhance your employee's productivity and performance.

We welcome companies to connect with us so we can take this forward. As for the webinars, we are holding our first informative session in August. This is a great opportunity for gear professionals to join, and learn from industry experts. You wouldn't want to miss this!

We hope you enjoy this issue, and also invite you to share your knowledge with this budding community of ours.

Happy Reading!

Anitha Raghunath

gear TECHNOLOGY INDIA

Gear Technology India is a quarterly magazine published through a partnership between American Gear Manufacturers Association (AGMA) and Virgo Communications & Exhibitions. The magazine will be the industry's go-to platform for world-class news, information and technical articles from the world of gears.

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FOUNDER

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

DISCLAIMER

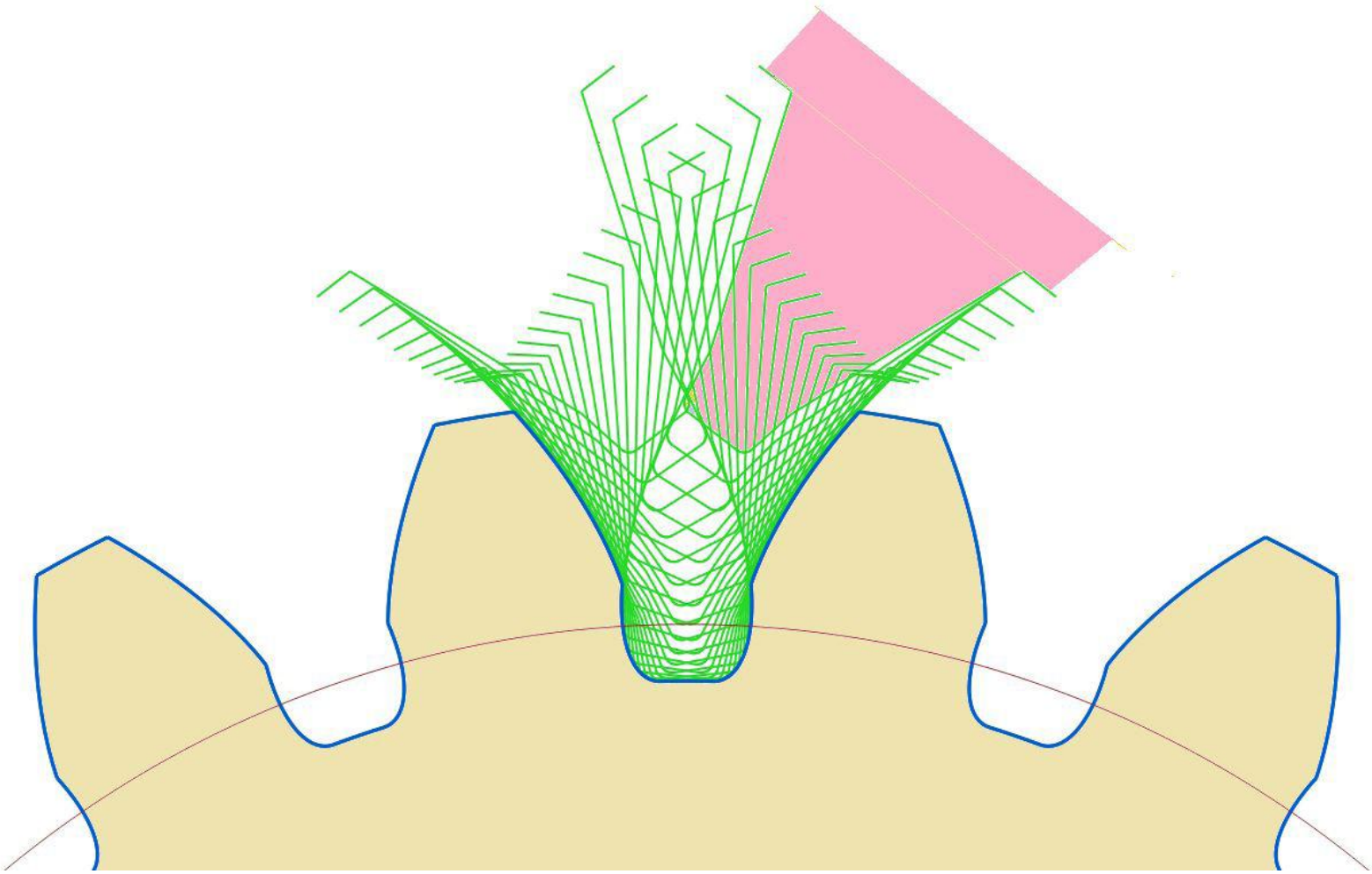
Contents



Harness the Optimum Torque Transmission With an In-Depth Look on Gear Root Forms

Here's how to get better gear root forms by designing tool parameters and software simulations of the manufacturing process like gear hobbing & profile grinding, primarily during the design stage

By: Mahendran Muthu



It's interesting to note that after freezing the gear geometry and drawing release, most design engineers don't seem to be particularly interested in verifying the quality of the gears during the various stages of manufacturing process on the shopfloor. There is an insufficiency of control data in drawings for setting the job, tools, fixtures, and quality inspection parameters that leads to non-conformities and deviations in many functional parameters of gears.

There is a silent reduction of the torque transmission capacity without anyone noticing. Among such parameters is the transition from flank to root form which decides the transverse contact ratios for better root strength, smooth torque transmission, and avoids the interference with the tip of the mating gear teeth.

Undercut

For gears finished by grinding, the semi-finishing tool is usually designed with protuberance geometry that would generate an intentional undercut in the gear to prevent a grinding notch. The protuberance provides stock for finishing operations like grinding. Here, the root circle is created by the pre-machining cutter and the flank and the final root form diameter is generated by the grinding process.

Form Diameters

The root form diameter (dFf) is the diameter of a circle at which the trochoid produced by the tooling intersects or joins the involute or specified profile. It is where the involute (unmodified or modified) part of the flank begins. It results from the respective final machining like grinding. It is a part property and not a gear pair property as is the case for the active root diameter (dNf).

The active (usable) root diameter (dNf) is determined by the starting or finishing point of the path of contact that is by the intersection of the usable tip circle of the mating gear with the line of action. The form diameter (dFf) of the finished gear must be smaller than the active root diameter (dNF) which is also called start of active profile (SAP) of the gear when the gear meshes with the mating gear.

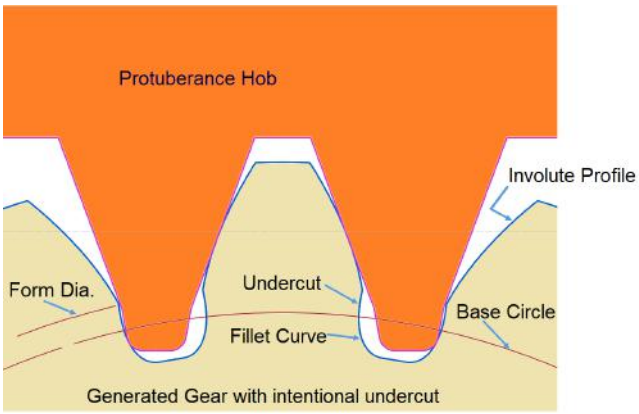


Fig 1: Undercut formation during hobbing

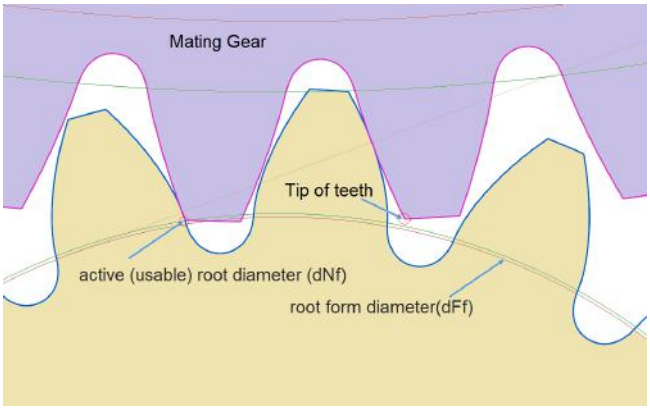


Fig 2: Root form diameters related with mating gear

Grinding Stock

It is important to maintain optimal stock during the hobbing process by considering the possible heat treatment distortions, root fillet / undercut proportions and required dNf or SAP parameters. If the undercut is insufficient, a grinding notch will form. If the undercut is higher, then the tooth root strength will be compromised. The process team then uses the state-of-the-art design and simulation tools (like KISSsoft) to ensure that the first time right tool (PGP Hobs) goes through excellent process control measures with validations. In many of the cases, the notches are not permitted to avoid stress concentration and tooth crack initiations.

To achieve the optimum gear tooth strength, the fillet portion has to blend as closely as possible nearer to the active root end of the involute profile. The shape of the transition zone is based on the protuberance height, protuberance angle, tip radius and the involute producing section of the hob cutter. The design computations must calculate and generate this condition with the grinding stock needed as per process engineering GD&T (Geometric Dimensioning and Tolerancing) parameters and heat treatment distortions.

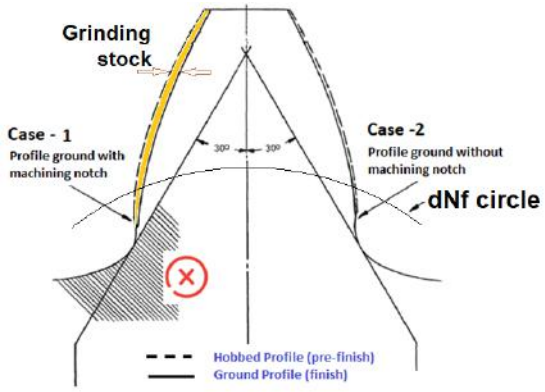


Fig 3: Grinding notch formation

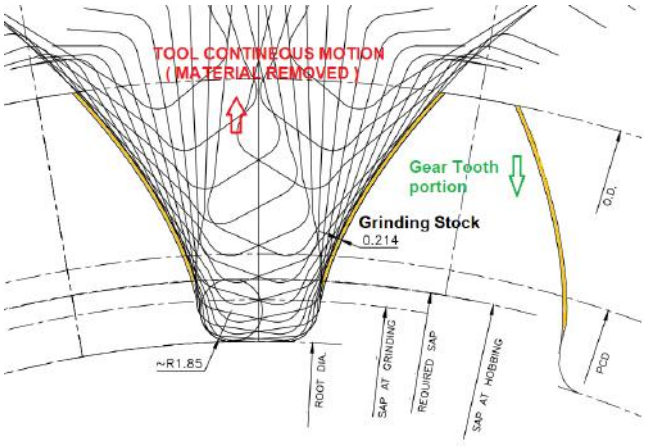


Fig 4: Simulation using tool geometry

Software Computations

In KISSsoft, it is a simple and user-friendly method to create tooth shapes using a Tooth Form-Manufacture Cylindrical gear with a gear generation process (Cutter, Grinding wheel) option.
An in-built intelligent algorithm suggests the tool parameters based on pre-final and final process selection, and the designer can modify those measurements accordingly.

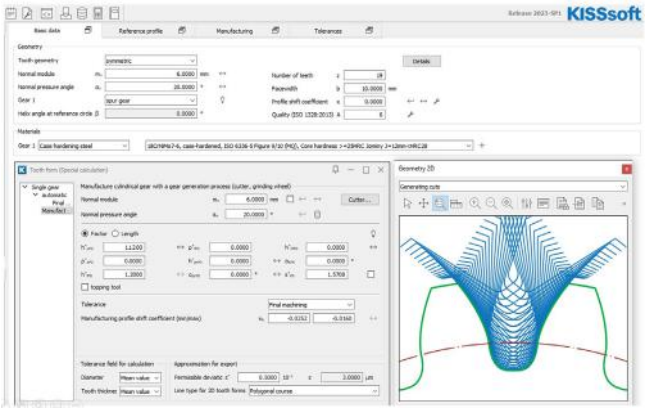


Fig 5: KISSsoft user interface Tooth Form – Manufacturing cylindrical gear with a gear generation

Sample Design

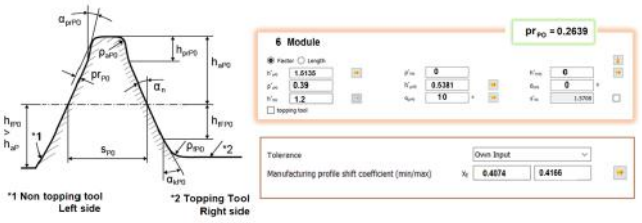
To explain the procedure, let's take a sample design, module mn = 6mm pinion with 19 teeth, protuberance hob parameters are sized and simulated in KISSsoft software, by considering the grinding stock 0.263mm.

While the geometry is frozen for design rating, export the gear geometry.dxf or .dwg file as the master reference to merge or overlap with the manufacturing simulations (example: design. dxf).

The first stage is to generate the gear geometry through the hobbing process in a manner that the hob depth (addendum, dedendum) is fixed, so that the generated root diameter is merged with design root diameter keeping the grinding stock for final machining.

Next, fix the appropriate manufacturing shift coefficient (XE) value through the sizing option. A key point to take into account is the heat treatment distortions, and the operator requiring allowances during grinding machine job setting.

However, it is a simple task while using the sizing option in the software which is a one-step process. Run the generation process and export the manufactured gear geometry in .dxf or .dwg file (example: hobbed.dxf).



m_n	α_n	h_{aP0} *	ρ_{aP0} *	h_{fP0} *	ρ_{fP0} *	h_{prP0} *	α_{prP0}	s_{P0} *	h_{fFP0} *	α_{kP0} *	pr_{P0}
6	20	1.5135	0.39	1.200	0.0	0.5381	10.0	1.5708	0.0	0.0	0.2639

Fig 6: Protuberance hob parameters (sample for 6 module gears)

The second stage is generating the standard grinding process (in general the grinding wheel parameters are standard 1.12 times depth for tool addendum and dedendum as shown in fig.5 Kisssoft user interface). During this stage, the manufacturing shift coefficient (XE) value shall be default "Final Machining". Run the generation process and export the manufactured gear geometry in .dxf or .dwg file (example: ground.dxf).

The tooth form can be visualized after each step of the above process, and the results of several steps can be placed on top of each other in order to show the material removal from one step to the next. The manufacturing process of tool and gear is also visualized in graphical form in the software itself or exported to other CAD systems in native / neutral formats.

Merge all the three files (design.dxf, hobbed.dxf, ground.dxf) in a 2D CAD software by placing them in different layers or different colors for easy identification of tooth root forms, whether a grinding notch is formed or not.

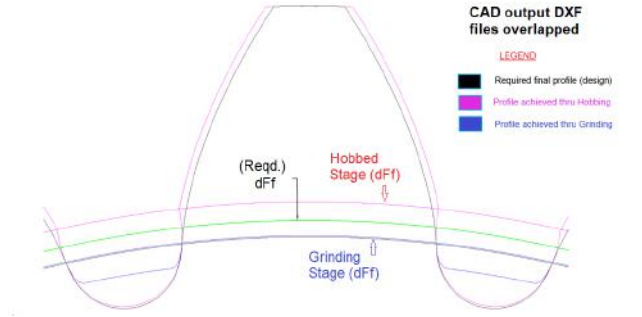


Fig 7: The simulated gear geometry of hobbing and grinding is overlapped over the kdesign geometry to understand the root form shape and dFf diameter

The notch effect may induce 20 percent of power rating capacity reduction in gears while put into maximum operating load. By analysing and predicting the "grinding notch", the designer can re-validate the safety factor for bending accounting notch (ISO6336-3, factor Ysg or through FEM calculation integrated in KISSsoft), can also ensure that the manufacturing process in the factory is in control.

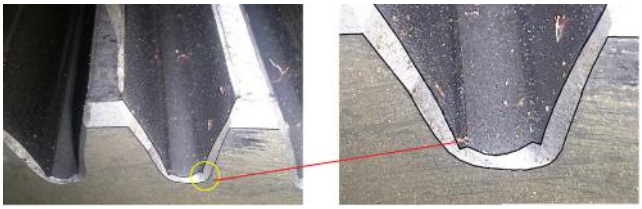


Fig 8: Notch found after gear grinding due to improper tool usage in gear cutting

Summary

The gears after manufacturing (in each stage) shall be inspected for the compliance on root form diameters, through profile inspection in gear CMM to ensure the design validation and further continual improvements in tool design.

The gear design engineer takes the responsibility of hand holding the project though quality inspections by aligning all stakeholders in manufacturing, heat treatment and quality control, so there's no requirement to do multiple iterations.

The need to say "quality is not at any additional cost" is not required if a focussed attention and an innovative approach were in practice at every level. Therefore, it is worthy to focus on gear root forms to harness the optimum torque transmission.

The author is a Principal engineering specialist with 20+ years of domain expertise in Gear Design, Manufacturing, Quality Assurance and Customer Technical Services.

HIGHLIGHT

The gear design engineer is responsible for the project by aligning all stakeholders in manufacturing, heat treatment and quality control, so there's no necessity to do multiple iterations.

Meet the Founder of Gear Technology, Michael Goldstein

In 1984, Michael Goldstein founded *Gear Technology*, and served as Publisher and Editor-in-Chief from 1984 through 2019. *Gear Technology India* had an email interview with him to discuss his illustrious career, the idea behind *Gear Technology*, and more.

Could you tell us a bit about yourself, and your journey with Gear Technology?

I started working in the machine tool industry full time in 1964, after graduating from Michigan State University with a major in engineering and a minor in accounting. I was active in our association, Machinery Dealers National Association (MDNA) and was on the Board, then President of their for-profit publishing company, MDNIS, publishers of the *Locator*, a monthly magazine with over 20,000 listings all the available used machines tools, with a format similar to a phone book (ask your parents) with a circulation of 100,000 books per month.

For much of the time as an officer, typesetting of the listings was manual but I was instrumental in purchasing a newly developed computer-controlled typesetting machine. I visited printing plants and learned all facets of this publishing undertaking, which gave me enormous experience in the publishing field.

What was the idea behind starting Gear Technology?

At my family-owned used machinery company, Cadillac Machinery Company, I specialized in used gear manufacturing equipment, concentrating on the cross-axis spiral bevel and straight bevel gear equipment.

As a result of my gear machinery specialty, I had a relationship with all of the gear manufacturing companies or their representatives, and, with my publishing experience at the

Locator, I felt that there was a need for a magazine to focus solely on the gear manufacturing community. I ended my presidency at the *Locator* in 1984, and launched *Gear Technology*, the Journal of Gear Manufacturing (GT), in 1985.

We subsequently launched a sister magazine, *Power Transmission Engineering* (PTE) whose focus was on all types of power transmission mechanical power transmission products, except gears, i.e. bearings, chains, pulleys, sprockets etc.

What was the market like?

At Cadillac Machinery, possibly over 50 percent of our sales were outside the United States, and I developed a growing customer base in India. In 2011, we launched *Gear Technology India* and I started attending Anitha & Raghus' Gear Exhibitions, to promote my magazine. But, after few years, we decided we were unable to develop the magazine to the extent we felt we needed and, as the magazine was only print, it had to be individually delivered, using couriers, which was cumbersome and inefficient.

It was the first exhibition I attended; I was the guest speaker along with another gentleman from the Indian Department of Defense. I remember distinctly him challenging the attendees to become suppliers of gears in the Department of Defence and he clearly told the audience that to do so, they would need to set up separate companies to deal with solely with the defense needs, as there were accuracy requirements, especially for aircraft gears, that far exceeded that which could be produced in commercial environment environments.

Why did you consider AGMA to take over the publication, and how has AGMA taken it forward since then?

A couple of years ago, I transitioned my publishing company to the American Gear Manufacturers Association (AGMA), as I wanted the magazines and the Library of material published over the 30-plus years to continue on after I'm gone. I'm very pleased that GT India is now being reborn with AGMA on one side, and Anitha and Raghu coming together to continue this important educational resource.

I'm confident that the Indian market has evolved, matured, and is now competitive worldwide and can support this educational resource.

What trends and technological advancements have you noticed in the last four decades in the gear industry?

The early year of publishing *Gear Technology* (GT) and *Power Transmission Engineering* (PTE) magazines was done on conventional printing presses and only after about 15 years were we printing digitally.

One of the things that I'm most proud of is I hired the children of my employees to come in for the summers to scan all of early issues, so they were available digitally. Our entire body of articles now make up the Michael Goldstein Technical Library, on the Gear Technology website, which attracts approximately 11,000 unique visitors per month.

What do you consider the most valuable part of the library?

I think one of the most valuable parts of that library is what we called Back to Basics, which came from the early manufacturer's handbooks of Fellows, for gear shaping, Barbera Coleman, for gear hobbing and hob design, Gould & Eberhardt, for large gear hobbing, Gleason, straight and spiral gears, National Broach for gear shaving. These were books published by manufacturers explaining the basics of all the processes. Young employees and those new to the gear field have found these Back to Basics to be invaluable.

What does the launch of Gear Technology in India mean to you?

Now that GT India can be published solely in a digital format and delivered electronically, it will become a valuable resource for the Indian gear manufacturing community. Best wishes to Anitha, Raghu, and AGMA on the continuation of this legacy that started so many years ago.

All about Diagonal Hobbing

By: Vishwajit Kothari

Introduction

In many cases, it is desirable to secure gears which transmit large forces with a tight fit at the shaft ends. Both parallel spline shafts and involute spline shafts can be considered for this purpose.

Connections with tapered root spline shafts are being in use with this feature. These not only hold on the flat tooth flanks, but also in the conical bottom at the root between the flanks. These spline shafts, with such requirements, can be cut diagonally by conical hob cutters.

For hobbing of these shafts, special hob cutters are used whose outside diameter is tapered. The cutters have constant pitch and tooth thickness.

Component

Sample component

The component has splines at one end. The splines have tapered root diameter but the top land and the gear teeth flanks are straight and run parallel to the component axis.

A photograph of the component as seen above gives a fairly good idea about the form of the gear tooth desired.

Gear Hobbing Machine

The machine must have a universal hob head with provision of compensating the tangential differential motion to the worktable rotation. This can be obtained through tangential differential change gears in conventional machines or through an Electronic Gearbox in CNC machines.

Gear Hob

In one of the examples in which we proved the diagonal hobbing, the hob developed had following unique characteristics:

1. The outer diameter was conical. The taper angle, half of the cone angle, is the same as that required on the workpiece root diameter.
2. The length of the taper portion of the hob used was the same as that of axial traverse used for cutting the gear.
3. The tooth height on the hob over the taper portion was appropriate to maintain the tooth depth on the workpiece for the corresponding axial face width.

Setup on a Cooper P 254 hobbing machine

Workholding Fixture

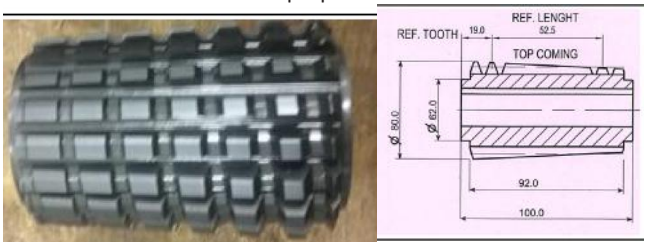
The workholding fixture developed was simple. It had a carrier for clamping and driving the workpiece while cutting. The component was located between centers. A steady rest can be provided to the component to impart firm support, if required.

NC Program

To facilitate diagonal hobbing (axial-tangential hobbing), which involves interpolation of two axes; a special menu driven parametric program was developed.

The main cutting block in the program must contain the end position coordinates for axial Z and tangential Y axes with their respective feed rates at a predetermined ratio.

Thus, there is simultaneous movement of hobs in tangential and axial direction with their proper feed rates.

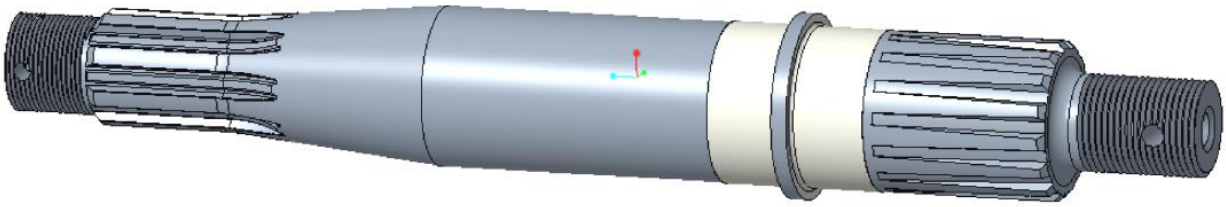


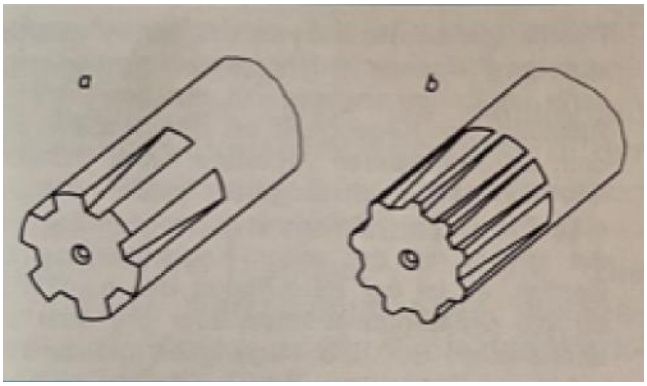
Sample hob

Cutting Process

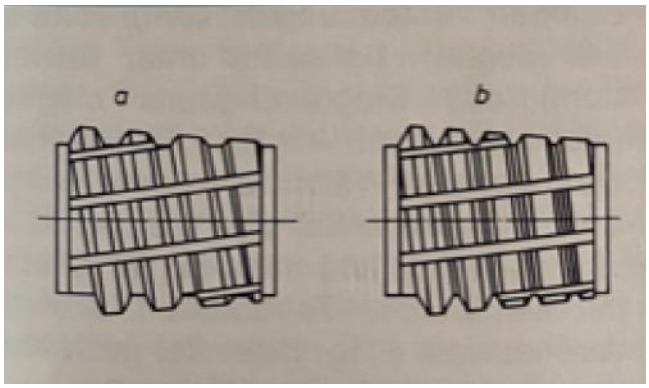
With the help of diagonal hobbing, the tapered outer contour of the hob cutter creates a tapered tooth base on the spline shaft. The cutting takes place in axial-tangential direction thereby producing root taper by virtue of tapered hob teeth.

In this method of hobbing, axial and tangential feeds are used simultaneously for cutting the gear. The hob continues to shift and its entire length is used in every pass.





a — parallel flank taper root spline
b — involute flank taper root spline



a — hob for parallel flank taper root spline
b — hob for involute flank taper root spline

Therefore, the cutting process is called Diagonal hobbing as the hob traverses diagonally in feed in Y-Z plane along an interpolated path.

The hobbed taper gear by diagonal hobbing has taper root with both flanks parallel, and width of top land remains the same across the face width of the workpiece.

At the start, the large diameter of the hob cuts at the position where the tooth depth on the workpiece is maximum. From this position, the hob travels both axially and tangentially producing lesser tooth depths on the workpiece.

At any axial position of hobbing during diagonal feed the center distance between the hob and workpiece is constant.

Other characteristics of the cutting process used for trial are as under:

1. Single cut cycle.
2. Conventional hobbing method.
3. The hob was right hand and its rotation was clockwise
4. The work table rotation is anticlockwise.
5. Ratio selected of axial feed rate to tangential feed rate is 1:1

Following conditions apply to the movements of the axial slide and the tangential slide while cutting splines by diagonal hobbing method.

While the axial slide moves by the axial path lz, the tangential slide has to move by the tangential path lt.

In relation to a workpiece revolution, this means:

An axial feed Sz includes a very specific tangential feed St.

The following applies: Sz / St = lz / lt

There is an important point to note; when the hob leaves the workpiece, there must not be any digging mark or radius left at the spline end. In fact, there should be a smooth merging of the teeth ending with the workpieces outside diameter all around.

This can be achieved by giving exact coordinates of start position and end position. It can also be done by adjusting the tangential position of the hob by desynchronizing the coupling to change the contact section of the hob.

Advantages of Diagonal Hobbing

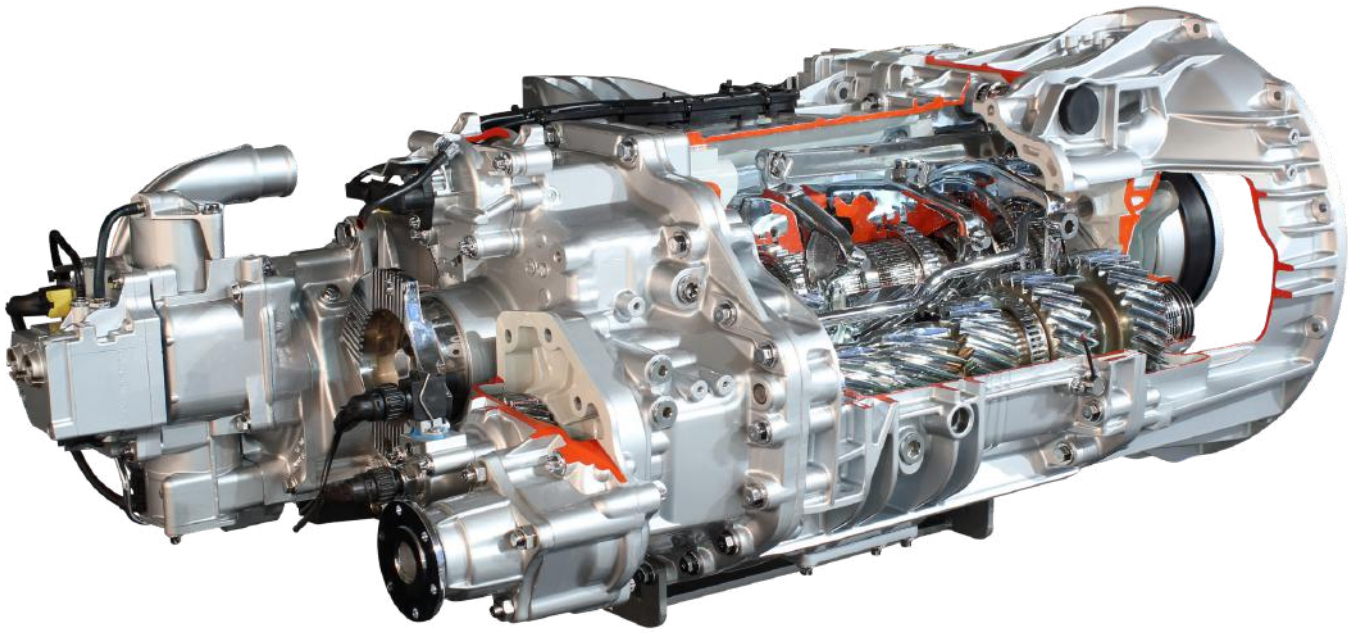
1. Better utilization of all teeth of hob takes place.
2. It is useful for cutting “taper root splines” by means of a conical hob.
3. It is used for cutting large face width of gears or large diameter gears used in operating sluice gate of dams. This diagonal hobbing process helps to achieve constant gear size across the face width.

Vishwajit Kothari, CEO, Cyber Gears. Former Head, Sales & Marketing, Premier Ltd. He has 32 years of experience and knowledge in machine tools, machining processes, tooling and workholding fixtures & application engineering

Importance of Servicing Gearboxes

To ensure the long life of a gearbox, regular servicing and maintenance must be done

By: Chinnappan Selvaraj



Machines over a period of time go through a lot of wear and tear. The gearbox is the heart and soul for any machine to keep running. To ensure its longevity, regular maintenance and servicing is a must.

One of the main problems that gearboxes suffer from is friction and heat due to lack of timely maintenance and care, and this can prove to be very costly, not to mention disastrous.
To prevent this from happening, here are some of the key areas that one must take into consideration during a service.

Gearbox condition monitoring

When gearboxes are in operation, one needs to monitor the conditions periodically by measuring several parameters like temperature, noise, and vibration to name a few.

Gearbox Monitoring Parameters with Frequency

1	Temperature	Daily
2	Noise	Daily
3	Oil Level	Daily
4	Breather Cleaning	Weekly
5	Water Content in Oil	Every 500 hrs of running
6	Oil Change	After 500 hrs
7	Oil Filter Cleaning	Once in 3 months
8	Vibration Comparison	Once in 3000 hrs running
9	Hose Line, Shrink Disc Checking	Every year
10	Tightness of Fasteners	After 500 hrs of running

The previous table indicates the parameters and frequency with which they must be checked regularly.

Based on the observations made during the monitoring, corrective action needs to be taken for the gearbox to be in operation.

For instance, in case of oil leakages, one must change the oil seals, apply the adequate amount of sealants in the bearing caps and casing joining faces and so on. Vibration and noise bearing conditions to be checked. Axial and radial plays to be adjusted. Noise observed in gear meshing, contact pattern for mating gear and pinion to be checked and adjusted accordingly. Oil grades used and oil levels to be corrected by adding oils to maintain the correct oil levels.

Sealant for case joining

Oil seal fitting

Axial Play of Bearings to be used in Gearboxes		
1	Deep Groove Ball Bearing (Bore up to 150mm)	0.2mm
2	Deep Groove Ball Bearing (Bore above to 150mm)	0.3mm
3	Taper Roller Bearing (Bore up to 70mm)	0.05mm
4	Taper Roller Bearing (Bore above to 70mm)	0.08mm
5	Angular Contact Ball Bearing (Bore up to 70mm)	0.05mm
6	Angular Contact Ball Bearing (Bore above to 70mm)	0.08mm
7	Cylindrical Roller Bearing (Bore up to 150mm)	0.2mm
8	Cylindrical Roller Bearing (Bore above to 150mm)	0.3mm
9	Spherical Roller Bearing (Bore up to 150mm)	0.2mm
10	Spherical Roller Bearing (Bore above to 150mm)	0.3mm

Critical issues that need to be looked at during servicing

Generally gearboxes are designed for 40,000 hours for bearing life. However, these days, designers are looking at infinite life also. During regular monitoring maintenance, the following issues are likely to crop up. These are:

- Bearing noise
- Gear and pinion noise
- Gear tooth worn out /damages
- Gearbox housing bore worn out

For the above mentioned issues based on the criticality, cost, and availability of the gearbox, customers have the option of either replacing them or getting them serviced. If the gearboxes have been imported more than 30 to 40 years ago, it is difficult to get the spares for the same. In these conditions, servicing plays a crucial role to put the gearbox back in operation.

Major activities to be carried out during servicing of gearboxes

1. Selection of appropriate raw materials for gears
2. Selection of correct heat treatment of process
3. Possibility of improving the rating of the gearbox by using right material, face width and tooth parameters of gears.
4. Incorporating temperature, vibration sensors, Inspection windows to make maintenance easy

Selection of raw materials/heat treatment/process

Forty years ago, gearbox manufacturers didn't have many options before them. They would select raw materials based on what would be available at the time.

However, nowadays, while replacing a gear set during servicing, designers check the possibility of using the latest alloy steels to improve the rating of gearboxes.

In addition to this, they choose the gear tooth parameters to enhance the rating by selecting appropriate heat treatment processes such as carburising & case hardening, gas nitriding, induction hardening and profile grinding operation to name a few. Previously, a supplier may have used herringbone type gears without gear profile grinding, but to make the manufacturing easy now, designers may opt for double helical gear design with case hardened and profile ground designs. Therefore, in this manner, a good improvement on gearbox rating is attained.

Steps to be followed during repairing of gearbox housing

a) Housing bores to be enlarged. Top and bottom housing face to be machined
b) Housing to be dismantled as top and bottom housing
c) Depending on the bore worn out , housing bore to be welded with appropriate welding electrode in consultation with welding experts
d) Top and bottom housing to be rejoined
e) Re-boring of housing to be done using CNC Horizontal machining centre/CNC Horizontal boring machine
f) Bores to be inspected by CMM to ensure the correct center distance

Advantages of servicing gearboxes

- The gearbox after servicing can run for an additional 5-10 years
- The rating of the gearboxes can be improved by going in for service
- They can incorporate the latest technology in old gearboxes also
- Customers can avoid to going for capex for buying new gearboxes

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

An Overview of Airborne Noise in a Gearbox

In a gearbox, the airborne noise is generated due to churning of air because of the rotating elements between the gear wheel and casing

By: Commander Srikanth

In many industrial environments, low frequency noise may occur in combination with vibrations.

High frequency noise is generally associated with high-speed machinery related noise because of pressure difference in various engineering elements related to flow parameters. While annoyance due to airborne noise has been found to be greater in combination with vibrations. Unfortunately, there is little information available about the combined effects of low frequency noise and vibration.

Furthermore, it can be expected that subjects confuse the exposures and thus have difficulty in differentiating between the sensation of vibration and noise. Present data indicate that a combined exposure would increase annoyance. Apart from sound emissions from vibrating building elements, secondary phenomena may occur in the form of rattling doors, clattering vessels, tea cups, plates (crockery), and glass panes. These phenomena are reported to significantly increase the annoyance and have typically been reported in more lightweight items with regard to aircraft take off, heavy artillery, and at a distance from highway bridges and high-speed trains.

In a gearbox, the airborne noise is generated due to churning of air due to rotating elements between gear wheel and casing. In some cases, due to spraying of lubricating oil, gear engagement and disengagement of various gear tooth and very minor bending due to these cyclic loads. Thin gear tooth at times exhibits a tunning fork-like phenomenon. In some instances, the support bearings and their condition, balancing and unbalancing also contribute to structural noise that are perceived as vibrations at the foot or pedestal of the gearbox. In certain cases, optimised casing thickness can also lead to vibration of casing elements made of fabricated thin sheets. This is termed as loudspeaker effect.

Airborne Noise

Typically, the airborne noise emits from:

Structure vibrations:

Also known as impact noise which in turn excite the surrounding medium resulting in audible sound. This happens when an element is stretched, held taut, and a small disturbance leads to vibrations. Examples include tuning fork, musical stringed instruments, percussion instruments and so on. In fact, a loudspeaker is one of the best examples which can be linked to a thin wall gear box fabricated casings having ribs as structural stiffeners. Between the ribs, the thin sheet metal acts as a diaphragm of a loudspeaker.

The same occurs on board ship also as the large area of plate is welded and is tightly held between frames with relatively low mass vis-à-vis that of support structures.

Therefore, any vibrations transmitted to ship's structural plates induces a loudspeaker effect and the water density being higher, the speed of sound in water is 1500 m/s as against speed of sound in air 340-350 m/s. Thus, even a small impact noise is

quickly and efficiently carried to a long distance three times faster than in air.

Pressure difference:

In any flow, the changes in flow pressure induces noise. The wind instruments is a classic example. Similarly, in IC engines the difference in atmospheric pressure and exhaust gas pressure which is made to expand to atmospheric pressure suddenly. Therefore, a muffler as the name suggests, muffles noise by gradual expansion in other words controlled reduction of pressure of gases. Similarly, whirling of fluids due to a rotating part of a mechanical equipment induces noise due to pressure difference across the path.

It is well known from the conservation principle of energy; higher speeds cause lower pressures and thus the pressure difference increases with that of the ambient. In gas turbines/ jet engines high pressure/high energy gases go through a thrust tube/jet tube which is suddenly exposed to atmospheric pressure. The high-speed high-volume exhaust thus causes very intense and high frequency sound. Similarly, flow through pipes wherever the pipe fittings and change of direction occurs results in pressure difference and this becomes the source of audible noise.

The same is true in a gearbox where each mating tooth deforms and regains its shape and is related to the speed of the gears / gear tooth engagement frequency. This again causes structural

deformation of tooth which excites the surrounding medium and passes out as airborne noise transmitted from the gearbox casing.

Effects of Airborne Noise

The sound pressure level is one of the main acoustical factors that affect comfort. Maximum sound pressure level (L_{max}) is typically used when predicting comfort with impact noise, whereas equivalent sound pressure level over a given period of time (L_{eq}) is used for airborne noise. Other acoustical factors that impact acoustic comfort are:

- Frequency of the noise
- Noise source
- Duration of noise
- Its variation with time

Acoustic comfort is, however, highly subjective, and noise sources with the same physical characteristics can be perceived differently by different people. Personal and societal characteristics, such as sensitivity to noise and attitude towards a noise source, are essential when quantifying acoustic comfort.

Due to the physical and psychological effects associated with acoustic discomfort, some regional and international standards provide guidelines on noise level limits and other acoustic performance evaluation metrics. These metrics vary based on the purpose of the space and the type of effect noise will have on occupants. For instance, in residences, the main effects of noise exposure are annoyance, activity interference, and sleep disturbance, while in offices, effects on communication, work performance, and speech privacy are more important.

Standards and Guidelines

Standards and guidelines thus provide different background noise level limits for different spaces to ensure minimum interference with the activities performed in the spaces.

The World Health Organization (WHO) for instance, identifies different noise level limits for several indoor spaces including residences, hospitals and schools. In open-plan offices, additional metrics, such as the speech transmission index, distraction distance, and privacy distance are typically used to quantify the performance of an office with respect to speech privacy as well as effects of speech on occupants' work performance. The structure borne vibration limits are laid out by ISO 10816 & ISO 11204:2010 so that ABN & SBN are well addressed.

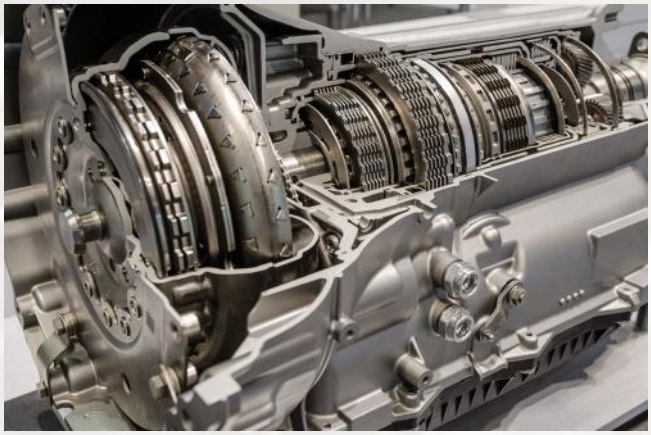
Drawbacks

Despite the available standards and guidelines, acoustic discomfort remains one of the most important comfort issues even in spaces that meet requirements set by standards. One reason for this is the lack of consideration of individual differences, such as noise sensitivity.

In addition, many guidelines fail to consider the effects of variable noise levels over time as well as variable noise sources. For example, the focus of most guidelines for residential spaces is outdoor noise sources such as traffic noise, and outdoor community noise, but do not include indoor sources.

Machinery sound measurement

Measurements from machinery which constitutes a sound source should be taken at 1 m from the machinery.



Commander Srikanth (Retired) has 44 years of experience in the engineering and allied industry, and 22 years in the Navy. He consults in the area of defence and general engineering and systems engineering to some of the leading companies

Premium Transmission Strives for Longevity and Performance of Gearboxes

What are Premium Transmission's manufacturing capabilities? What would be the maximum size of gears, and gearboxes supplied to various industries?

We are known for our exceptional engineering and manufacturing capabilities, delivering high-quality gears and gearboxes that cater to diverse industrial needs. Over the years, we have developed cutting-edge technology and advanced processes that are capable of meeting the requirements of various industries across the globe.

Manufacturing quality gears & gearboxes isn't an easy task, but we as a group, have excelled in providing different types and sizes for various applications. We manufacture gearboxes as per DIN 6/7 standard.

Our manufacturing capabilities encompass a range of advanced techniques including hobbing, skiving, heat treatment, case carbonizing up to 5mm, profile grinding up to 24 modules, and shaping and milling of internal gears up to 3 meters.
We specialize in manufacturing worm gears which have a maximum torque capacity of up to 50 kNm.

Our gears are designed to offer efficient power transmission which are ideal for applications requiring high torque and low speed.

Our expertise extends to helical and bevel-helical gears with a maximum torque capacity of up to 850 kNm. These gears provide smooth and precise motion transmission, ensuring optimal performance in demanding industrial environments.
Our Planetary Gears are designed with a maximum torque capacity of up to 6000 kNm. They are well-known for their compact design, high torque density, and exceptional load-carrying capabilities.

Our gearmotors are designed with a maximum torque capacity upto 25kNm to deliver reliable and efficient solutions.
These integrated motor and gear units offer compactness, energy efficiency, and versatility for a wide range of applications.
We also manufacture Fluid Couplings which are designed to deliver a maximum power capacity of up to 11 MW.

These couplings provide smooth power transmission, ensuring excellent torque control and enhancing the overall efficiency of drive systems. We take pride in our ability to deliver gears and gearboxes of varying sizes and capacities, ensuring that our

customers receive tailor-made solutions that meet their specific requirements.

Have you supplied anything specially for the defence sector?

Premium is proud to make notable contributions to the defence sector. So far, we have supplied Mechanical and Hydraulic Winch for ARV (Armored Recovery Vehicle) & Retarder for Armored Vehicles.

We have designed and supplied Mechanical and Hydraulic Winch up to 30 tons for ARV. These winches play a crucial role in the recovery and towing operations of armored vehicles, ensuring efficient and safe maneuverability in challenging terrains.

Secondly, we have supplied Fan Drive Coupling for Engines used in defense vehicles. These couplings provide efficient and controlled operation of cooling fans, ensuring optimal engine performance and temperature regulation.

These innovative solutions showcase our commitment to meeting the unique needs and challenges of the defense sector. We truly feel proud in serving our armed forces under the Make in India program.

Can you tell us more about IoT on gear boxes/ condition monitoring? Do you provide condition monitoring support to customers?

Our customers have always been our priority. To achieve the highest customer satisfaction, we established a dedicated service vertical called “Premium Care.” This provides support of IoT and condition monitoring per customer requirements.
Through this, we are available 24/7 to our customers across India. Due to this proactive approach, this allows for timely maintenance interventions, minimizes downtime, and extends the lifespan of gearboxes, resulting in enhanced operational efficiency and cost savings. We provide conditioning monitoring on customer requests.

Are there any updates regarding automation at your company? Please explain your digitalization initiatives.

With years of presence in the business which is constantly growing, it was not only a need but also a want to initiate digitalization in the organization to leverage its benefits.

An area where digitalization has made a significant impact is in our enquiry management process. By implementing advanced digital tools and technologies, we have streamlined and automated our enquiry management system, thus seamlessly improving our communication and made ourselves efficient enough in tracking enquiries, and responsiveness to customer needs.

Design automation is another area where we have integrated advanced design software and tools that enable us to automate and optimize the design process. This not only accelerates our product development, but also enhances accuracy and precision in our designs, resulting in superior quality gearboxes.

Furthermore, we have implemented a Product Lifecycle Management (PLM) system to effectively manage the entire lifecycle of our products. The PLM system enables us to centralize product data, streamline collaboration among different teams, and ensure efficient change management.

At Premium Transmission, we continuously strive to enhance the customer experience through innovative technologies and

automation. Our range of digital tools and applications ensures seamless interaction and support for our valued customers. Our Product Configurator is a powerful tool that simplifies the product selection process. With its user-friendly interface and advanced features, customers can easily customize and configure the perfect solution to meet their specific requirements.

To streamline communication and provide efficient customer service, we have developed a CRM portal. This portal allows customers to access relevant information, track their orders, and communicate with our dedicated support team, ensuring a smooth and hassle-free experience.

In line with our commitment to manufacturing excellence, we have implemented advanced automation technologies. Our SCADA control system optimizes the manufacturing process, enhancing efficiency and precision.
Additionally, we utilize cutting-edge gear testers from trusted brands like TTI, Wenzel, and Klingenberg for accurate and reliable testing automation.

The Enterprise Resource Planning (ERP) system has made the management & planning process with the organization easier than ever before. We are now able to initiate various other crucial exercises effortlessly.

We continue to invest in technology and innovation to exceed customer expectations and maintain our position as a leader in the industry.

Can you explain a bit about the latest technology on lubricants which helps improve gear lifespan?

It is important for us to make sure our gearboxes serve the maximum benefit for our clients. We are dedicated towards the performance and longevity of our gearboxes.
One area where we have made significant advancements is in lubricant technology.

Under our renowned brand, Protomac, these lubricants are meticulously formulated to provide exceptional protection, reduce friction, and minimize wear and tear on gears.
We have noticed a significant improvement in the life span and more efficiency of our gearboxes.

We also provide comprehensive support and guidance to our customers in selecting the right lubricants for their specific gear applications with the help of our experts who are available to offer technical assistance, recommend suitable lubricants, and provide insights on best practices for lubrication maintenance.

Could you explain about your sales and service network?

Premium Transmission takes pride in its extensive sales presence, ensuring that we are accessible to our valued customers worldwide. In India, we have established offices in Delhi, Mumbai, Chandigarh, Jaipur, Raipur, Ahmedabad, Lucknow, Bangalore, Chennai, Hyderabad, and Pune.

To cater to the international market, we have a dedicated International Operations (IO) team strategically located across the globe. This enables us to provide localized support

and meet the unique requirements of our global customers.
In addition to our strong physical presence, we have established Premium Care centers in Pune, Ahmedabad, and Bhubaneswar. These centers provide comprehensive after-sales support and ensure the optimal performance of our products in the Indian market.

Furthermore, our network is strengthened by our trusted channel partners, who are present across the globe.
This extensive network of channel partners enables us to reach customers in various regions and deliver our high-quality products and services with utmost efficiency.

Is there anything planned for training customers?

We place great importance on the training and development of our valued customers. We recognize that providing comprehensive training programs not only enhances their knowledge and skills, but also strengthens their partnership with us.

To ensure that our customers have the necessary expertise to maximize the performance and longevity of our products, we have various training initiatives. One of which is conducting regular customer meets and service camps where we bring together industry experts, technical specialists, and our customers for interactive sessions.

To provide our customers with the best experience, we have placed a strong emphasis on training programs that focus on product selection, enquiry management, and installation.

These training sessions aim to equip our team with the necessary knowledge and skills to assist customers in making informed decisions, effectively manage enquiries, and ensure smooth and efficient installations.

By prioritizing training in these areas, we are able to enhance our overall service quality and deliver greater value to our valued customers.

Raghavendra Kini, CEO,
Premium Transmission Private Limited

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Exploring Strategies to Analyze and Prevent Common Gear Failures

As gears are prone to failure, understanding why this happens and how to prevent it leads to a better working industrial machine

By: Sushmita Das

Gears are fundamental components in machinery and play a vital role in transmitting power and motion. However, like any mechanical device, gears are prone to failure. Gear failure can result in costly downtime, repairs, and even safety hazards. Understanding the common causes of gear failure and implementing preventive measures is crucial for maintaining smooth operations in various industries. Here, we will analyze the common gear failure modes and explore effective strategies for prevention.

Types of Gear Failure

Wear and Surface Fatigue:

One of the most common gear failure modes is wear and surface fatigue. Over time, the repeated contact and sliding between gear teeth can lead to material degradation and surface damage. This can manifest as pitting, scoring or spalling that ultimately compromises the gear's functionality. Inadequate lubrication, high loads, and improper gear alignment are key contributors to wear and surface fatigue.

Tooth Breakage:

Tooth breakage occurs when the load on a gear exceeds its design capacity resulting in the fracture or shearing of gear teeth. Overloading, shock loads, or sudden impacts can induce tooth breakage leading to catastrophic failures.

Tooth Deformation:

Gear teeth can also deform under excessive loads leading to gear failure. When subjected to high forces, gear teeth may experience plastic deformation or bending.
This can cause misalignment, tooth meshing issues, and subsequent gear failure. Inadequate gear design, improper material selection, or excessive operating loads contribute to tooth deformation.

Preventive Measures

Regular Maintenance and Inspection:

Implementing a proactive maintenance regime is essential for detecting and addressing gear failure precursors.
Regular inspections can identify wear, cracks, or other signs of damage at an early stage. Monitoring gear temperature, vibration, and noise levels can also provide valuable insights into the gear's condition.

Proper Lubrication:

Appropriate lubrication is vital for minimizing wear and surface fatigue in gears. Lubricants reduce friction, dissipate heat, and prevent metal-to-metal contact. Regular lubricant analysis should be conducted to ensure the lubrication's quality and effectiveness. It is essential to follow manufacturer guidelines for lubricant selection and application.

Load Analysis and Gear Design:

Understanding the operating loads and accurately analyzing the gear design are crucial steps in preventing gear failure.
Load calculations should consider both static and dynamic loads, ensuring the gear's strength and durability. Designing gears with adequate safety margins and using high-quality materials can enhance their load-bearing capacity.

Proper Alignment and Installation:

Improper gear alignment and installation can lead to premature gear failure. Ensuring correct alignment of gears, shafts, and bearings minimizes excessive loads, reduces tooth stress, and improves overall gear performance. Proper installation techniques, including torque specifications should be followed to maintain gear integrity.

Training and Education:

Investing in employee training and education regarding gear operation, maintenance, and failure analysis can greatly contribute to preventing gear failures. Knowledgeable personnel can identify warning signs, take appropriate actions, and implement preventive measures to avoid gear failure incidents.

Gear failures can disrupt operations, lead to costly repairs, and pose safety risks. By understanding the common causes of gear failure and implementing preventive measures, industries can mitigate the likelihood of gear failures and their associated consequences. Regular maintenance, proper lubrication, load analysis, gear design, alignment, and employee education are vital elements in preventing gear failures. By prioritizing gear health and investing in proactive strategies, organizations can ensure the longevity and reliability of their machinery.

UCAM Nimble Machines Drive to Commitment for Quality Gear Manufacturing Solutions

Nimble Machines was established with the vision of providing innovative gear manufacturing solutions that are productive, precise and rigid.

By: Sai Sagar

With over 30 years of rich expertise in manufacturing sophisticated & technologically advanced CNC machines, UCAM launched a strategic business vertical in 2015 under the brand name "Nimble Machines".

Nimble Machines offers high-speed CNC gear manufacturing solutions. Their portfolios consist of CNC gear hobbing machines- VAJRA 130, VAJRA 250 and VAJRA 400 capable of up to 8 modules and 400mm diameter.

Nimble Machines also manufactures TARANG-325, a 5 axis CNC spiral bevel gear generator machine. It is capable of machining gears up to 7 modules and 325mm diameter using a face milling method.

World Class Facility

Nimble machines manufacturing facility is located in a lush green facility in the industrial town of Dobaspet on the outskirts of Bangalore.

It is home to the state-of-the-art manufacturing facility that boasts of features like dust proof, energy efficient, pressurized air conditioning environment coupled with the best 5-axis machining centers, Horizontal Machining Centers, Vertical Machining Centers, Vertical Turning Lathe among others. The precise and consistent control of temperature is very important in terms of product quality and process efficiency.

High quality inspection equipment and practices play a vital role in inspecting high precise parts which go into the VAJRA gear hobbing machines for achieving high repeatability and accuracy of up to DIN 7 class.

The Nimble Machines facility consist of equipment such as laser calibration equipment, auto-collimator, CMMs, and roundness tester. Every part is inspected so as to adhere to the tight tolerances and achieve the best quality output.

High Skill and Superior Practices

Nimble machines consist of a passionate, highly skilled and efficient assembly team backed with the rich experience of manufacturing industry leading UCAM's Rotary tables among other CNC machines.

As part of the quality assurance programs, each machine undergoes laser calibration and documentation to ensure that they are working to the best of their ability and improved + accuracy, efficiency and yield. This enables the machine geometry and alignment to adhere to the latest IS: 8407 acceptance conditions for gear hobbing machines.

To further enhance the quality, productivity and improvement of work, 5S has been implemented and followed. This helps the organization to strengthen Total Productive Maintenance (TPM).

Conclusion

Nimble machines' drive to quality gear-related solutions is a long-standing testament to their in-house excellence.

6 Key Factors to Consider Before Choosing Materials for Gear Manufacturing

For machines to run efficiently and effectively, there are certain metrics that it should adhere to. We find out what they are

By: Nishant Kashyap

Gears are an essential component of many machines and mechanical systems. They transmit power and torque from one component to another, which allows machines to function efficiently and effectively. When it comes to designing gears, selecting the right material is crucial for ensuring their performance, durability, and reliability. Here, we look at six key factors when it comes to choosing the right gear material for your application.

Load Capacity

Load capacity is a crucial factor to consider when selecting materials for gear manufacturing because gears are primarily used to transmit power from one machine component to another. This power transmission process is typically achieved through the meshing of the teeth on the gears, which can experience high levels of force and pressure during operation. Therefore, the material used to manufacture the gears must have sufficient strength and durability to withstand these loads without deforming or failing. The load capacity of a gear material refers to its ability to withstand the forces and stresses generated by the transmitted power. It is directly related to the material's mechanical properties such as tensile, yield, and fatigue strength. When designing gears, it is pertinent that the gear material's load capacity is greater than the maximum loads and stresses it will experience during operation. Failure to do so can result in premature wear, damage, or even catastrophic failure of the gears, leading to downtime, increased maintenance costs, and potential safety hazards.

Different gear applications may require different load capacities depending on factors such as the amount of power being transmitted, the speed of rotation, the direction of the load, and the operating environment. For example, gears used in heavy-duty industrial applications, such as mining equipment, may require materials with high load capacities to withstand the high levels of stress and shock loads. On the other hand, gears used in low-load applications, such as office equipment, may not require materials with high load capacities.

Overall, considering load capacity when selecting materials for gear manufacturing is critical to ensure that the gears can withstand the forces and stresses generated during operation. Choosing the right gear material with sufficient load capacity

can help to improve gear performance, reduce downtime, and increase the overall reliability and efficiency of the machinery.

Wear Resistance

Wear resistance is also an important factor to consider when selecting materials for gear manufacturing because it directly affects the lifespan and performance of the gear. Gears are subjected to constant motion and friction, which can cause them to wear out over time. This wear can result in reduced efficiency, increased noise, and even gear failure. By selecting materials with high wear resistance, gear manufacturers can ensure that the gears will maintain their integrity and performance over a longer period of time. Wear-resistant materials are able to withstand the constant motion and friction of gears without degrading or losing their properties, which makes them ideal for high-stress applications.

There are several factors that affect the wear resistance of a material. One of the most important is hardness, which is the material's ability to resist deformation and scratching. Materials with higher hardness are generally more wear-resistant and less susceptible to damage from abrasive particles or contact with other surfaces. Other factors that affect wear resistance include the material's composition, microstructure, and the presence of lubricants or coatings. For instance, materials with a fine-grained microstructure are generally more wear-resistant than those with a coarse microstructure. Similarly, coatings and lubricants can help reduce friction and wear by creating a barrier between the gear teeth.

Fatigue Resistance

When gears are in use, they experience cyclic loads as they transmit power and motion. This can result in fatigue failure where the material fails due to repeated stress cycles. Therefore, it is crucial to consider the fatigue resistance of the material when selecting a material for gear manufacturing.

The fatigue resistance of a material is its ability to resist failure under cyclic loading. It is often measured using a stress vs. cycles to failure (S-N) curve. The S-N curve provides information on the number of cycles that a material can withstand at a given stress level before it fails due to fatigue.

It is essential to ensure that the material has a high fatigue resistance so that the gear can withstand the cyclic loads it will experience during use. Choosing a material with low fatigue resistance can lead to premature gear failure, which can be costly and potentially dangerous.

Factors that can affect the fatigue resistance of a material include its microstructure, surface condition, and manufacturing process. For example, materials that have a fine and uniform microstructure tend to have better fatigue resistance compared to those with a coarse or non-uniform microstructure. Similarly, materials that are manufactured with high-quality surface finishes tend to have better fatigue resistance than those with rough surfaces.

Corrosion Resistance

When gears are often exposed to harsh environments like high humidity, extreme temperatures, and corrosive chemicals. Corrosion can lead to pitting, cracking, and other forms of damage which can ultimately cause gear failure. Materials that are highly resistant to corrosion such as stainless steel or some types of bronze are often preferred for gear manufacturing. These materials are able to withstand exposure to harsh environments without corroding or degrading, thus ensuring that the gears remain functional over their intended lifespan.
In addition, corrosion can also weaken the structure of a gear reducing its load carrying capacity and overall performance. By choosing materials that are highly resistant to corrosion, manufacturers can ensure that their gears will maintain their structural integrity and continue to perform optimally over the long term.

It is also worth noting that the type and severity of the corrosive environment can impact the selection of materials. For example, if gears are exposed to high levels of acidity, a material that is highly resistant to acids such as Hastelloy or titanium may be more appropriate. Similarly, if the gears are exposed to saltwater or other highly corrosive substances, a material that is highly resistant to saltwater corrosion like super duplex stainless steel may be a better choice.

Cost

Choosing a cost-effective material can help manufacturers keep their production costs low and remain competitive in the market. However, it is important to balance the cost with the required performance characteristics, and see to it that the selected material is suitable for the intended application. Selecting a cheaper material with lower strength or wear resistance may result in shorter gear life and increased maintenance costs in the long run. Whereas selecting a more expensive material with superior properties may result in longer gear life and reduced maintenance costs over time. It is important for manufacturers to carefully evaluate the cost of the material against the required performance characteristics and pick the most cost-effective material that meets the specific application's requirements.This will help in achieving a balance between performance, reliability, and cost-effectiveness in gear manufacturing.

Manufacturing Considerations

The choice of manufacturing process is crucial in determining the material that can be used for gear manufacturing. Certain processes may be better suited for certain materials, while some materials may not be suitable for certain processes.

Some materials may be difficult to machine, which can increase the manufacturing time and cost. In contrast, other materials may be easier to machine and can be manufactured at a lower cost. Therefore, the choice of manufacturing process should be considered while selecting the material for gear manufacturing.

In addition, the manufacturing process can also impact the properties of the gear material. For instance, the heat treatment process can improve the strength and hardness of certain materials that may be beneficial for high load and high-speed applications. However, some materials may not respond well to certain heat treatment processes, which can result in reduced performance.

Conclusion

Selecting the right gear material is crucial for ensuring the performance, durability, and reliability of your gears. When choosing a material, you should consider the load capacity, wear resistance, fatigue resistance, corrosion resistance, cost, and manufacturing considerations. By carefully selecting the right gear material for your application, you can ensure that your gears will perform reliably and efficiently for years to come.

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Accuspirals is in the business of manufacturing quality gears, gear units, and allied products. Established in the year 1980, today it has turned into a full-fledged gear manufacturing unit with over 75 machine tools.

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How the Indian Gear Manufacturers Association Was Created on WhatsApp

By: Divya Sudarsanan

In 2018, a WhatsApp group for Indian gear manufacturers was born. What started out as a 25-member group has now grown to around 130 members. The genesis of this group came to be when Prakash Kadam, MD, Pragati Transmissions, a passionate gear head, found that there was a disconnect between the Indian and global gear manufacturing market. He said, "We are following others. We haven't made a footprint yet." As India is a vast country with a pool of resources at hand, Kadam realized that this was a ripe opportunity to gather industry figures from across the gear manufacturing board. "With India being such a large country and we have different levels of expertise in the industry, I figured why don't we explore. There were informal connections, so the first step was to connect formally."

Together with his industry colleague, Mr. Gawande, and their respective contacts that they had accumulated over their years of experience, the Indian Gear Manufacturers Association was created on WhatsApp. "At first, various members would post about the surplus tools, or second-hand dealers would send information and so on. It became a sort of B2B. Then it became like a small exchange platform where people would share their thoughts, or pose a technical query and it would get answered." The next step that Kadam has in mind is for the members to meet in person. "We have not met formally, yet. We are thinking of doing a formal meeting of the members but we haven't set a date as of now. People in the group talk about individual challenges and problems. As we haven't made an association formally, the WhatsApp group serves as a forum for members to discuss their concerns," he said.

Having been part of the industry, and so closely connected, Kadam has seen the gear industry undergo a sea of change. "I have seen the gear industry go through a transformation in terms of technology, trends, and the ups and downs of the industry," he noted.

The Indian gear manufacturing industry is heavily dependent on machine tools, cutting tools and technology from the Western world. He said, "Basic gear technology in India is not a limiting factor. We have absorption technology which is limited by the guidelines which they give. We haven't made it indigenous. It is better to Indianize it. For that we must have a platform."

One of Kadam's concerns is that India does not have its own gear-based standards. "We have DIN, which has no base. It is a copy of other standards, and we follow that. Though standards were developed ages ago, they are all generic standards. There is no customization for different industries. Now, in Europe it's being done. Industry based standards should be made available. It cannot be generic. People say DIN 7 class; it is very generic. In the competitive world, we have to see what is exactly required for this." Kadam's preference for gear standards is Japan. He added, "That way I respect JIS. JIS is very practical as what is required by the industry, it is defined by the industry, whereas DIN, AGMA are more generic and have customized it for the specific industries. So, as a result, it is sometimes not economical to produce the gears in that standard as it is demanded and it is not required also. On that basis I thought why not have a thought process to go in line with that."

He candidly admits that he is unsure if an Indian standard of gear manufacturing can be implemented successfully but is willing to give it a try. He stated that the gear manufacturing machines are imported and India is highly dependent on them.
"Our contribution to the gear industry is not more than 5%, barring gear hobbing machines. In that also 30-40% is import content. The world is using India for its requirements, they sell the machines and use the cheap workforce."

Kadam would like to see the Indian gear industry to be united as this is not the case at the moment. He concludes, "The first step is to get all the industries under one umbrella. We should have an ideology that benefits both the people and the industry."

Optimized Solutions for Every Aspect of Gear Grinding

Tyrolit is manufacturing to meet today's needs of high-quality gearing tools at a reasonable cost

By: Karl-Heinz Gies

Today, there are ever increasing quality requirements from gear manufacturers, along with constant demands for cost reduction. Having a broad range of different grinding and dressing tools means Tyrolit can offer a host of solutions to customers, tailored exactly to their specific needs. As a gear manufacturing specialist, the company can optimize processes on location, saving the operator time and money.

In many areas of technology, transmissions and their components make an ever-increasing, valuable contribution to the safe, long-term operation of products, not just in terms of efficiency and lifetime, but also energy consumption, emissions, and economic efficiency.

In today's engineering industry – specifically in the automotive and aircraft industries, wind turbine operators and other power generators – the performance demanded from gear wheels and shafts is more or less the same. There is a demand for surfaces with a constantly improving finish and optimized geometries.

In this way, the percentage contact area is increased, which in turn makes for even better power transfer. As a result, gear wheels can be made smaller with the same performance, which reduces the weight of both gear and shaft. In the drive train, this decreases energy consumption, with the further benefit of reduced emission of polluting exhaust gases. At the same time, a better finish of the contact area promotes smooth running, i.e. lower noise, with the added benefit of an increase in component lifetime.

However, machining requirements of hardened gear surfaces differ significantly from one use case to the next. There are major differences in size and design, which in turn demand a plethora of different tools. Not surprisingly, a great variety of machining concepts are employed. These range from intermittent profile grinding, through bevel gear grinding and continuous generating grinding to power honing.

A comprehensive product range

Whereas some suppliers concentrate on a limited range of specific technologies, Tyrolit is a system supplier that covers every aspect of gearing and is therefore able to offer its customers truly optimised solutions that meet virtually every tooling and process technology requirement. The range of bonded grinding wheels is further enhanced by dressing tools which Tyrolit – as one of the leading manufacturers of bonded grinding tools – offers to all its customers worldwide.

The many different Tyrolit product lines, in particular MIRA Ultra, MIRA Ice, MIRA Alpha and MIRA Ultra SF worm grinding wheels, the Mira BK, MIRA Ice BK and MIRA Alpha BK single profile grinding wheels, the MIRA REX honing rings and the MIRA DDG dressing gears are equally well-known products for gear machining.

They offer outstanding performance in everyday use, not merely because of their stock removal rate, but above all, because of their consistent product quality, which optimizes the manufacturing process and makes it safer. Apart from the cool cut which is reflected in the name MIRA Ice, it boasts other features such as shape retention, extended dressing cycles, long-lasting sharpness and maintenance of contour.

Technical consultancy services

This short list of the different types of MIRA grinding tools alone shows that no two grinding wheels are alike. Local ambient conditions at a customer's site also have a significant effect on the grinding results and the requirements that need to be met. This starts with the machinery used and the clamping of the component, and continues with process parameters, cooling lubricants, their quantity and temperature, right up to handling and conditioning of the grinding wheels.

All this goes far beyond the production of grinding wheels for hard finishing of gears, which Tyrolit carries out exclusively at its plants in Austria and Germany. Apart from product know-how, Tyrolit's development and application engineers need to have extensive experience with engineering processes and knowledge of the effects to be expected when certain machining parameters are changed.

To ensure meaningful communication between its development engineers in the field of gearing and to provide a knowledge base that is up to date at all times, Tyrolit has set up a Competence Centre at Neuenrade (not far from Dortmund).

This centre looks after all customers that are involved in the gearbox business and in gear machining, for the benefit of everyone. From here, Tyrolit application engineering teams can respond quickly with development and implementation support and can offer customer-specific solutions, always with the option of referring back to a strong development team at the company's Head Office in Schwarz (Austria).

This Competence Centre also offers machines for trialling purposes and process development, making it possible to provide the client not just with products, but with safe and reliable processes. As a rule, these are optimized further by application engineering teams that will work on the customer's own premises. This ensures the ongoing further development of Tyrolit products.

More cost-effective customer processes

Apart from offering reliable products, Tyrolit's position as technical market leader also relies on further technological development. The performance of the deployed machines is becoming more efficient. Therefore, grinding tools used must keep up with the development process. For example, the MIRA Ultra, MIRA Ice and MIRA Alpha worm grinding wheels now have operating speeds of up to 80 m/s.

This creates the highest chip removal rate over time, which for the operator means the shortest possible grinding time. At the same time, these worm grinding wheels still produce the well-known cool cut and have a high resistance to burning.

The known homogeneity of the grinding body is a guarantee for high, reproducible grinding quality.

When it comes to generating grinding, Tyrolit dedicates much time to the so-called superfinishing process which involves the MIRA Ultra SF product range and polish grinding. Again, working speeds of 80 m/s are mainly used.

Thanks to the development of a novel kind of worm grinding wheel with two different machining zones: one with ceramic bonding, the other epoxy resin-bonded, pre-grinding, finish grinding and superfinishing can now be performed with a single clamping operation, with a single tool. This saves customers long processing times, enables surface accuracies of Ra 0.05µm and improves productivity.

Tyrolit has also improved and completed the honing rings product assortment. The new honing rings MIRA REX VTEC-20, VTEC-30, VTEC-40 und VTEC-50 offer further advantages, especially when used on machines with path-controlled dressing tools (VSD). With the new 2-zone composite design MIRA REX COMP range, technically optimised and adapted honing wheels for power honing were launched.

The abrasive inner ring is produced using vitrified bonding. The outer ring is made of an PU bonding without abrasive grains. A patent application was filed for this innovative honing wheel design. With the additional performance upgrade with the specifications MIRA REX-580, REX-1200 and REX-1300, Tyrolit offers best technical solutions. By employing "gentler" honing, machining times can be shortened and/or dressing cycles extended. At the same time, the risk of breakage of overstressed honing rings is reduced.

Next, Tyrolit plans to offer an additional component acceptance service on a high-performance honing machine for MIRA DDG (diamond dressing gears). The standard quality assessment is made on the MIRA DDG dressing gear wheel.

With the additional workpiece acceptance offered, quality assessment then takes place by reference to the honed workpiece. Along with the workpiece, the customer is provided the acceptance diagram and the directly adapted honing ring. This means that the customer is fully aware of the results that can be expected in actual production. It is also acts as an investment guarantee and assurance of uninterrupted production.

New techniques

Working closely with manufacturers of machinery and in its own development department, Tyrolit is now investigating news in dressing techniques and in the development of innovative dressing tools. Ultimately, the frequency of the necessary dressing operations not only affects their productivity, but also the cost of dressing tools and of the actual grinding wheels.

Dressing also means wear and tear on both sides. Optimization means immediate cost savings. Tyrolit translates customer needs into action.

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Fractal Geometry Characteristics in Gear Tooth Surface Wear Evaluation

It is important to evaluate a number of parameters using Fractal Geometry in gear design/life. Here's how it's done

By: KP Soundararajan

Quite often gear tooth finish machined surfaces when in motion under load experience abrasion wear. The unavoidable abrasion wear is controlled or managed by lubrication where the mineral oil as the lubricant acts as a pressure sustaining medium to separate the load bearing surfaces. Here, the lubricant's EHD (Elasto Hydro Dynamic) or full film characteristics retard the flank surfaces to undergo abrasion wear. The transition from EHL (Elasto Hydro Dynamic Lubrication) towards mixed lubrication has several phenomena.

As the predictable gear life from surface finish to micropitting gains importance in gear design it is necessary to evaluate the loading pattern, elastic tooth deflection, transition zone between EHD and mixed lubrication, and asperities behaviour systematically.

It is a complex topic to go into the details of every aspect in one coverage. The contemporary research efforts address the wear growth rate and micropitting features under different factors. Accordingly the surface feature analysis using fractal geometry achieves an attention for convenience in mathematical interpretation and addresses the physical characters through fractal dimension.

Fractal Geometry: Using Fractal Theory To Determine 3D Phenomena

Fractal Theory is used to simulate rough surfaces with fractal characteristics. The rough surface profile is shown below in figure 1:

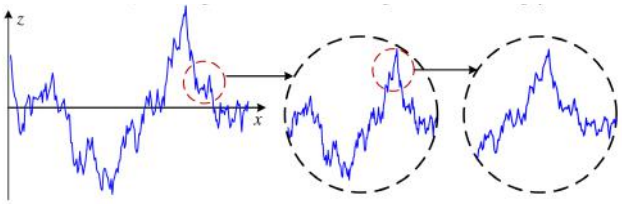

Fig 1: Description of self-affinity for a rough surface profile

This surface has the 2D roughness profile and considering the face width along with profile contact enables one to observe a 3D phenomenon of rough surface topography. The associated features are:

- Height of rough surface profile
- Number of superimposed peaks under a given microscopic surface
- Sampling dimension 3D and length in 2D
- Scaling parameter γ
- Fractal dimension
- Scale coefficient

Z represents contour height in 2D rough profile, x a position coordinate, D the fractal dimension, G the scale coefficient, γ^n represents frequency spectrum of surface roughness where γ takes a value of 1.5 or less, and n being the frequency index of asperities.

$$z(x) = G^{D-1} \sum_{n=n_{\min}}^{n=n_{\max}} \frac{\cos(2\pi\gamma^n x + \varphi_n)}{\gamma^{(2-D)n}}$$

Fig 2

The above concept and height of 2D rough profile cannot characterise the fractal property of 3D rough surface or for gear tooth surface in mesh contact of tooth flanks except X direction to indicate the rolling direction. As the actual tooth surface has the morphology which is anisotropic the 3D WM (Weierstrass & Mandalbrot function) of anisotrophy can be obtained by super-imposing 2D WM function with X and Y directions. Therefore the previous equation (figure 2) becomes as seen below in figure 3:

$$z(x,y) = \sum_{n=n_{\min}}^{n=n_{\max}} \left[G_x^{(D_x-1)} \frac{\cos(2\pi\gamma^n x + \varphi_{nx})}{\gamma^{(2-D_x)n}} + G_y^{(D_y-1)} \frac{\cos(2\pi\gamma^n y + \varphi_{ny})}{\gamma^{(2-D_y)n}} \right]$$

Fig 3

where Z(x, y) is the amplitude of 3D rough surface. Dx & Dy are the fractal dimensions along the X and Y axes respectively. Gx & Gy are the scale coefficients for X and Y directions. ϕnx and ϕny are random phase conditions while other parameters remain the same.

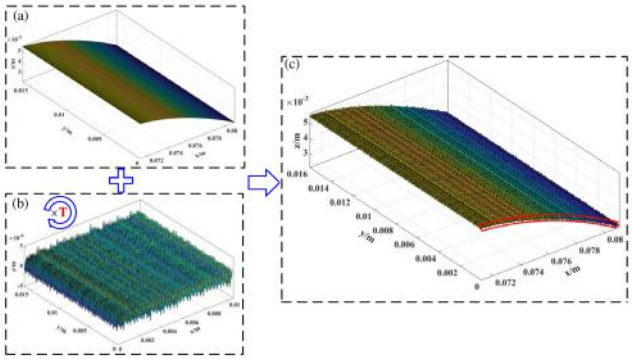

Fig 4

The 3D surface shown in figure 4(a) and 4(b) gets merged into a shape as seen in figure 4(c).

The sketch of the pinion and gear wheel fractal surface for 2D surface topography can be realized as shown below:

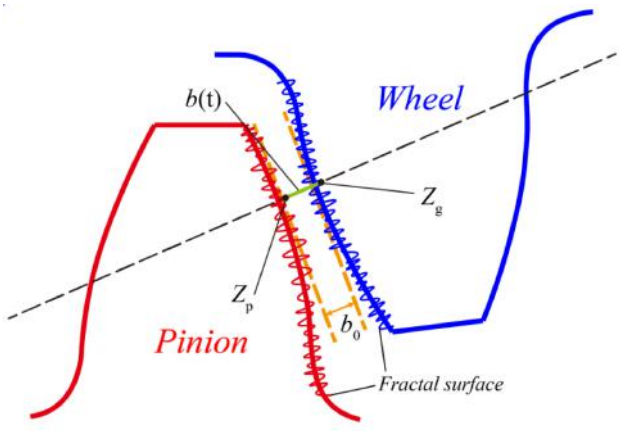

Fig 5

Fractal Tooth Surface:

The surface wear evaluation by prediction method for tooth surfaces is subject to a complex contour and requires integration of a few separate models after analysing the microgeometry features. These can be described as follows:

The prediction of abrasion or material wear of tooth surfaces will evolve microgeometry features and associates with contact stresses between the flanks and the load. It also includes implicitly the effects of sliding between meshing tooth surfaces. The amount of sliding can change with slip per design.

Slip S = Ur / Ue.
Ur = Surface velocity of rough surface.
Ue = Mean entrainment speed.

The models that come are:
a) **Real tooth surface models on an involute gear pair to enable described the microgeometry.**
For the construction of real tooth surface models of a gear pair there is a need to segment the active phases theoretically to explain the microgeometry. It is done better using a CMM (Coordinate Measuring Machine) where the measured coordinates of a tooth surface can be converted into a 3D curved surface analysis. The use of projections to get nominal points in spatial domain under aerial metrology with surface normals and unit vectors yield the expected point coordinates.

b) Load distribution model is to measure the contact pressure at each point of mesh along with the angle of rotation in every mesh cycle.

c) **The asperities contact model facilitates better understanding of asperities deflection under elastic & plastic phases in motion.**
Modified fractal method is used to estimate the deformation since the manufacturing process of involute gears may be irregular due to several reasons yet the tooth flanks have fine structure and statistically compatible. Hence WM function is applied to describe the micro geometrical features to relate the operating conditions to wear and its progression.

$$W(\xi) = \Lambda^{D-1} \sum_{\sigma=1}^{+\infty} \frac{\cos(2\pi\gamma^{\sigma}\xi)}{\gamma^{(2-D)\sigma}} \quad 1 \le D \le 2,\ \gamma > 1$$

Fig 6

ζ is the profile parameter of asperity, Λ is the fractal roughness of actual tooth surface, D is Housdorff-Besicovitvh fractal dimension, δ is the frequency factor, and γ a scaling parameter: γ is chosen between 1 and 2, and 1.2 often applied.

When D and γ with properly chosen values gives W(ζ) in the above equation, seen in figure 6, a deterministic value. The elastic deformation of an asperity of real tooth under meshing condition is represented as seen below in figure 7:

$$\delta_e = \Lambda^{D-1} \frac{1}{\gamma^{(2-D)\sigma}} = \Lambda^{D-1} \left(\frac{1}{\gamma^{\sigma}}\right)^{2-D} = \Lambda^{D-1} a_e^{1-0.5D}$$

Fig 7

Then the normal elastic contact load is finally arrived at after finding the elastic contact area, modified contact radius of curvature of asperity as:

$$F_e(a_e) = \frac{4}{3\pi^{1/2}} E\Lambda^{D-1} a_e^{1.5-0.5D}$$

Fig 8

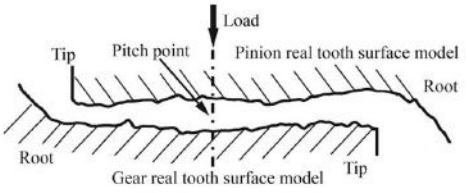

Fig 9

The cross-sectional tooth contact load bearing profile normal section is shown in figure 9.
Full plastic contact load on the asperity is found by calculating the plastic area of contact ap: fixing δc the critical deformation between elastic and plastic range of asperity and finding whether δc < δe and if so the deformation of real tooth surface model is a full plastic deformation regime.

$$\frac{4}{3\pi^{1/2}} E\Lambda^{D-1} a_c^{1.5-0.5D} = 2Ha_c$$

Fig 10

$$F(A_r > A_{rc}) = \begin{cases} \dfrac{2DE\Lambda^{D-1} a_m^{0.5D}}{3\pi^{0.5}(1.5-D)} \left(a_m^{1.5-D} - a_c^{1.5-D}\right) \\ + \dfrac{2DH}{2-D} a_m^{0.5D} a_c^{1-0.5D}, & \text{if } D \neq 1.5 \\ E\left(\dfrac{\Lambda}{\pi}\right)^{0.5} a_m^{0.75} \ln\dfrac{a_m}{a_c} + 6Ha_m^{0.75} a_c^{0.25}, & \text{if } D = 1.5 \end{cases}$$

Fig 11

H represents the actual gear tooth surface hardness.

d) **Abrasion wear model**
Sliding distance, local contact pressure, and direction of wear progression are key factors for abrasion wear growth. Following Archard's method for local contact point can be represented as seen in figure 12:

$$\frac{dh}{dS_i} = k \frac{F(A_r > A_{rc})}{A_r}$$

Fig 12

Where S_1 is a sliding distance of a contact point on pinion and gear real tooth surfaces. K is the wear coefficient.

$$\gamma(y) = \gamma_b - 2v(y)$$

$$U = U_x + U_n + U_s$$

$$\begin{cases} U_x = 6\dfrac{F^2 \cos^2\alpha_c}{EB} \displaystyle\int_{y_p}^{y_c} \frac{(y_c - y)^2}{e^3(y)} dy \\ U_n = 6\dfrac{F^2 \sin^2\alpha_c}{EB} \displaystyle\int_{y_p}^{y_c} \frac{1}{e(y)} dy \\ U_s = C\dfrac{1}{2}\dfrac{F^2 \cos^2\alpha_c}{GB} \displaystyle\int_{y_p}^{y_c} \frac{1}{e(y)} dy \end{cases}$$

Fig 13, 14, 15

The wear depth h of any contact point can be calculated by the above expression.

Conclusion

Gear tooth wear mechanism and wear progression under operating factors such as those which chiefly influence in consideration have been adopted to model the phenomena. The wear contributing factors have different impact on the wear value, rate of progression and direction towards ultimate micropitting.

The fractal features such as D, G, γ, n or δ while transforming into analytical way enable a useful correlation of actual factors on the real tooth surface wear without changing the logical impact.

Taking specific criterion like the work done on the asperities under elastic deflection of real tooth surface the equation under the load distribution model shows that it is a function proportional to actual surface fractal roughness raised to a power of fractal parameter D. In practice the real value and its rate affecting the gear surface finish worsens in proportion to the load continually. Similarly, area of deformation under force is also proportional to the load expressed as exponential function of the fractal parameter D.

What Lies Ahead: Scope and Direction of Future Efforts

The introduction of fractal characteristics of their parameters is applied to other areas as well. Determination and monitoring wear on grinding abrasive worm used in generating grinding of gears is an important phenomenon to capture for it helps to:

a) know the grinding wheel behaviour on the load
b) suitability of grinding wheel specification for the given application and scope to improve
c) monitor the dressing interval in process
d) impact on the quality of the gear in grinding and so on

The process software has the method existing already to decide the dressing frequency, the grinding wheel surface quality in dressing, depth and mode of dressing. Yet the area may need more research and automated applications than now in the future.

Fractal features are finding their way in evaluating this approach using power spectrum method and applying WM function on the effects of grinding volume Vh and thereafter the specific material removal rate Qw', axial feed rate, tangential grinding wheel shift, shift increments, and number of starts of grinding abrasive worm under closed study in research domain. The influence of lubricating oil film pressure and its effect on wear deceleration may also be considered in gear tooth surface wear prediction probably in the future.

The growth of artificial intelligence for application into process management, determination of gear tooth life and specific design loads and stress cycles with consequent failure analysis to seamlessly integrate at the design stage itself for performance prediction may be expected in the gear industry in the future.

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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.

Blaser Swisslube's Liquid Tool helps Improve Productivity and Reduce Cycle Times

Blaser Swisslube helps manufacturers fully capitalize on the potential of their machines and tools and turn the metalworking fluid into a key success factor – a Liquid Tool

History

Headquartered in Hasle-Rüegsau, Switzerland, with production facilities in Switzerland and America, the family-owned Swiss company develops, produces and sells a comprehensive range of metalworking fluids of the highest quality, performance and reliability for a variety of industries.

Global CEO Marc Blaser, who represents the third generation of the family-owned business, believes that manufacturers can fully capitalize on the potential of their machines and tools and turn the metalworking fluid into a key success factor — a Liquid Tool — that can improve productivity for customers and help them succeed.

In India, the Blaser Swisslube subsidiary began in 2001. Under the leadership of Mr. Punit Gupta, it is contributing to its customer's productivity, economic efficiency and machining quality. In terms of new gear hobbing and grinding technologies, Blaser Swisslube offers solutions to its customers and addresses their challenges for improved efficiency, increased tool life, and reduced cycle times. These can be accomplished with higher parameters, which cause higher machining temperatures.

"We aim to improve these points in cooperation with our customers," Punit Gupta, Managing Director West Asia at Blaser Swisslube says. "As higher parameters produce more heat in the machine, we have to find the optimal cutting fluids. With our product range of cutting fluids, we want to deliver an added value where higher cutting parameters in combination with lowest risk of smoke formation are achievable.

The focus to reduce smoke production is a need in the area of environmental health which the top management needs to focus on", he adds.

Range of Metalworking Fluids and Its Applications in Various Industries

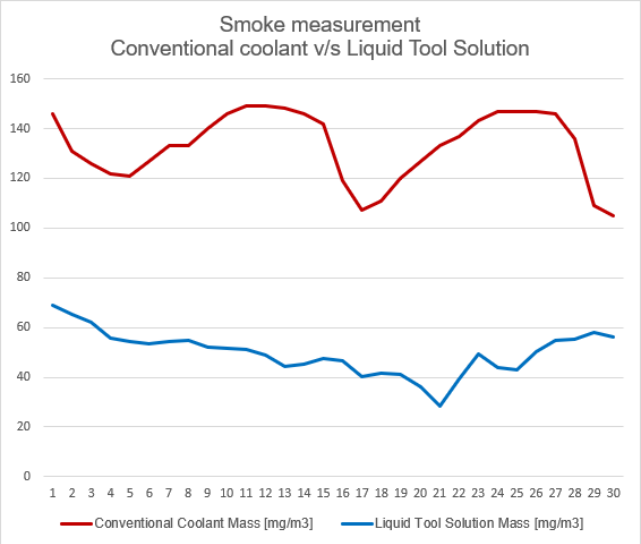
Our focus is to work on all the materials and applications within machining & grinding operations. We offer our customers water miscible coolants, neat oils & MQL (Minimal Quantity Lubrication) range for different segments and applications. These products are built on various technology platforms like a unique bio concept, zero germ principal, ester based and fully synthetic.

Neat oils offer high success in gear cutting, gear grinding, broaching, tool grinding, gun drilling applications etc. Materials like steel, cast iron & aluminium in the automotive industry to materials like Titanium, Inconel, SS etc are very interesting to look at for increasing productivity and machining performance.

MQL has been a niche area in industry so far, however, we are geared for the same with many happy customers.

All these areas have a potential to offer up to 20-40% increase in tool life and/or 8-15% increase in productivity as per various projects records. However, we always analyse the process of the customer and then make a proposal.

Case Study about Productivity Increase in Gear Technology



Recently, Blaser Swisslube India was able to help increase the productivity of a customer in the field of Gear Technology. The goal was to reduce the cut time of forged steel components and lower smoke and mist in the facility.

The Blaser Sales Engineer, in close collaboration with the customer, switched during a test phase a conventional cutting fluid to a Blaser ester oil-based cutting oil and increased the cutting speed by 20% with convincing results. The cut time was reduced by 24%, the advent of smoke and mist was reduced by 51% and lowered the overall costs per component. Gupta says "Many applications have a potential to increase up to 20-40% in tool life and/ or 8-15% in improved productivity as per various projects records. We at Blaser always analyse the process in the beginning and then make a proposal to the customer of what he can improve in the long run."

Service Support for Customers

We have an experienced and trained team of technical salespeople, application engineers to help customers onsite. Blaser Swisslube is renowned for its personal on-site support. If we're not on site, we're still there for you with our Remote Care Tool. With Blaser Remote Care, we can support our customers quickly and completely from a distance — live via video — and also due to our "augmented reality." We can discuss and solve issues quickly and effectively via mobile phone or tablet.

All customers need is access to the Internet without installing any app or software. This increases productivity and customer satisfaction, as we save time and travel costs and customers quickly receive the support they need. We continuously invest in know-how and facilities — in India and globally. The recent investment in the Country Competence Centre in India (named CCC) is an example of the future oriented journey of the coolant company. The CCC gives Blaser customers an opportunity to monitor their critical coolant parameters. The CCC is equipped with state-of-the-art laboratory equipment. It is also open for customers and partners for visits and training.

Collaboration between your research team and manufacturing expertise in creating metalworking fluid

At our Research and Development facilities in Switzerland, we have the opportunity to test the latest metalworking fluids and recreate the versatile machining operations of our customers and partners in a realistic way. At present, research is carried out using four CNC milling machines and a state-of-the-art grinding machine. The latest high-precision measuring devices and sensors enable the data acquired to be interpreted correctly. So, at this in-house facility, our laboratory research team works hand in hand with our manufacturing experts to ensure that our latest metalworking fluids meet the expectations in the customer production halls. For this purpose, we have set-up various performance tests in our technology centre. It's only when a new development has cleared all hurdles, it is ready for the market.

Training Programs for Customers

We are fully committed to provide customers with comprehensive solutions rather than merely products. It triggers the role of a good maintenance & monitoring system onsite by customers. We also help customers by imparting the know-how and training to their people.

New Product Launches

Our product portfolio is reviewed and adjusted every year. While developing new formulations, we always keep our customers' needs in the centre. We receive consistent feedback from the customers in the market, so that the right solution can be given to our customers.

We have new oil Blasogrind GTS 15 for gear grinding application which is especially formulated to reduce burn marks and increase feed rate thereby higher productivity. The increased lubricity allows faster metal removal rates while avoiding grinder burn, reduced scrap rate due to decreased risk of grinder burn. This high-performance grinding oil is optimised for high feed rates, long dressing intervals and excellent surface quality.

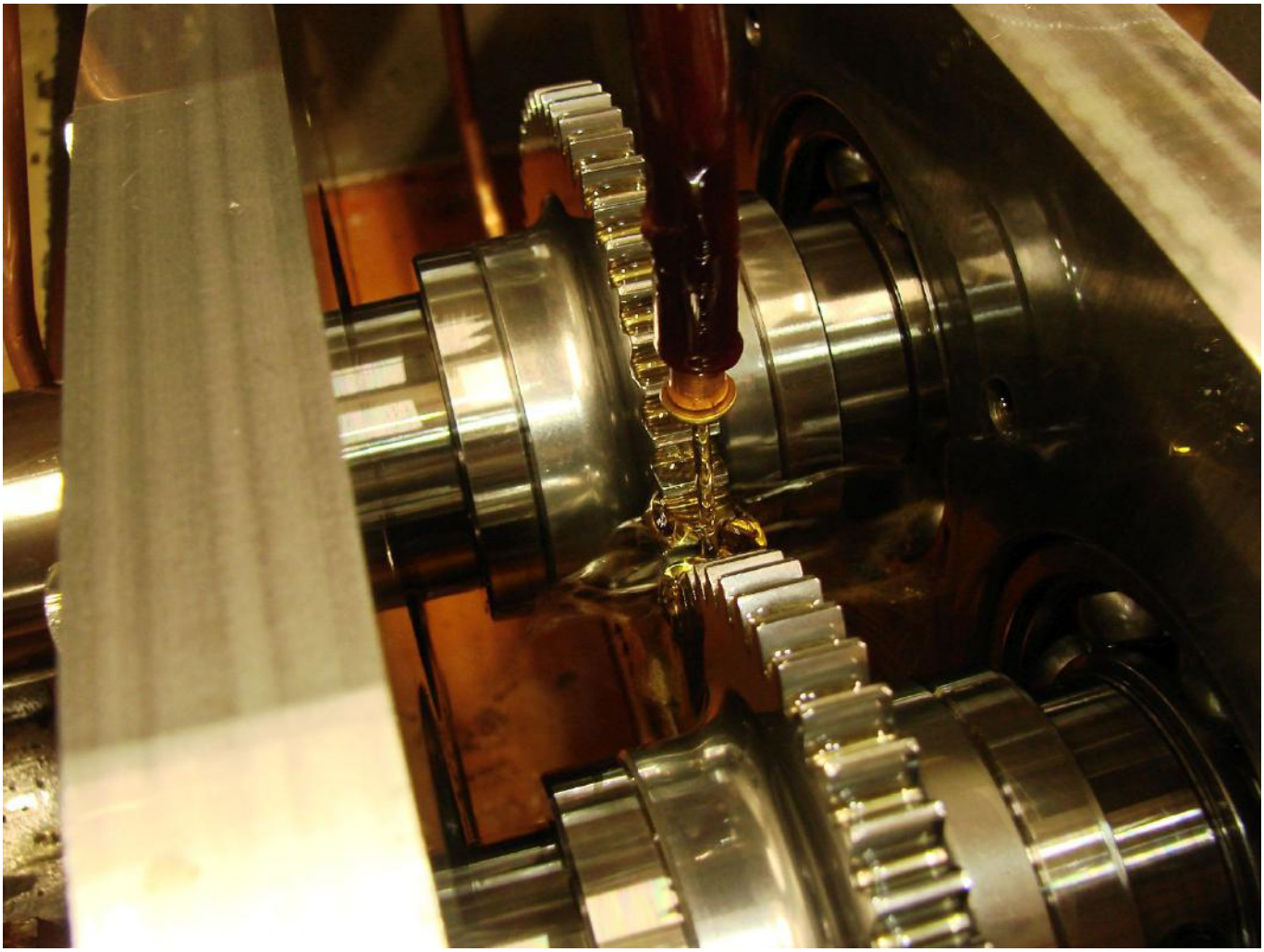
How will Gear Technology India help the industry?

It is good that Gear Technology India has been launched in India. There is a lot of development happening in the gear industry and Gear Technology India can serve as a platform for the distribution of knowledge related to gear technology. This can help professionals and companies stay updated with the latest developments.

Punit Gupta, Managing Director, West Asia at Blaser Swisslube

Spraying to All Fields: Catching Up on Some Lubrication Trends and Issues

By: Jack McGuinn



Lubrication — as it pertains to the gear industry — is a rather large universe, much, much more than the old double-entendre "the squeaky wheel gets the grease."

Indeed, lubrication in this universe encompasses gear oils, coolants, greases, oils and sophisticated lubricants — intended for everything gear-related from bearings to gearboxes to pinions to couplings to machinery, and more. Add in the lubrication equipment — some of it quite sophisticated — used to deliver these various lubricants — including synthetics — to where they need to go, and it's easy to understand there's a lot going on.

To try and bring some clarity to the situation, we enlisted several experts to offer their thoughts on a number of issues addressing lubrication. It's a general approach to seeking information on the current trends and challenges inherently relevant to lubrication technology and its ever-evolving development and usage.

Synthetic lubricants are now a front-and-center issue in the industry. The question that this presents is whether there is an industry-recognized definition of a "synthetic" lubricant.

As you might expect, it's more complicated than trying to decide whether using a synthetic for your next oil change is a good idea. "In Germany they define a synthetic PAO as 100% PAO," says Robert XX Errichello, president of GEARTECH. "In the U.S. and elsewhere, a synthetic PAO can be a blend of 1-30% PAO and mineral oil. Sometimes these PAOs are called semi-synthetic. PAG is considered synthetic oil in every country (Ref. 1).

Meanwhile, according to René Greschert, WZL gear testing engineer, "There has already been a legal dispute about (this) — but no industry-recognized standard. Therefore, the term 'synthetic' is used very creatively. However, completely chemically formulated oils are mostly referred as "full synthetic," (i.e. — mixtures of full synthetic) and mineral oils as "semi-synthetic." On the other hand, even hydro-crack oils,

which are actually based on mineral oils, are often advertised as "HC-synthesis," probably to make them appear more valuable."

Fixed viscosity grades are another key consideration for lubricants — particularly relevant to micropitting protection. The question: what works best?
"PAG has the highest micropitting resistance, and mineral and PAO have less — but similar — micropitting resistance," says Errichello. While on one hand Aaron Isaacson, Senior Research Engineer and Head of the Drivetrain Technology Center at the Applied Research Laboratory of The Pennsylvania State University and Managing Director of the Gear Research Institute, states, "I wouldn't think that film thickness would depend on base stock."

Greschert offers that "The tendency for micropitting resistance and gearbox efficiency (correlates) with the EHL film thickness," adding, "therefore, the lubricant performance tends to improve in the order of mineral – PAO – PAG. However, it is possible to observe different trends in practice, since the lubrication is also affected by other factors as, for example, the additives of the lubricant as well as by their complex interdependencies and side effects."

Relatedly, EHL film thickness is another crucial component of lubrication. It requires determining the correct base stock (mineral, PAO, or PAG) for use in the application. "It depends on the gear tooth temperature," Errichello states. "PAG has thicker films than PAO and mineral over the entire range of practical temperature. There is little difference between PAO and mineral for the range of 70-90°C. At < 70°C, mineral and PAG have thicker films than PAO. At >90°C, PAO and PAG have thicker films than mineral (Ref. 2).

Gearbox efficiency is a condition that is constantly under industry-wide pressure for improvement. Expectedly, lubrication plays a significant role in that improvement. And what lubrication parameter has the greatest impact on that efficiency?

"There are many ways to increase the efficiency of a gearbox," says Isaacson. "Generally, you want to decrease losses. Losses are due to friction, churning, and/or windage. Friction can be reduced by a number of methods — such as reducing surface roughness, adding low-friction coatings to rolling/sliding components such as gears and bearings, adding additives to the lubricant, and probably a handful more.
Churning losses can be reduced by using a lower- viscosity lubricant, running at a higher lubricant temperature, or reducing the level of oil that rotating parts are forced to churn through. Windage losses can be reduced in jet-lubricated gearboxes by incorporating shrouding around the gears or adding drag-reducing features (air foil winglets!) to the gear design."

Errichello adds that "PAG has the lowest traction coefficient and therefore gives the highest efficiency. PAG with low viscosity and low traction coefficient generally result in the highest efficiency."

Relatedly, Greschert adds that "On the one hand, the viscosity grade is predominantly correlating with the no-load losses of a gearbox. Higher viscosity leads to higher churning losses and thus less efficiency. On the other hand, the choice of base oil and additives affects the lubrication regime especially concerning the load-dependent losses of a gearbox. In this context, PAG are reported to perform better than PAO and mineral oils.

One possible explanation for that differentiation between the base oils is their different potential to establish elastohydrodynamic lubrication (EHL) instead of mixed lubrication."

Not surprisingly, a robust maintenance regimen is required for consistent-performance lubrication. Without it, downtime and costly repairs are in your future. So what constitutes robust maintenance?

"The basic laboratory tests are viscosity, acid number, water content, and spectrometric analysis," says Errichello. "If questions arise from the basic tests, other tests such as ferrographic, particle counts, and ferrous debris by PQ analyzer should be done."

"It really depends on your application," says Isaacson. "Are you generating a lot of debris or particulate? If so, then you'll likely want to monitor particle counts. Are you operating at high temperatures? If so, you may want to monitor the viscosity and additive contents. Are you concerned about picking up water content or other contaminants? If so, they you'll likely want to test for those. A great deal can be learned by partnering with a knowledgeable oil analysis company to recommend the proper tests and sampling intervals for your application. Interpretation of results is also not always straightforward. So, having a test lab that understands your goals is a must."

Finally, manufacturing processes and attendant requirements continue to advance at seemingly break-neck speed. Lubrication is no exception.

"Currently, lubricants and additives are quite good and should continue to improve in the future," Isaacson says. "Current research areas include nanoparticle additives, ionic lubricants, graphene- based friction reducers, ZDDP additive optimization, viscosity index improvers and a long list of others — any number of which could result in the next big breakthrough in lubrication technology. However, your previous question on preventive maintenance would be where I would focus my efforts. Implementation of a lubrication monitoring system or routine sampling schedule will provide immediate payoff, whereas waiting for the next big thing could take a while."

WZL's Greschert explains, "We are currently observing efforts to optimize lubricant compatibility and to expand its functionality. Compatibility requirements are increasing as a result of legal standards (e.g. — compatibility with human organisms), or as a result of a more universal area of application (e.g. — compatibility with sealing elements). For example, metalworking fluids are more and more containing amounts of high-tech synthetic ester oils with excellent performance and sealing compatibility. However, machine tool manufacturers and users are very cautious in using them due to their bad experiences with the first naturally produced ester oils in the 1990's.

"Another interesting topic is the improvement or substitution of the run-in procedure at the beginning of the application. The most changes to the surface zone of a gear take place at the very beginning of its operation, e.g. — the surface roughness gets flattened, the microstructure is becoming fine-grained and the chemical composition is changed. We've had a big research program 2012-2018 (and a continuation starting in 2020 is planned) of more than 20 institutes trying to understand and improve the run-in procedure and its working mechanisms to improve the resource efficiency in the application of lubricants and machine elements." And, "Yes," says Errichello, "electric vehicles require special lubricants because the lubricant acts as

a coolant to cool the electric motor in addition to lubricating the gears and rolling element bearings in the gearbox. Because of the extreme heat in the motor, mineral, PAO, and PAG do not have the desired properties. This is currently a hot research topic. Perhaps a poly ester fluid, which has superior high temperature performance and increased lubricity that increases efficiency might fill the bill."

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Lubrication Issues — New and Ongoing

René Greschert

What are some of the developing trends and newest and/or ongoing challenges regarding lubrication and its many applications? Not enough available space here to address that question comprehensively, but here, from WZL's Réne Greschert, are some good talking points.

Improvement of lubricant performance.
For example, transmission fluids contain additives to improve their behavior regarding:

- Scuffing
- Micropitting
- Efficiency

For these three different points you also need three different types of additives, and you have to make sure that there are no interactions between them. If one ingredient of the lubricant is modified, you have to check all the points again to ensure that the overall performance is not changed.

Improvement of lubricant compatibility, for example:

- Reactive additives should not be harmful to humans
- Ester oils should not damage the sealants. These two (reactive additives and ester oils), especially, are excellent solutions to improve the lubricant performance, but they need to be carefully handled in terms of compatibility. Today's metalworking fluids contain minor amounts of high-tech synthetic ester oils with great performance and excellent sealing compatibility. However, machine tool manufacturers and users are very cautious in using them.

Improvement or substitution of the run-in procedure at the beginning of the application.
The most changes to the surface zone of a gear take place at the very beginning of its operation, i.e.:

- Surface roughness gets flattened
- Microstructure is becoming fine-grained
- Chemical composition is changed

We have had a significant research program 2012-2018 (and a continuation starting in 2020 is planned) of more than 20 institutes trying to understand and improve the run-in procedure and its working mechanisms.

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In Conversation with LMT Tools

Please tell us a little about your company. How do your offerings support the gear industry?

LMT Tools is one of the most renowned specialists in the development and production of precision tools. To ease machining is the company purpose of LMT Tools. We believe that customers should focus on their own operations because they can easily rely on the performance of LMT Tools' machining solutions. This enables them to offer excellent products that are successful in the market.

We serve the product lines of Gear Cutting, Milling & Threading, Reaming, Rolling Systems and Advanced Tooling. As an international network of experts, LMT Tools develops innovative tool solutions with reliability and fast services.

With our high performing gear cutting tools, we partner & provide solutions to leading gear manufacturing companies for their gear production. Our high productivity gear cutting tools help manufacturers to reduce their production cycle time coupled with our consistent engineering support and supplied reliable tools. LMT Tools is considered as a preferred & leading cutting solution provider in the gear manufacturing industry. Our state-of-the art manufacturing facility in Pune caters to the Indian as well global demands. Our niche offerings support the gear manufacturing industries in challenging application & technological advancements.

What are the latest advances in your field? How have you incorporated them into your business?

Increase in demand across industries leads for faster production requirements, which furthermore generates demand for machining solutions with less cycle time. This industry demand is pushing the tooling industry forward at a rapid pace. In keeping with these new trends in the cutting tool industry, we have taken a step forward and put in place our tooling solution. Recently, we have launched our Gear Skiving solutions with process reliable simulation.

With its high performance and wide range of applications, gear skiving offers great potential to produce internal and external gears and is clearly superior to conventional manufacturing processes in many cases. For example, it enables faster

Ramakant Reddy,
Managing Director, LMT Tools India Pvt Ltd

The hobbing of gears from module 6 onwards can be carried out extremely economical with LMT's modern hobs with indexable carbide inserts. Image: LMT Tools

machining times than hobbing, it offers a wider range of applications than gear hobbing, and thanks to lower tool costs and the elimination of special machines, it also has an advantage over broaching.

To meet the challenging finish quality requirements, our finish hobbing tools are set in order to it. Finish hobbing tools produce superior quality gears, achieving required finish quality of gears. also shaving operation can be skipped for such gears. This enables gear manufacturers to achieve the required finish quality in production along with eliminating one operation resulting in great time saving.

What are some of the latest product launches? Please elaborate about their capabilities and applications.

With our ongoing R&D, and an international network of experts within organization, LMT Tools continues to add innovative tooling solution in the product portfolio. Our latest addition in Gear Cutting tools include: Gear Skiving cutter, ChamferCut, next generation gear cutting inserts, and combination tools.

The ChamferCut allows cost-effective deburring & chamfering operation along with most accurate & consistent chamfer quality. In addition, there is the innovative Gear Skiving solutions with process reliable simulation. With its high performance and wide range of applications, gear skiving offers great potential to produce internal and external gears and is superior to conventional manufacturing processes in many cases.

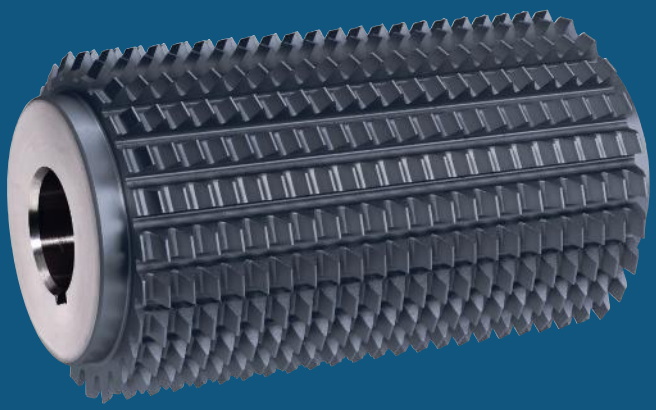
Our Gear Cutting combination tools have Hob & ChamferCut on a single arbor. It is designed and produced to allow manufacturing flexibility with production of gear in a single set up. Separate machines for hobbing and chamfering can be eliminated with the help of combination tool. These tools help save on capital investment on one hand, and eliminate additional manpower on other.

What are your production capabilities? What industries do you serve?

LMT Tools is a technology driven & multi-product company, our Gear Cutting, Milling & Threading, Rolling Systems, Reaming and Advanced Tools are widely used in Automotive, Aerospace, Die & Mold, General Machining, and Wind Energy. LMT Tools combines its competencies in the brands LMT Fette, LMT Kieninger, LMT Onsrud and LMT Belin. Our production sites are in Germany, USA, China and India. The demand for our cutting tools ensures that we are well positioned to make the most of the opportunities presented. Innovation makes us competitive.

Our state-of-the-art manufacturing facility in Pune has a production facility for Hobs & SC End Mills with center of competence for Gear Cutting, Milling & Tapping, Thread rolling and Advanced tools. Currently we manufacture 15,000 hobs in a year at our Pune facility.

We have investment plans in our existing manufacturing facility making it more competent for round tools, hobs, and coating technology. All our engineers are trained in Germany and thus caters to the export demand for Gear hobs, SC End Mills. Our Indian manufacturing facility has been recognized with star performer award for highest export.



LMT's High Performer Carbide Hobs allows highest cutting speeds results into short machining time also its longer tool life lowers down the gear production costs. Image: LMT Tools

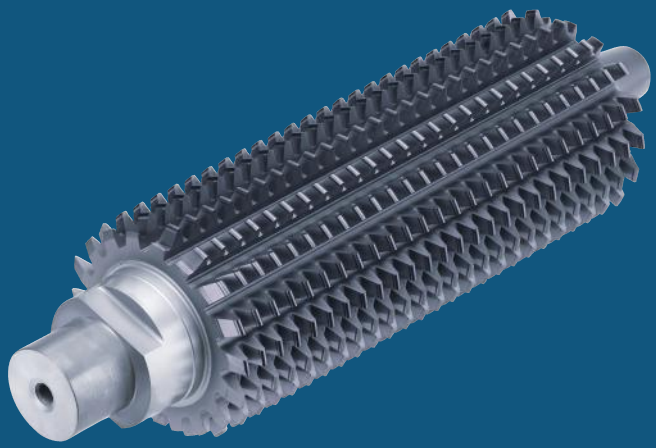
What are your impressions of the overall India market? What are the unique challenges and opportunities in this market?

The Indian manufacturing sectors is growing well, and we are witnessing good investments. Not only do they cater to the local demands but also serve to global requirements as well. Indian manufacturers are exporting quality products to multiple countries which shows the global reliability in our manufacturing.

There are certain manufacturing challenges still existing as we are still in a developing stage. In the manufacturing industry there is huge potential for automation, also few production facilities need to go for single piece workflow systems. Despite the challenges, there are multiple opportunities present that are knocking on the India's manufacturing sector.

What applications do you foresee for your products? Are there any specific machine types attracting the attention of the Indian buyer right now?

LMT Tools offers a range of gear cutting tools for a variety of application like Hobbing, Skiving, Chamfering in the gear manufacturing process. Our range of Gear hobs, skiving cutters and Chamfering tools are applicable across various module types. Our engineered and customized tools are being produced as per



SpeedCore is LMT's developed substrate for hobs which allows upto 50% higher cutting speeds compared with HSS hobs. Image: LMT Tools

customer specific applications. We foresee lot many opportunities in the power generation & wind energy industries. Indian gear manufacturers rely on multinational sophisticated CNC hobbing machine builders to achieve precision in production.

Do you do any CSR activities? What do you do for sustainability and the environment? What measures have you taken to reduce your carbon footprint?

Our CSR activities focus on taking a positive step towards collective upliftment and well-being of the community. With a focus on the education of bright minds of future India, we work with multiple educational institutions.

We insist on including essential vocational skill training that enhances employability. Besides this, we participate in promotional activities for health care in rural areas. Apart from this, we are adopting green manufacturing processes in our manufacturing facilities in accordance with international manufacturing standards. There is a zero-carbon generation within the complete production process.

How will the launch of Gear Technology India help the industry?

Gear Technology India has taken a good initiative to build a rigid and one of its kind platform beneficial for all involved in the gear manufacturing ecosystem. With the introduction of Gear Technology India, we foresee a lot of knowledge exchange within the industry. In addition, shared upcoming trends and technological advancements will surely be helpful for process enhancement and improvisation in gear manufacturing. The lag of information availability at single place has been rightly addressed by Gear Technology India.

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Best Practices for Designing Efficient and Reliable Gears

Gears are an essential component of many machines, from automobiles to industrial machinery. The efficiency and reliability of these machines depend heavily on the design of the gears

By: Nishant Kashyap

Choose the Right Gear Type

Choosing the right gear type is crucial for designing efficient and reliable gears. There are various gear types available such as spur gears, helical gears, bevel gears, and worm gears. Each type of gear has its own advantages and disadvantages.

For instance, spur gears are the most common and economical, while helical gears offer more contact area, resulting in smoother and quieter operation. Bevel gears are suitable for transmitting motion between intersecting shafts, and worm gears are best suited for high torque applications.

Understanding the requirements of the gear system and selecting the right gear type can improve gear efficiency and reliability.

Material Selection

The characteristics of using high-quality materials for gears are high strength, good wear resistance, and high fatigue strength. Commonly used materials for gears include alloy steel, stainless steel, and bronze.

The material selection should be based on the application requirements and environmental conditions. By using high-quality materials, this will improve gear durability, reduce wear, and increase gear life.

Gear Geometry

The geometry of gears plays an important role in their performance. The gear tooth profile and the pitch diameter are critical factors that affect the efficiency and reliability of gears.

The gear tooth profile should be designed to minimize contact stress and provide maximum load-carrying capacity. The pitch diameter should be optimized to achieve the desired gear ratio while ensuring the gears are not too small or too large in size. Optimizing gear geometry can improve gear efficiency, reduce wear, and increase gear life.

Lubrication

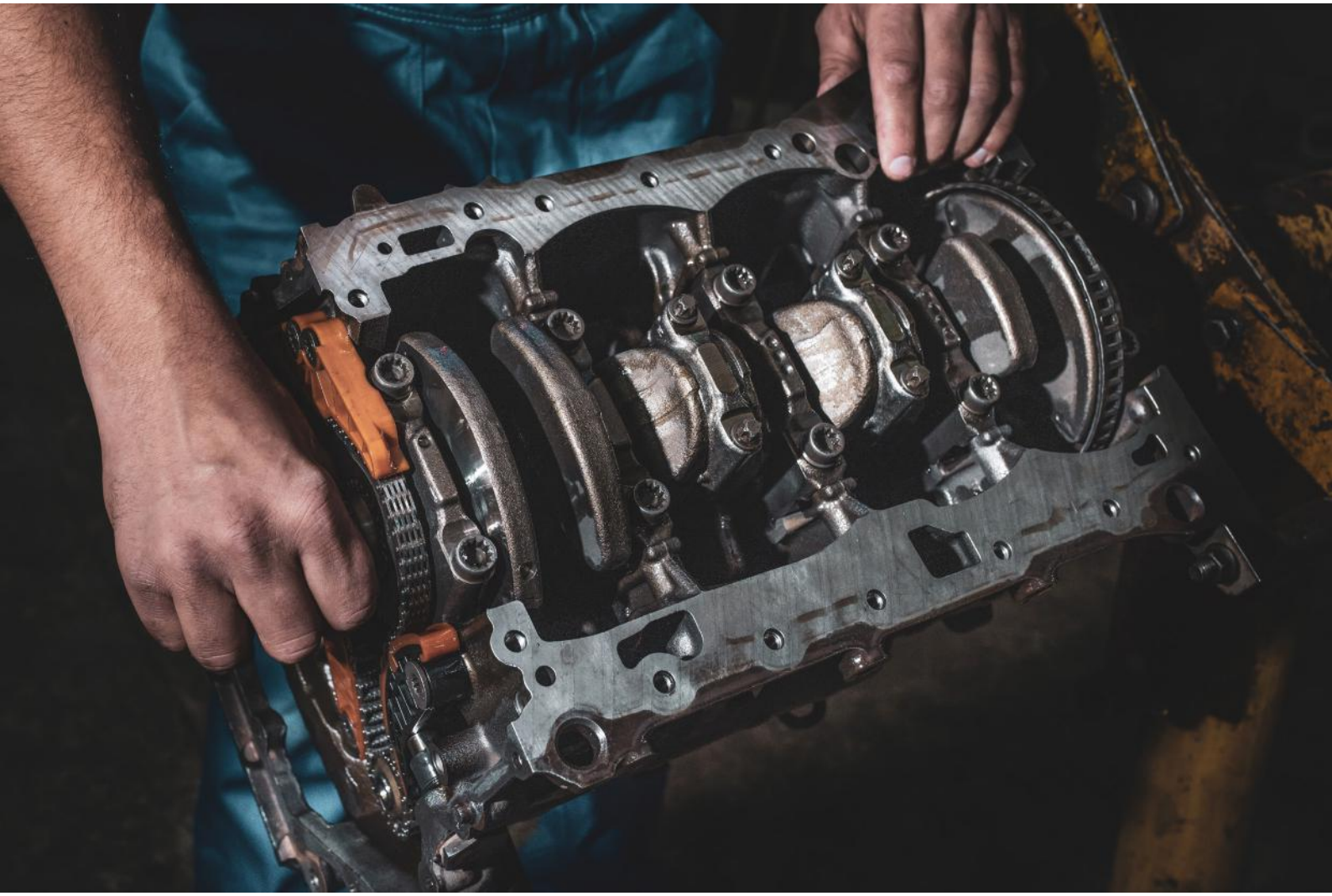
Proper lubrication is critical for the efficient and reliable operation of gears. Lubrication helps to reduce friction, wear, and heat generation. The lubricant used should have the right viscosity and be able to withstand the operating conditions of the gear system.

Over-lubrication or under-lubrication can cause gear failure. It is important to ensure that the gear system is properly lubricated at all times for it to function optimally.

Heat Treatment

Heat treatment is used to improve the mechanical properties of gears. The most common heat treatment processes are quenching and tempering. Quenching involves rapid cooling of the gear from a high temperature, while tempering involves reheating the gear to a lower temperature.

The heat treatment process should be optimized to provide the required strength and durability while minimizing distortion.



Precise Manufacturing

Manufacturing tolerances are the allowable variations in the dimensions of the gear. These tolerances are critical for achieving proper fit and ensuring smooth operation. The manufacturing process should be designed to minimize the tolerances and ensure that the gear is within the specified tolerance range.

The manufacturing process should ensure that the gears are accurately produced with the correct tooth profile and pitch diameter. Any deviations in the manufacturing process can result in reduced gear efficiency and reliability. The use of modern manufacturing technologies such as CNC machining, gear hobbing, and gear shaping can improve the accuracy and consistency of gear manufacturing.

Regular Maintenance

Quality control is essential for ensuring that the gears meet the required specifications. This involves inspection and testing of the gears to ensure that they are within the specified tolerances and meet the required mechanical properties.

Regular maintenance is crucial for ensuring the efficient and reliable operation of gears. The gear system should be inspected periodically for any signs of wear or damage.

Any worn or damaged gears should be replaced immediately to prevent further damage to the gear system. Proper maintenance also includes proper lubrication, cleaning, and inspection of the gear system. Regular maintenance can help to extend gear life and prevent gear failure.

Conclusion

Designing efficient and reliable gears requires a comprehensive understanding of the application, material selection, gear geometry, lubrication, heat treatment, manufacturing tolerances, and quality control.

By following these best practices, engineers can design gears that provide the required performance, durability, and reliability leading to the success of a machine.

Forward-Looking Companies Drive Growth and Innovation in the Gear Sector

In a bold move that promises to fuel growth and innovation, the gear industry is receiving a significant boost with a flurry of new investments. Companies across the globe are recognizing the pivotal role that gear technology plays in various sectors, including automotive, aerospace, robotics, and manufacturing.

With a fresh influx of capital, the industry is poised to scale new heights, revolutionize production processes, and pave the way for cutting-edge advancements.

One of the primary drivers behind this recent surge in investments is the growing demand for highly efficient and reliable gear systems. As industries strive to optimize their operations and deliver products of superior quality, the need for advanced gear technology has become paramount.

Manufacturers are keen to develop gears that offer enhanced power transmission, increased durability, and reduced noise levels. These requirements have sparked a wave of research and development activities, which, in turn, have attracted substantial investments.

Market Size and Growth

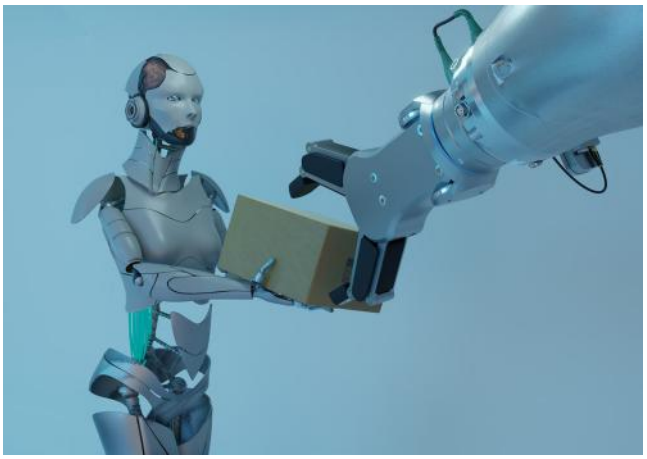
Based on reports, the valuation of the Global Industrial Gearbox Market was USD 27.01 Billion in 2022 and is expected to reach USD 36.69 Billion by 2030. The market is anticipated to grow at a Compound Annual Growth Rate (CAGR) of 3.90% throughout the forecast period.

Prominent players in the gear industry are seizing this opportune moment to expand their operations and push the boundaries of what is possible.

With the infusion of new capital, companies are investing in state-of-the-art manufacturing facilities, advanced machinery, and cutting-edge technologies.

These advancements not only enhance production capabilities but also enable the development of gears with higher precision, improved performance, and greater energy efficiency.

Furthermore, the rise of automation and robotics in various sectors has created a massive demand for specialized gears. As industrial robots become increasingly sophisticated and intricate, the need for compact and high-precision gears has skyrocketed.



Focus on Energy Efficiency

Gear manufacturers are increasingly focusing on developing energy-efficient gear solutions to reduce power consumption and environmental impact. These efforts align with sustainability goals and regulations aimed at reducing carbon emissions.

Investments in the gear industry are directed towards developing gears that can seamlessly integrate with robotic systems, offering unparalleled reliability and precision in their movements. This synergy between gears and robotics holds tremendous potential for revolutionizing automation in manufacturing, logistics, and other industries.

Another driving force behind the investments in the gear industry is the pursuit of sustainable solutions. As the world grapples with climate change and environmental concerns, companies are embracing sustainable practices and technologies.

The gear sector, too, is playing its part by investing in eco-friendly gear systems that reduce energy consumption and minimize carbon footprints.

By channeling resources into research and development of eco-conscious gears, companies are not only contributing to a

greener future but also appealing to an increasingly environmentally conscious market. Moreover, the investments in the gear industry are expected to have a ripple effect on the broader economy. As companies expand their operations and establish new manufacturing facilities, job opportunities will be created, providing a much-needed boost to local economies. The growth of the gear industry will also foster collaboration among different sectors, as manufacturers partner with research

institutions, universities, and technology companies to drive innovation and accelerate product development. With these recent investments, the gear industry is set to enter a new era of growth and advancement.

The influx of capital combined with a relentless pursuit of innovation, will propel the industry forward and unlock untapped potential. As gears become increasingly integral to numerous sectors, the investments will not only spur economic growth but also revolutionize the way we produce, manufacture, and automate.

Gear Manufacturing Technologies

Innovations in gear manufacturing technologies such as additive manufacturing (3D printing) have expanded the possibilities in gear production. Additive manufacturing enables the creation of complex and customized gear geometries, reduces material waste, and offers faster production cycles.

Conclusion

The gear industry is experiencing a remarkable surge in investments driven by the demand for cutting-edge gear technology, the rise of automation, and a push for sustainable solutions.

With this newfound momentum, companies are investing in advanced manufacturing facilities, machinery, and research and development, setting the stage for groundbreaking advancements.

The impact of these investments will extend beyond the gear industry, shaping the future of multiple sectors and laying the foundation for a more efficient, sustainable, and technologically advanced world.

"The domestic market is going to be propelling forward": RDMC's Tarun Nahata

By: Divya Sudarsanan

Trailblazers in the gear manufacturing industry, and a five-decade run family business, Tarun Nahata, Partner of RDMC, spoke with *Gear Technology India* of their journey, the defence sector, the challenges of the Indian gear industry and more.

Journey of RDMC

In 1972, RDMC was started by Tarun Nahata's father, JK Nahata. Tarun Nahata says, "He came with a mindset that he wanted to enter into the manufacturing of heavy engineering segment. He chose this segment because he wanted to add value rather than do a run-of-the-mill job. He started off with earth moving and off-highway segments."

RDMC is predominantly into manufacturing of high precision gears and CNC components for the off-highway, locomotive, defence, marine, windmill, cement, and tanks.

"We have partnered with all our customers, and proudly say that in the 50 years of journey, they are still with us. We benefit from not just being a partner to them, but also being a partner to learning from them which has been very huge," he adds.

Exports

RDMC is committed to delivering world-class products. He says, "We do export to the European and the North American markets, and we have the top-of-the-line customers like Caterpillar, Renk and Flender to name a few.

These are the world leaders in whatever they do. We only follow the world leaders, and try to make a niche, by giving them the best product that India can give." One of his proudest moments was when a customer commended their superior work stating that their work was parallel with German gear manufacturing, if not better.

Maximum Size of Gears

He says, "Typically, we do gears for gearboxes and transmissions and we have the capacity to do up to 1.8 meter external gears in finished cut, and up to 1.5 meter we can do ground gears. We can give them accuracy of DIN 6. In aerospace components that we do, we typically try to do it within DIN 4 and 5."

In addition, RDMC does high precision and high-speed gears for the textile and printing machines, especially printing machines where the RPM goes about 70,000.

The gears are explicitly qualified for DIN 5 accuracy. "Our manufacturing resources have the best grinding, hobbing, and testing machines. We have everything on top of the line, you could say, the Bentleys and the Bugattis of the gear industry," he matter-of-factly states.

Gears in Different Segments

RDMC's gears are used in windmills, and industries such as cement plants, steel mills, sugar mills, and power plants. He notes, "We also do gears for winches. Sometimes, we do get some requirement from the Army for their old gearboxes for rehauling and refurbishing." Besides this, they also do gears for the marine industry. They also happen to be globally certified. Nahata explains, "You need a certificate. Only then can you qualify as a supplier, and we are. We are certified, so globally any of their franchisees can come to me."

Defence Sector

RDMC has also made its mark in the defence industry which is a growing sector, and elaborates on the progress they have made. He says, "We are currently doing one of the most complex gears for the transmission of the T-72 and T-90 tank.

We have successfully completed the carrier assembly, and now the sun gear train where there are three different sun gears wherein the wall thickness is very less, the accuracies after gear cutting are within 18 microns; the runout after induction hardening and wall thickness is so less, which initially when we had a look, we said, 'I think we are going to burn our hands,' and we did lose a lot of jobs on the path. But finally, when we succeeded, it was a fantastic process that we got in control. It was phenomenal because we could see the repeatability of that."

They were also a part of the ATAGS – Advanced Towed Artillery Gun System. He proudly notes, "We have been given a certification by Tata SED for successfully proving out the breach to housing, and breach to assembly, which was used for the ATAGS that did a firing of 48 kms with a barrel of Ø155 mm, and broke the world record. The MoD also appreciated us through TATA SED." Besides this, Nahata is also involved with the K9-Vajra tanks for L&T.

Accuracy Maintenance Range

He explains, "The accuracies that we maintain are definitely precision in terms of gear quality DIN 5/6. We can do DIN 4 but that is on the tooling level where everything is pre-conditioned, the tooling, the temperature. We did a slender gear for one of the satellite programs where the precision was for DIN 4.

The runout between the spline and the gear was about 12 microns. So it was a lot of effort to get that accuracy, and we achieved it." In addition, they are also working on the T-72 tanks, which is a gost standard. "People are terrified of the gost standard because they don't know what the top or bottom limit is."

Facilities & Expansion Plans

RDMC has three units in Bangalore's industrial hub within a one-kilometre radius in Peenya. Each unit houses a different function right from CNC machining and gear finishing to hobbing, shaping and gear grinding. As for their expansion plans, Nahata is looking at getting into the heat treatment process. He says, "Right now our contribution is maybe 10% of our turnover, but we are looking at getting 30%."

Technology Upgradation

The company is focused on getting more precision gears as far as technology upgradation goes. That being said, RDMC also keeps themselves abreast of the latest technology in the market. He notes, "Gear skiving is another disruptive thing that is coming up." However, Nahata remains sceptical where technology and manpower resources are concerned. He opines, "Personally, I would prefer to maintain a balance between the workforce and using the technology," whilst adding, "Technology, for me, is like a tool which will serve as an extended arm. I don't believe in doing away with manpower. I'd rather connect with more people than machines."

India and the Gear Industry

Nahata believes that it's India's time to shine. He refers to Mr. Modi, who stated that India is in a period of *amrit kaal* which translates to "golden period." With the unfortunate war in Ukraine, and recession-hit US, all signs point to manufacturing coming back to India. He says, "The domestic market is going to be propelling forward especially locomotives, road construction, and defence. We see huge prospects in these segments. Railways is going to be on track for the next ten years.

Off-shore markets like windmills will pick up some speed. If we take a measured vision, we will definitely grow."

Challenges in the Indian Gear Industry

The need for a good heat treatment source is one of the biggest hurdles in the gear industry. He says, "Heat treatment is an important process and the fate of the gear largely depends on the success of this process. Attaining the right microstructure, hardness, case depth, while maintaining the mechanical properties and not displacing the dimensions is key to a good quality gear. Unfortunately, due to various reasons, India is yet to master the art of heat treatment unlike Europe and the US. There is a lack of consistency in the process affecting the gears' subsequent processes like OD/ID grinding, gear grinding or even machining (Turning, VMC, and HMC). If this hurdle is overcome, I am 100% sure that India would be at par with Europe and other countries that manufacture precision gears."

He continues, "Another challenge that this industry faces, and I am sure my peers, too, would agree is the availability and retention of skilled manpower. Post pandemic this challenge has magnified leaving the industry high and dry with an empty pool of skilled manpower resources. I feel that this needs to be taken up as a common cause, and the industry together must come up with a solution to overcome this obstacle by training more and more people, standardizing the pay package, and incentivizing this industry."

The third problem that he sees is resources, particularly power. He says, "We don't have an uninterrupted supply of power, and as a result, this leads to a huge production loss and rejection." He also touches upon the kind of raw material that is supplied. "Right now, that has changed but that has been marred by Chinese suppliers, and local suppliers who sell composite material that's mixed with we don't know what. So that's why the MNCs have standardized their vendors. Competition is good but not at the risk of one's business. It's not a healthy practice," he concludes.

Small Dimensions with Huge Potential

Generating grinding with dressable tools is very productive. Workpieces with interference contours, however, such as two gears on one shaft, impose limitations on conventional grinding worms. In order to avoid time intensive processes such as profile grinding with small tools or honing, the tools have to be configured to be very small. This is possible by optimizing the worm, tooling and technology accordingly to fit the workpiece and machine.

Generating grinding with dressable tools is a common process for series production. Despite the auxiliary times for dressing, the advantages prevail: cutting speeds between 63 and 80 m/s provide high productivity. This is accomplished with conventional tools such as grinding worms with a diameter of 300 mm and approximately 5,000-7,500 RPM.

The large tool diameter, however, causes problems with interference contours because the tool requires room next to the gear to finish its grinding path. Typical examples are a bearing seat or an adjacent gear near the gear to be processed.
It is possible to utilize tools with smaller diameter, but unless the RPM is increased, the result would be lower cutting speeds.

Furthermore, standard machines are generally not capable of accepting small tools or processing workpieces with such small center distances without encountering interference conditions. Conventional generating grinding machines require a minimum tool diameter of at least 170-200 mm.
This is why manufacturers had to resort to other, less efficient processes for critical workpieces.

Small generating worms

Conventional processing of interference contours

The traditional process for hard finishing of gears with interference contours has been discontinuous profile grinding or gear honing. Both processes are suitable for complex components; however, they are not as productive and economical as continuous generating grinding. The outside diameter of dressable and non-dressable profile grinding wheels can easily be reduced to 30-50 mm with CBN plated wheels. They also do not require as much axial clearance next to the gear being processed compared to a grinding worm. However, this process does involve long auxiliary times.

Another alternative is gear honing which is a process during which the profile of the honing ring meshes with the workpiece and removes material. Due to process-related reasons, however, the cutting speed of honing is very low which in turn demands higher operating forces. This process is therefore not suitable for gears with large moduls or large gear widths as the forces during processing would negatively influence quality, cost and productivity.

Despite these disadvantages manufacturers had to resort to either of these processes even for large series manufacturing. Continuous generating grinding of interference contours had not been an option due to the lacking capabilities of gear grinding machines. The dynamic demands to tool and workpiece drives, in particular, were too high. Meanwhile, new market developments have closed the gap.

Continuous generating grinding with small tools

Kapp Niles developed the gear centers KX 160 TWIN and KX 260 TWIN specifically for hard finishing of gears with interference contours using the continuous generating grinding process. Thanks to high speed grinding spindles these machines are now capable of generating grinding gears that require a tool diameter as small as 55 mm.

In combination with a maximum possible tool width of 180 mm this allows for processing times and costs that have so far not been possible for gears with interference contours while at the same time meeting the quality demands common to series production.

Thomas Nitzsche, project manager for small grinding worms at Kapp Niles, explains, “A typical tool drive has max. 7,500 RPM. In order to reach the same cutting speed with a small tool, a RPM of up to 25,000 is necessary, depending on the tool diameter. This creates completely different forces than commonly expected on traditional machines: the workpiece must rotate faster proportional to the tool RPM. Kapp Niles specifically considered this and provided the standard workpiece spindle with 5,000 RPM.”

Aside from the high forces, restricted space also posed a unique challenge for the developers: each tool required a stable, quick-change mounting, and the tool arbor had to accommodate the entire sensor and dynamic technology: the machine detects contact between workpiece and grinding tool, or grinding tool and dressing tool respectively, via structure-borne noise sensors. Automatic balancing of the tool arbor on the machine is integrated into the arbor itself, as well.

Shorter auxiliary times thanks to second workpiece spindle

In order to increase productivity yet more, the machine concept includes two identical workpiece spindles, which are positioned on the indexing table opposite each other. While one workpiece is processed on one spindle, another workpiece is automatically unloaded and loaded on the other workpiece spindle and then aligned.

This reduces the auxiliary times to a minimum.
The machines are suitable for external, spur and helical gears. Optimal measuring systems determine profile and flank, runout and gear width.

Thomas Nitzsche continues, “With these two gear centers, we are targeting high production volumes of large and series manufacturing for gears of high-quality requirements. It was therefore important for us to explore all possible options to maximize productivity. Obviously, in addition to the small diameter tools, these machines can handle larger tools with diameters of up to 200 mm, as well. As such, they are quite suitable and not to mention economical for processing of workpieces without interference contours.”

These small generating grinding worms have definite advantages over profile grinding with CBN wheels. The following comparison demonstrates this clearly.

Small generating grinding worms in direct comparison

Dr. Sergiy Grinko, a key contributor to this technology development at Kapp Niles, presents two typical cases:

*Image SEQ Abbildung * ARABIC 1: Generating grinding of a gear with interference contour*

“If two gears are positioned on one axis with little distance between them, there is insufficient room for a generating worm. That means, one would have to use profile grinding or small ceramic worms.” Image 1 demonstrates such application.

Sergiy Grinko calculated the cycle time for one specific customer workpiece. The result: non-dressable profile grinding with a CBN wheel required a cycle time of 5.4 minutes versus 2.9 minutes for dressable generating grinding with a dressing interval of 25 workpieces.

An additional example shows a gear with runout in the bearing seat (image 2).

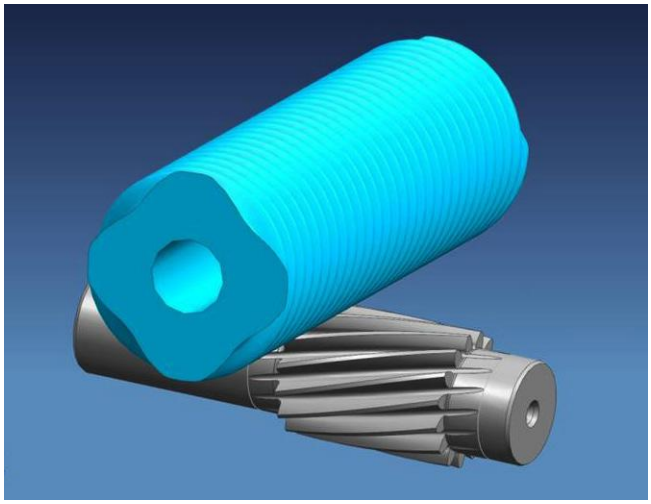
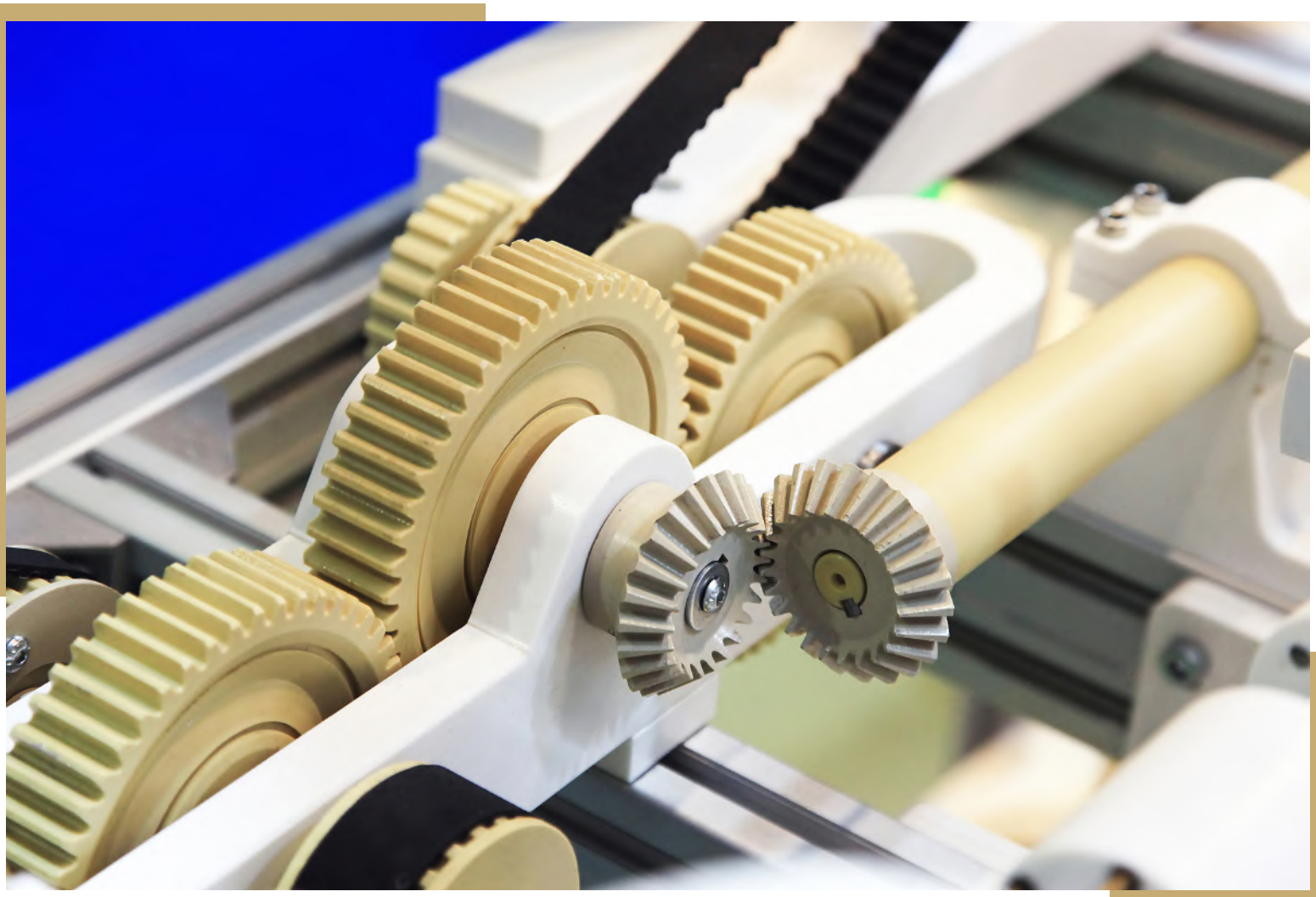


*Image SEQ Abbildung * ARABIC 2: Example of a gear with a hob breakout*

Dr. Grinko explains, “A normal gear has a root diameter larger than the diameter of the bearing seat. In some cases this reverses and the runout may happen in the bearing seat.

A worm with conventional diameter can therefore not be used. And even in this case does the small grinding worm offer time savings: The example demonstrated that the processing with non-dressable CBN profile grinding wheels had a cycle time of 1.8 minutes versus 1.2 minutes with dressable generating grinding. The dressing interval reached 74 workpieces. Properly utilized, the smaller tools result in a clear productivity increase and present more than just an alternative to discontinuous profile grinding and gear honing.”

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



The Impact of 3D Printing in Gear Manufacturing

By eliminating the need for traditional tooling and machining processes, 3D printing streamlines production and reduces lead times, making it an attractive option for various industries

By: Nishant Kashyap

Gear manufacturing has long been a critical component of various industries ranging from automotive and aerospace to robotics and medical devices. Traditional methods of gear production have relied on complex machining processes, which often pose limitations in terms of design flexibility, cost-effectiveness, and lead times. However, with the advent of 3D printing, a revolutionary shift has taken place in the manufacturing landscape.

3D printing, also known as additive manufacturing, offers a groundbreaking approach to gear production, transforming the way gears are designed, prototyped, and manufactured. This technology enables the creation of intricate gear geometries and opens up new possibilities for customization, lightweight design, and material savings. By eliminating the need for traditional tooling and machining processes, 3D printing streamlines production and reduces lead times, making it an attractive option for various industries.

Advantages of using 3D printing in Gear Manufacturing

Design Flexibility and Customization:
3D printing allows for unprecedented design freedom, enabling the creation of complex and intricate gear geometries that would be challenging or impossible to produce with traditional manufacturing methods. Designers can optimize gear performance by incorporating features such as internal lattice

structures, variable tooth profiles, and integrated cooling channels.

Rapid Prototyping and Reduced Lead Times: Unlike traditional methods, 3D printing eliminates the need for specialized tooling, allowing for rapid prototyping and quick iterations. Design changes can be implemented and tested without significant delays, accelerating the development cycle and reducing time-to-market.

Cost-Effectiveness and Material Savings: It enables the production of complex geometries as a single part, eliminating the assembly of multiple components. Additionally, material waste is minimized as 3D printers adds material by layers, only using the necessary amount of material for each gear.

Lightweight and Optimized Designs: By utilizing internal lattice structures and optimized geometries, gears can be engineered to have reduced weight while maintaining their structural integrity.

Consolidation of Multiple Parts: Traditional gear assemblies often require the manufacturing and assembly of several individual components. With 3D printing, complex gear assemblies can be consolidated into a single, integrated part, reducing the number of components, assembly steps, and potential points of failure. This consolidation simplifies production, improves reliability, and reduces the overall complexity of the gear system.

These advantages of 3D printing in gear manufacturing have transformative implications for various industries, including automotive, aerospace, robotics, and more. The flexibility, speed, cost-effectiveness, and customization possibilities offered by 3D printing open up new horizons for gear design and production, fostering innovation and efficiency.

"3D printing allows for the production of customized gears tailored to specific applications, enabling a higher degree of precision and efficiency. Another application of 3D printing in gear manufacturing is rapid prototyping. Design iterations can be quickly produced and tested, reducing the time and cost associated with traditional prototyping methods.

> With 3D printing, gears can be produced with complex geometries & customized designs, leading to improved performance and efficiency. It enables rapid prototyping, allowing for quick validation of gear designs before mass production. 3D printing also offers cost reduction potential for low-volume or custom gear production by eliminating the need for expensive tooling.
>
> *- Ankit Sahu, Co-founder & Director, Objectify Technologies.*

This enables gear manufacturers to accelerate the product development process and bring new gear designs to market faster, added Vishwanath Sridhar Harpanahalli, Country Manager, Formlabs India.

Techniques and Materials

Different techniques and materials are utilized in 3D printed gears to meet specific requirements and achieve desired properties. Here are some commonly used techniques and materials:

Selective Laser Sintering (SLS): SLS is a popular 3D printing technique for gears. It involves using a high-power laser to selectively fuse powdered materials, typically nylon or other thermoplastic polymers. SLS offers good mechanical properties, durability, and the ability to produce complex geometries with high accuracy.

Stereolithography (SLA): SLA utilizes a liquid resin that is cured layer by layer using a UV laser or light source. SLA is known for its high resolution and smooth surface finish, making it suitable for producing detailed and intricate gear designs. SLA-printed gears are often used for prototyping or applications that require high precision.

Fused Deposition Modeling (FDM): FDM is one of the most widely used 3D printing techniques. It involves extruding molten thermoplastic filament through a nozzle, layer by layer, to create the desired shape. FDM-printed gears are durable and suitable for functional prototypes or low-load applications.

Direct Metal Laser Sintering (DMLS): DMLS is a technique used for 3D printing gears in metal alloys. It employs a high-powered laser to selectively fuse metal powders, such as stainless steel, titanium, or aluminum, to build up the gear layer by layer.

With respect to materials, various types of engineering-grade plastics can be used in 3D printed gears, depending on the required properties. Nylon (polyamide), polycarbonate (PC), and polyether ether ketone (PEEK) are commonly used for their high strength, durability, and resistance to wear and temperature. In addition, for applications where metal gears are required, 3D printing allows for the use of metal alloys. Commonly used alloys include stainless steel, aluminum, titanium, and cobalt-chrome.

Metal 3D printed gears offer high strength, heat resistance, and excellent wear properties. Besides this, in 3D printed gears, composite materials such as carbon fiber reinforced polymers (CFRPs) can be used to enhance strength, stiffness, and lightweight characteristics.

Image courtesy: Formlabs

> The availability of a wide range of materials suitable for 3D printing allows for flexibility in material selection based on specific application requirements. The consolidation of multiple parts into a single printed component reduces assembly steps & potential failure points. It accelerates time-to-market, enabling gear manufacturers to respond quickly to market demands & stay competitive in the industry.
>
> - *Vishwanath Harpanahalli, Country Manager, Formlabs India*

The selection of the appropriate 3D printing technique and material depends on factors such as the desired mechanical properties, operating conditions, cost considerations, and application requirements. Each technique and material has its advantages and limitations, and the choice should be based on the specific needs of the gear application.

Limitations of 3D printing in Gear Manufacturing

While 3D printing has brought about revolutionary advancements in gear manufacturing, it is not without its limitations. One of the primary limitations is the restricted selection of materials compared to traditional manufacturing processes.

Although the range of materials available for 3D printing has expanded, it is still more limited. Certain specialized materials commonly used in gear manufacturing may not be suitable for 3D printing.

Another limitation lies in the anisotropic properties exhibited by 3D printed gears. Anisotropy refers to the variation in mechanical properties based on the orientation of the printed layers. This variation can impact the overall strength, durability, and performance of the gears, particularly under high loads or complex stress conditions.

Surface finish is another aspect that can be challenging in 3D printed gears. The resulting surface finishes from 3D printing may be rougher compared to traditionally manufactured gears. Achieving the desired surface quality may require additional post-processing steps such as sanding, polishing, or coating, which can add time and effort to the manufacturing process.

Sahu said, “While 3D printing offers flexibility and innovation in gear production, it is important to recognise that post-processing remains a critical aspect to achieve the desired quality, functionality, and performance of the gears. Therefore, even with the use of additive manufacturing techniques, the requirements for post-processing in gear manufacturing remain essential for meeting industry standards and functional requirements.”

Looking Ahead

The utilization of 3D printing in gear manufacturing has revolutionized the way gears are designed and produced, offering a range of advantages like rapid prototyping, customization, complex geometries, lightweighting, and on-demand manufacturing. While 3D printing has its limitations, ongoing advancements in materials, printing techniques, and quality control processes continues to address these challenges.

As technology progresses, we can anticipate further breakthroughs in gear manufacturing through 3D printing. The future holds exciting possibilities including the development of new materials with enhanced properties, improved printing techniques for higher precision and larger-scale production, and the integration of digital design optimization tools for even more efficient and innovative gear systems.

With these advancements, 3D printing will continue to shape the future of gear manufacturing, enabling greater efficiency, customization, and performance in various industries, from transportation and aerospace to robotics and manufacturing. Embracing the transformative potential of 3D printing in gear manufacturing will undoubtedly pave the way for remarkable advancements in the field, ushering in a new era of gears that are lighter, stronger, and tailored to meet the specific demands of modern industries.

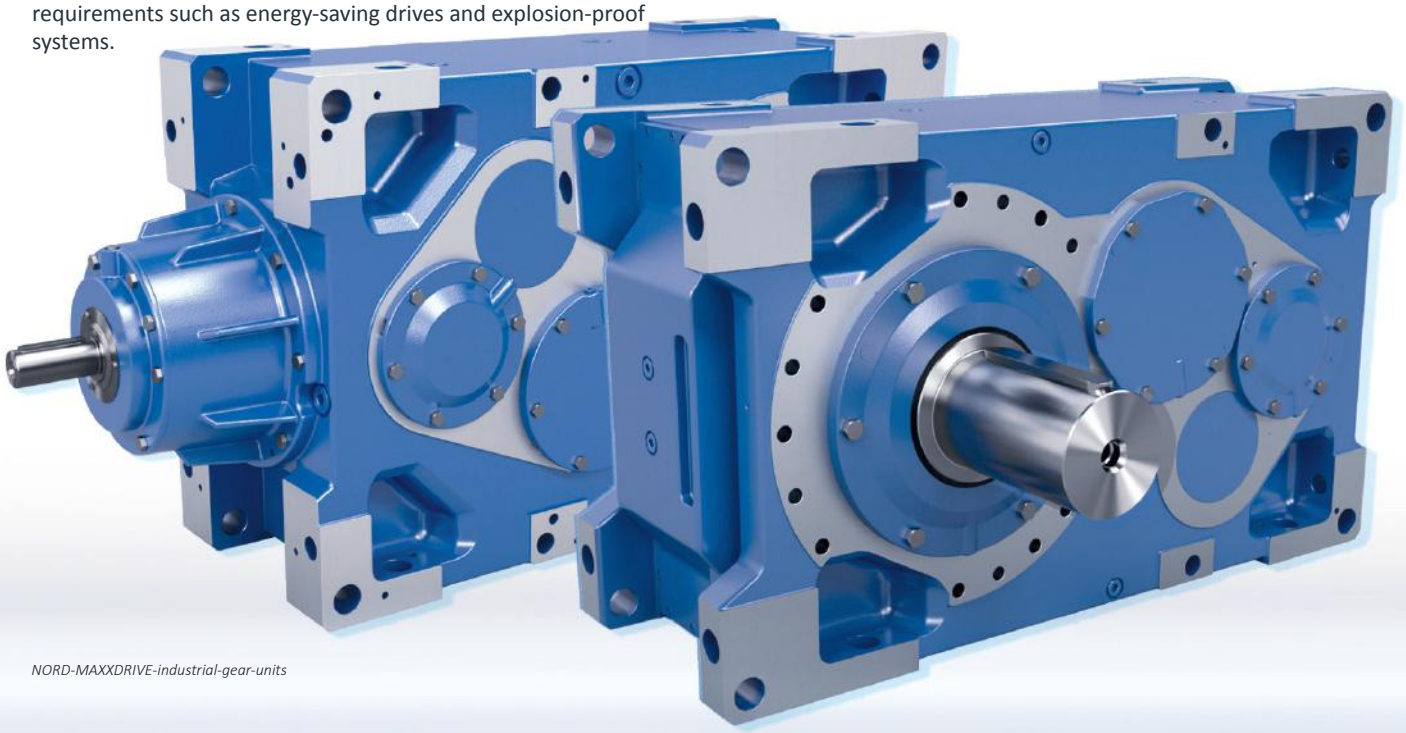
NORD offers Complete System Solutions for Drive System Requirements

Please tell us a bit about your company

With approximately 5,000 employees worldwide, NORD develops & produces a market driven technology, and is one of the industry's leading international suppliers of all-in-one solutions. In addition to standard drives, NORD supplies application-specific concepts and solutions that fulfil special requirements such as energy-saving drives and explosion-proof systems.

Could you elaborate about your strategy for the Indian customers?

We believe in offering complete system solutions for drive system requirements to our customers. This also includes application study & optimum products with acceptable delivery times.



NORD-MAXXDRIVE-industrial-gear-units

Founded in 1965, NORD presently has 38 subsidiaries worldwide. In India incorporated in the year 2005, NORD Drivesystems Pvt Ltd is the 100% subsidiary of Getriebebau NORD in Germany. We have a full-fledged assembly unit in Hinjewadi, Pune from where we cater to pan India & SAARC country market.

What are your manufacturing capabilities? What is the maximum size of gearboxes supplied?

Our Pune plant has a production capacity of 42,000 units per year including gearboxes, motors & Maxxdrive. The largest we assemble is case size 10, which can offer a maximum torque capacity of 50000NM.

What are the different types of gear units used in various segments?

Mainly there are Helical, Helical Parallel Shaft, Bevel, Worm & Planetary types of gearboxes which are used in various sectors. This depends on application, loading & demands.
Except Planetary, NORD can offer solutions to all sectors.

We offer innovative products like decentralize drives, IE4/IE5 motors, Maxxdrive XD for various applications.

What is the USP of NORD?

Customer satisfaction with timely responses. Our highly efficient products which helps in improving system efficiency.

Tell us about IoT on gearboxes/condition monitoring support to customers?

Complete drive solution from a single source:
An optimum and individual drive solution can be created using the modular NORD system consisting of the gear unit, motor, and drive electronics coupled with the highest product quality, short planning and assembly times, high delivery availability and a good price/performance ratio.

Condition Monitoring for predictive Maintenance:
For condition monitoring, the drive and status data are recorded periodically or continuously to optimise the operational safety and efficiency of machines and plants. This can provide major information for predictive maintenance. The objective is to

BLOCK Helical Bevel Geared Motor with SK 200EWeb

maintain machines and plants proactively, to reduce downtimes, and to increase the efficiency of the entire plant.

It has the following advantages for our customers:

- Detection and avoidance of impermissible operating states at an early stage
- Status-oriented maintenance replaces time-based maintenance
- Plannable machinery and plant downtimes based on real drive and process data
- Reduction of service and material costs
- Longer service life of components and machine
- Increase in system availability
- Avoidance of unplanned downtimes
- Plannable and cost-optimised repair

Please explain the initiatives taken about digitalization

With effect from the start of the LogiMAT trade show at the end of April 2023, NORD DRIVESYSTEMS will equip its products with a QR code. Scanning this code with your mobile forwards you to the "Digital services" selection menu. From here, customers can contact the service department and directly reach the right contact persons of their country organisation.

The contact persons speak the customers' mother tongue and the individually used drive solution is directly displayed on their monitors. Of course, it is also possible to establish contact by telephone. Here, customers must indicate the serial number of their drive component displayed in "Digital Services"

Customers can also navigate to the documentation of their components and to a list of potential spare parts via our E-spares shop. Furthermore, they can contact their responsible sales department or directly jump to the myNORD customer portal.

In the long run, NORD is working on the possibility to inform its customers of digital updates for their frequency inverters etc. via "Digital Services".

Amit Deokule, Director,
Sales & Marketing at NORD Drivesystems Pvt. Ltd.

BLOCK Parallel Shaft Geared Motor 2

Driving Innovation and Efficiency in the Gear Industry

From additive manufacturing to advanced machining processes, gear manufacturing technologies are paving the way for a new era of innovation and excellence

By: Sushmita Das

The gear manufacturing industry has witnessed a significant transformation in recent years, thanks to groundbreaking advancements in manufacturing technologies. These innovative techniques are revolutionizing the production of gears, enabling manufacturers to meet the growing demands for efficiency, precision, and customization.

Additive Manufacturing: Redefining Gear Production Possibilities

Additive manufacturing, also known as 3D printing, has emerged as a game-changer in the gear manufacturing sector. This technology allows for the creation of complex gear geometries that were previously difficult or impossible to achieve using traditional manufacturing methods. With additive manufacturing, gears can be produced with intricate internal structures, custom teeth profiles, and optimized weight distribution.

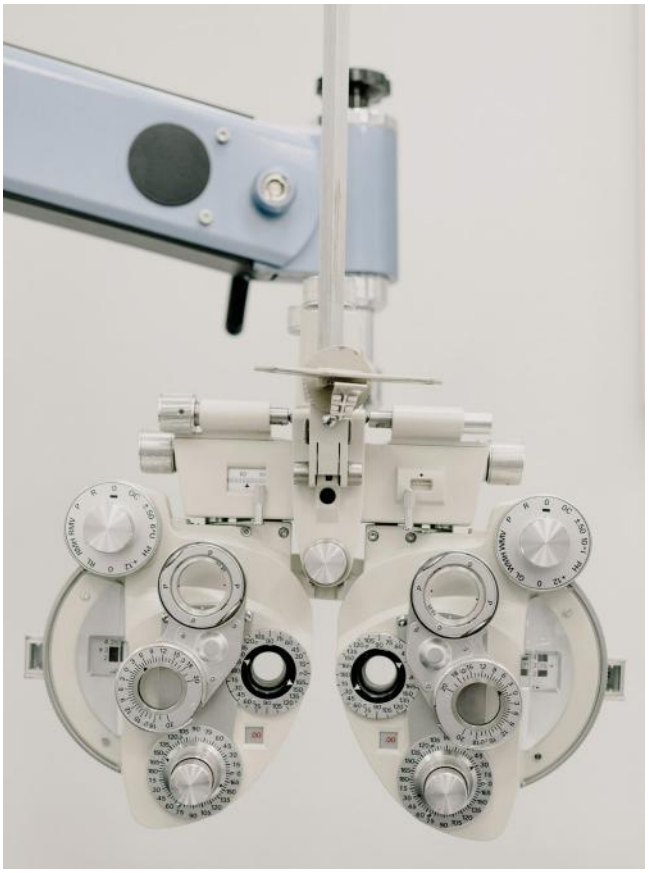
One of the significant advantages of additive manufacturing in gear production is its ability to reduce material waste. By building gears layer by layer using only the necessary material, manufacturers can minimize material usage, leading to cost savings and environmental sustainability.

Furthermore, the flexibility offered by additive manufacturing enables rapid prototyping and customization allowing gears to be tailored to specific applications and requirements.

Advanced Machining Techniques: Precision and Efficiency Unleashed

Traditional machining techniques have also undergone significant advancements, enabling manufacturers to achieve higher levels of precision and efficiency in gear production. Computer Numerical Control (CNC) machining, for instance, has revolutionized the way gears are manufactured. By utilizing CNC machining, this ensures exceptional accuracy, consistency, and repeatability in gear production.

Additionally, advancements in multi-axis machining have opened up new possibilities for gear manufacturing. Multi-axis machines can produce gears with complex geometries and intricate tooth profiles, expanding the design and application options for gears. The ability to machine gears from a variety of materials including metals, alloys, and composites, further enhances the versatility and performance of gears in different industries.



Gear Hobbing and Shaping: Traditional Techniques Evolved

While additive manufacturing and advanced machining techniques have gained prominence, traditional gear manufacturing methods such as gear hobbing and shaping continue to play a crucial role in the industry. These techniques have evolved to meet the demands of modern gear applications, incorporating automation, computer controls, and advanced tooling systems.

Gear hobbing, a well-established method, involves cutting gear teeth using a specialized hob. Modern gear hobbing machines offer high precision, allowing manufacturers to produce gears with tight tolerances and smooth tooth profiles. Gear shaping, on the other hand, utilizes a cutting tool to form gear teeth gradually.

This technique is often preferred for producing gears with large diameters or when high accuracy is required.

Digitalization and Simulation: Enhancing Efficiency and Performance

The integration of digitalization and simulation tools has enabled manufacturers to optimize production and enhance gear performance. Computer-aided design (CAD) software allows for precise gear design, with virtual simulations enabling engineers to analyze and fine-tune gear performance before physical production.

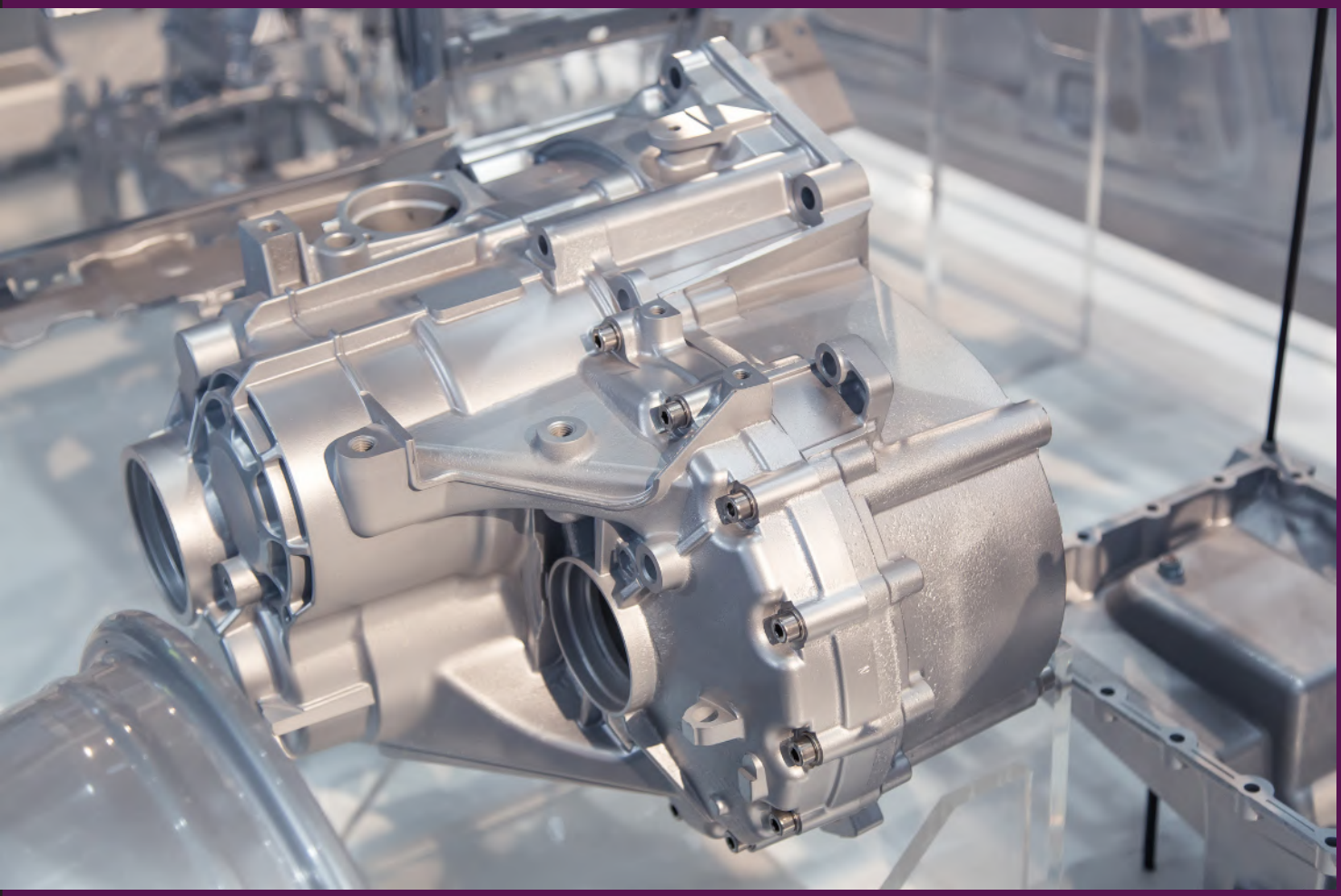
Simulation software helps identify potential issues such as tooth contact errors, gear misalignment, or noise generation, allowing for optimization and refinement before gears are manufactured. These digital tools reduce the time and cost associated with physical prototyping, while also minimizing the risk of defects and errors during gear production.

Conclusion

The gear manufacturing industry is undergoing a remarkable transformation driven by advanced manufacturing technologies that are pushing the boundaries of what is possible. Additive manufacturing, advanced machining techniques, traditional methods, and digitalization tools are collectively revolutionizing the production of gears, resulting in higher precision, customization, and efficiency.

As these technologies continue to evolve, the gear manufacturing industry is poised to meet the increasing demands of various sectors, driving innovation and propelling industries towards a more advanced and efficient future.

Why does Bearing Selection Play a Crucial Role in Gearbox Performance?



By: Nishant Kashyap

Bearings play a critical role in the smooth and efficient operation of gearboxes. They are responsible for supporting the rotating shafts and gears, distributing loads, and minimizing friction. Understanding the function and challenges faced by bearings in gearboxes is essential for appreciating their importance in overall performance.

Some key aspects to consider are: load distribution, rotational stability, friction reduction, lubrication management, operating conditions, noise and vibration control among others.

It is important for engineers to recognize the challenges faced by bearings in gearboxes and consider these factors during the selection process, so they can make informed decisions to ensure optimal gearbox performance and reliability.

Impact of Bearing Selection on Gearbox Performance

A key area where bearing selection influences gearbox performance is durability and lifespan. By choosing bearings with appropriate load capacities and robust construction, engineers can enhance the durability of gearboxes, and reduce the risk of unexpected failures and ensure long-term performance.

Additionally, bearing selection directly affects the efficiency and power transmission within gearboxes. Bearings with low friction and high efficiency minimize energy losses, leading to improved power transmission, reduced energy consumption, and enhanced system performance.

Another important aspect influenced by bearing selection is the noise and vibration levels. By selecting bearings with optimized design features, precision manufacturing, and appropriate internal clearances, unwanted noise and vibrations can be reduced, resulting in a better user experience and prolonged lifespan of gearbox components. Moreover, the operating speed and temperature range of gearboxes must be considered when selecting bearings.

Different bearing types and designs have specific speed and temperature limitations, and choosing bearings suitable for the

intended operating conditions ensures reliable performance. Proper bearing selection also affects lubrication and maintenance requirements. Bearings have specific lubrication needs, and selecting bearings compatible with the intended lubrication method and frequency, simplifies maintenance procedures and improves overall gearbox performance.

Furthermore, ensuring compatibility with application requirements is crucial. Gearboxes are used in various applications with specific operational demands, and selecting bearings that align with these requirements, considering factors such as load type, operating environment, speed variations, and expected service life, ensures reliable and efficient gearbox operation.

Factors to Consider for Bearing Selection

The following factors should be carefully considered during the bearing selection process:

Load Capacity: One of the primary considerations is the bearing's load capacity. It should be able to handle the anticipated radial and axial loads generated within the gearbox, while taking into account peak loads and variations during operation. Choosing bearings with appropriate load ratings ensures that they can effectively support the applied loads without premature wear or failure.

Speed and Operating Conditions: The operating speed of the gearbox is a critical factor in bearing selection. Different bearing types have specific speed limitations, and exceeding these limits can result in overheating, accelerated wear, and reduced service life. Additionally, the operating conditions, such as temperature, humidity, and presence of contaminants should be evaluated to ensure the selected bearings can withstand the environmental demands.

Lubrication Requirements: Proper lubrication is vital for bearing performance. The type and amount of lubricant required should be considered during bearing selection. Factors such as speed, temperature, and operating conditions influence the lubrication requirements. Bearings may require grease or oil lubrication, and the appropriate lubrication intervals and methods should be determined to ensure optimal performance and minimize friction-related issues.

Bearing Clearance and Preload: The clearance or preload of the bearings affects their internal fit and play a role in overall gearbox performance. The choice of clearance or preload depends on factors such as the desired level of rigidity, operating conditions, and the specific application requirements. Proper clearance or preload selection ensures the desired balance between smooth operation and load-bearing capacity.

Bearing Material and Design: Bearings can be made from various materials including steel, ceramic or polymers each with its own advantages and limitations. The material selection should consider factors such as load capacity, temperature resistance, corrosion resistance, and desired performance characteristics. Additionally, bearing design features such as cage design, sealing options, and lubrication systems should be assessed to ensure compatibility with the gearbox requirements.

Reliability and Maintenance: The reliability and maintenance requirements of the chosen bearings should align with the operational demands of the gearbox. Considerations such as expected service life, maintenance intervals, and availability of replacement parts or support should be evaluated to minimize downtime and ensure long-term reliability.

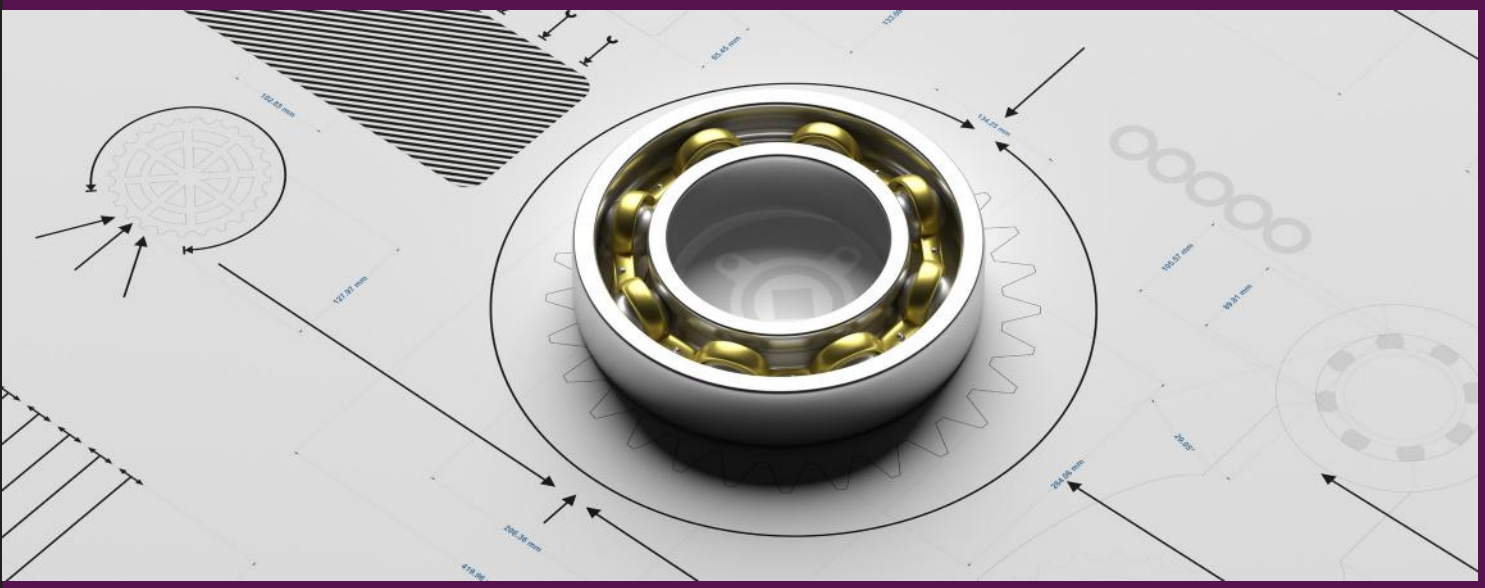
Types of Bearings for Gearbox Applications

Image source: A needle roller bearing (Red Rooster / Wikimedia Commons)

Various types of bearings are commonly used in gearbox applications with each offering unique characteristics and benefits. Understanding the different types of bearings helps in selecting the most suitable option for specific gearbox requirements. Here are some commonly used bearing types in gearbox applications:

Ball Bearings: Ball bearings are widely utilized in gearboxes due to their versatility and high-speed capabilities. They consist of steel balls housed within inner and outer races, enabling smooth rotation with low friction. Ball bearings are suitable for applications with moderate radial and axial loads, providing good radial support. They come in various configurations, including deep groove ball bearings, angular contact ball bearings, and thrust ball bearings.

Roller Bearings: Roller bearings are known for their ability to handle heavy radial loads and moderate axial loads. They utilize cylindrical or tapered rollers instead of balls, distributing loads over a larger contact area. Roller bearings are suitable for gearboxes with higher load capacities and applications with significant radial and axial loads.



Common types include: cylindrical roller bearings, spherical roller bearings, and tapered roller bearings.

Thrust Bearings: Designed to support axial loads and prevent axial movement within gearboxes, they are often used in conjunction with other bearing types to handle axial forces generated by gears or shafts. These come in various configurations like thrust ball bearings, thrust roller bearings, and thrust needle roller bearings.

Plain Bearings/Bushings: Plain bearings, also known as bushings or sleeve bearings, provide a simple and cost-effective solution for certain gearbox applications. They consist of a cylindrical sleeve made of a low-friction material such as bronze or composite polymers that slides directly against a shaft or housing. Plain bearings excel in applications with lower speeds and lighter loads.

Needle Bearings: Needle bearings are a type of roller bearing that utilize long, thin cylindrical rollers. They have a high length-to-diameter ratio enabling them to handle high radial loads within limited space. Needle bearings are commonly used in gearboxes where compact design and high load capacity are required.

Tapered Bearings: Tapered roller bearings feature conical rollers and races that allows them to handle both radial and axial loads. They are commonly used in gearboxes where axial forces are present such as in automotive applications. Tapered bearings provide high load-carrying capacity and excellent resistance to misalignment.

Conclusion

The importance of bearing selection in gearbox performance cannot be understated. It directly impacts the durability, efficiency, and reliability of gearboxes. Bearings serve crucial functions within gearboxes including load distribution, rotational stability, friction reduction, lubrication management, and noise/vibration control. Proper bearing selection is essential to enhance the durability of gearboxes, ensuring long-term performance while minimizing the risk of unexpected failures.

The right bearings contribute to improved efficiency and power transmission within gearboxes, reducing energy losses and enhancing overall system performance. Furthermore, bearing selection plays a significant role in controlling the noise and vibration levels generated within gearboxes leading to a better user experience and extending the lifespan of gearbox components.

Taking into account the operating speed and temperature range is crucial when selecting bearings to ensure that they can operate effectively under varying conditions. Additionally, lubrication and maintenance requirements that align with the chosen bearings helps optimize performance and minimize friction-related issues should be considered.

The compatibility of application requirements, such as load type, operating environment, and speed variations is also vital for reliable and efficient gearbox operation.

By carefully considering the above factors, engineers can optimize gearbox performance, minimize downtime, and ensure the longevity of gearboxes in diverse applications. Bearing selection should be approached as a critical aspect of gearbox design and maintenance with the aim of achieving long-term performance, reliability, and efficiency.

Updates from the AGMA Newsletter

Training Courses & Webinars

Gear Box Systems Design Course

This three-day program will cover the supporting elements of a gearbox that allow gears and bearings to do their jobs most efficiently. Learn about seals, lubrication, lubricants, housings, breathers, and other details that go into designing gearbox systems. The course is aimed at Gear design engineers; management involved with the design and manufacture of gearing type components; metallurgists and materials engineers; laboratory technicians; quality assurance technicians; furnace design engineers; and equipment suppliers.

Design Basics for Spur and Helical Gears

This live online virtual training session will help you understand and develop customer gear drive application specifications and target performance expectations. In addition, the training session will also cover how to optimize gear fatigue Safety Factors for a given target design life and fit new gear designs and ratios into existing centre distance using profile shift and review common gear failure modes if the design or final accuracy does not meet application requirements among other details.

Analytical Gear Chart Interpretation

This course is an introduction to the methodology of analytical gear inspection and the evaluation and interpretation of the resulting data. The application of this information to identify and correct manufacturing errors will begin to be explored. Additionally, it reviews chart interpretation and applies inspection data to understand the causes and cures of manufacturing errors. Many chart examples are used to understand cause and effect.

Product News

Gates Announces Mobile Version of Design Power

The award-winning Gates Design Power now has a mobile version. This launch was announced by Bill Gates. The expanded mobile app toolkit takes the drive design experience to a new level with five extended support modules and an upgraded version of Design Flex Pro to support the engineering of belt drive systems on customers' mobile devices. Some of the upgrades include: Facility Management that allows customers to monitor and update all their power transmission drive projects in one place.

There is also a Sonic Tension Meter, Flashlight RPM Meter, Sound Meter, and Distance Measurement tool. It is available on IoS and Android stores globally

SKF Adds Microlog Analyzer dBX to Condition Monitoring Portfolio

SKF has extended its Microlog Analyzer family of data collection devices with a new model that offers faster measurement collection and greater diagnostic power. The device allows the user to carry out a range of tasks including impact tests, digital recording, modal analysis, multi-plane balancing and cross channel phase.

Miki Pulley ALS Machined Couplings Solve Misalignment Challenges

For handling parallel, angular or axial misalignment applications with more precision, ALS Couplings from Miki Pulley has a latest design which is a simplistic, three-piece construction. This is available in three different models.

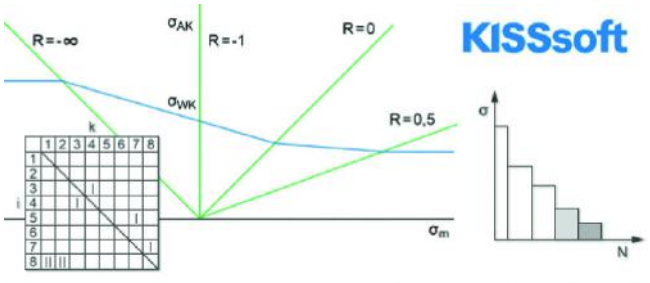
DMG MORI Launches Lasertec 30 SLM for Additive Manufacturing

The LASERTEC 30 SLM US will start delivery from December 2023, focusing on best-in-class cost per part and complex geometries in an envelope of 11.8 x 11.8 x 11.8 in. Breaking the mold of incumbent technology, the machine features several key advancements—Adaptive Beam Control enabling dynamic changes to Laser Power, Laser Speed, and Laser Beam Profile.

Seco Propels Manufacturing with Smart Software and Actionable Intelligence

Smart software is leading the way to an optimized production and improved decision making. Digital technology and smart software have already transformed the machining industry with unprecedented access to actionable data for better results in less time. With a wealth of data generated from production processes of all kinds, shops need to understand how to use that data to their advantage.

KISSsoft Offers FKM Shaft Strength Calculation



FKM shaft rating with rainflow matrix

According to the FKM Guideline, in the KISSsoft shaft calculation, the proof of fatigue strength can be performed by generating an equivalent stress verification.

This verification is equal to the amplitude verification which has been performed up to now. With the equivalent stress verification, different stress ratios can be taken into account for each load case (for example, a Rainflow matrix). The load cases are defined in a load spectrum, which can be entered directly via a table or imported from a text file.

Role of Gear Technology in Improving Wind Turbine Efficiency

The wind energy sector is a rapidly growing industry, and with technological advancements in gearboxes, it is only going to get bigger

By: Sushmita Das

Wind energy is a rapidly growing sector of the power industry with wind turbines playing a crucial role in generating clean, renewable energy. As demand for wind energy continues to rise, there is a growing need for more efficient and reliable wind turbine designs. Thus, gear technology plays a vital role in achieving these very goals of wind turbines.

How it works

Put simply, wind turbines rely on gears to convert the rotational energy of the blades into electricity. The blades spin the rotor, which in turn spins a shaft. This shaft is connected to a gearbox which increases the speed of the rotational energy and transfers it to a generator that produces electricity.

The gearbox is a critical component of the wind turbine, and its overall efficiency has a direct impact on the system.

According to the International Energy Agency (IEA), renewable electricity generation increased by almost 7% in 2021 with wind and solar PV (photovoltaic) accounting for nearly 90 % of the growth.
Renewables made up 28.7 % of global electricity generation, but only saw a modest 0.4% increase due to the high electricity demand and decreased hydropower generation from droughts.

Key technological advancements

Direct Drive Systems

One of the most significant and recent advances in gear technology for wind turbines is the use of direct drive systems. In these systems, the gearbox is eliminated entirely, and the rotor is directly connected to a low-speed generator. This reduces the number of moving parts in the wind turbine which can lead to higher reliability and efficiency.

Hybrid Drives

Another recent development in gear technology for wind turbines is the use of hybrid drives. These systems combine elements of both direct drive and traditional gearbox designs. Here, a smaller gearbox is used to increase the speed of the rotational energy from the blades, which is then transferred to a larger generator. With this nifty feature, it allows for a more suitable/sustainable transfer of energy, and can result in higher overall efficiency and reliability.

Material Technology

Materials technology is yet another advancement that have also played a significant role in improving the efficiency of wind turbine gears. For example, the use of carbon fiber composite materials can significantly reduce the weight of the gearbox, which in turn reduces friction and improves efficiency.

Similarly, the use of advanced coatings and surface treatments can help reduce wear and extend the lifespan of the gears.

Wind Turbine Efficiency

Another important factor in improving wind turbine efficiency is the optimization of gear design. By using advanced simulation and modeling tools, engineers can design gears with the most efficient geometry and tooth profiles. This helps to reduce friction and minimize losses due to misalignment among other factors.

Operational Strategies

Besides technological advancements, there are several operational strategies that aid in wind turbine efficiency. For example, wind turbines can be equipped with sensors that monitor wind conditions and adjust the pitch of the blades.

This helps ensure that the blades are always operating at the most efficient angle, leading to better performance.

According to a report by the Global Wind Energy Council, following a year in which global momentum for net zero commitments increased, along with a renewed sense of urgency for accomplishing energy security, the market outlook for the global wind industry appears to be increasingly positive.

Current policies indicate the addition of 557 GW of new capacity within the next five years translates to over 110 GW of new installations annually until 2026.

Challenges

Regular maintenance and inspection of the gears is also critical for ensuring optimal efficiency and reliability. Gearboxes should be inspected regularly for signs of wear or damage, and any issues should be addressed promptly to prevent further damage or failure.

Conclusion

Looking ahead, the role of gear technology in wind turbines is likely to evolve as the industry grows and matures. Thanks to advanced technological developments in material science, simulation tools and operational strategies, these factors will drive improvements in the coming years.

As wind energy becomes an increasingly important part of the global energy mix, the importance of gear technology in achieving sustainable, reliable, and efficient wind power will only continue to grow. By installing the planned 6044 GW of wind energy, over one-third of the total electricity demand in 2050 can be generated. This would result in a reduction of 6.3 gigatons of carbon dioxide in energy-related carbon emissions, which is over a quarter of the potential reduction in emissions from renewable energy and energy efficiency measures.

From a Flawed Start to a Flawless Finish

We look at the five types of gear finishings that are commonly used in the gear industry

By: Nishant Kashyap

Gear finishing is the process of enhancing the accuracy, surface finish, and durability of gear teeth. Typically, this process is performed after the gears have been manufactured. But there are cases where it can also be performed to repair gears that have been damaged. Here, we take a look at the different finishing methods.

Gears find any applicability that requires the power and/or motion to be transmitted between two shafts. This essential mechanical component can be found in automobile, construction, biomedical, agricultural appliances, and machine tools applications among others. Therefore, the importance of gears cannot be undermined. When a gear is manufactured, it comes with its own set of flaws. For instance, the surface of a gear's teeth are inaccurate. Dimensional inaccuracies are known to cause noise, excessive wear, and backlash between the gears during the mesh cycle.

But did you know that the type and characteristics of the finishing process of gears are also critical factors that need to be taken into consideration? If ignored, these could have a significant impact on the surface quality, microgeometry, surface integrity, and fatigue behavior of gears — all of which control a gear's operating performance, transmission, noise and wear characteristics, and service life. Hence, selecting the proper finishing process is paramount.

Let's take a look at some of the finishing processes, and understand how they can optimize the load carrying capacity of gears.

Finishing Methods

Shaving

Post hobbing or gear shaping, this method is used to improve the accuracy of a gear's tooth profile and reduce the roughness on its surface. In this finishing process, a gear tooth along with a gear shaving tool run together at high RPM. The grooves on the gear shaving tool serve as cutting edges, which scrape the mating faces of gear to be finished. The cutting edges on the shaving cutter's tooth surface chip from the surface of the gear to enhance tooth profile accuracy and reduce roughness along the tooth surface.

Gear shaving is a cost-effective process that results in low-noise gear surfaces. It may be used to better the quality of meshing between two gears or between a gear and a rack. Soft metals including aluminum alloys, bronze, brass, cast iron, and unhardened steels are mostly finished using the shaving method.

Burnishing/ Rolling

In this finishing method, the gear is rolled under pressure along with three hardened master gears of high accuracy and finish. Subsequently, the cold flow process is used to smear off the miniscule irregularities thereby enhancing the surface integrity of the desired teeth. Cold flow refers to the process of putting malleable metals under stress wherein the metal yields cause it to smoothen out.

Besides creating a smoother surface, burnishing hardens metal, reduces the risk of corrosion and even lowers manufacturing time by eliminating the extra steps of honing or grinding.
Metals like brass, bronze, aluminum, stainless steel and copper are commonly burnished. The burnishing method is often used to finish automotive components, including pistons and transmissions parts, and non-automotive parts such as plumbing fixtures and valves, among others.

Grinding

Sometimes, hardened gears don't get the required finish with the shaving or burnishing methods, especially when the heat treatment causes severe distortion and oxide film formation on the gear's teeth. In such a scenario, the grinding method can help remove stock from the teeth and give the heat-treated gears the required finish. Here, an abrasive grinding wheel of a particular shape and geometry is used for finishing the gear teeth.

Gear grinding can be performed on a variety of gear materials including steel, cast iron, and aluminum. The choice of abrasive wheel depends on the material of the gear and the desired surface finish. Gear grinding can be used to process a variety of gears with high accuracy and surface finish. It is often used on gears for high-performance applications including automotive engines and gearboxes.

Lapping

Gear lapping is the process of refining gears made of hardened steel or other materials that are difficult to machine after heat treatment. Here, the gear and the lap tool are rotated as inter meshing gears with an abrasive compound forced between the teeth. This improves the surface finish and reduces the friction between the teeth.

Typically, this finishing method is performed after the gears have been manufactured. However, it can also be used to repair damaged gears.
Gear lapping can improve the accuracy of the tooth profile, reduce the surface roughness, and improve the durability of the teeth. This helps to ensure that gears operate smoothly and efficiently, and that they have a long service life.

Honing

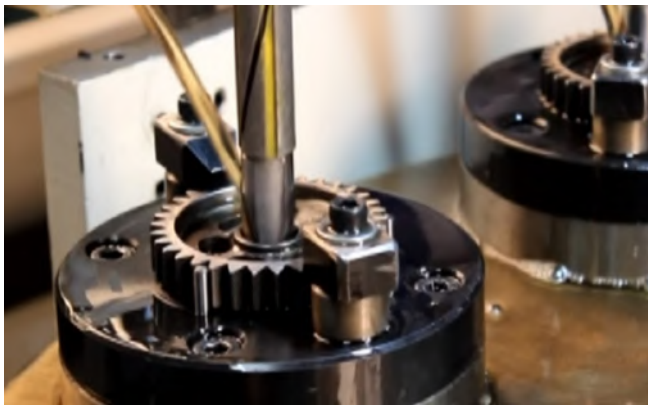


Image source: Amos1947/CC BY-SA 4.0/Wikimedia Commons

This process is used for super finishing the generated gear teeth after heat treatment using honing machines. A special tool called a honing stone or a hone is used to achieve the desired precision surface. A honing stone is similar to a grinding wheel. However, it is more friable, so that it conforms to the shape of the workpiece as it wears in. Honing can be performed by hand, too.

While larger and more complex parts are honed using the machine, the small, delicate parts are hand honed. Honing is a super finishing operation used for previously machined surfaces. It is used to finish internal cylindrical surfaces, drilled or bored holes. It is a cost-effective way to improve the performance and durability of metal parts, and it can help to extend their service life.

Conclusion

Gear finishing is an important part of the gear manufacturing process. Smooth surface finish, much more durability, enhanced accuracy, reduced noise and vibration are only some of the benefits of using gear finishing methods. Factors such as the type of gear, the desired accuracy and surface finish, and the cost of the process may affect the choice of finalizing which gear finishing method to choose. Thus, the intended outcome will always be to ensure that gears operate smoothly and efficiently, and that they have a long service life.

Recent Advances in the Evolution of Gear Technology in the Power Sector

With ongoing advancements in technology and materials, it's an exciting time to be involved in the world of gear manufacturing and power generation

By: Sushmita Das

The use of gear technology has been an integral part of the power sector for many years. From the earliest water and windmills to the most advanced power plants of today, gears have played a critical role in converting rotational motion into useful energy.

As the power sector continues to evolve, so does the technology that drives it. Here, we will take a closer look at recent advances in gear technology and its significant impact on the power sector.

As per a report by Research and Markets, the worldwide market for industrial gearboxes attained a valuation of USD 24.90 billion in 2020 and is anticipated to exhibit a CAGR of 4.20% over a forecast period between 2021-2026, culminating in a market worth USD 31.31 billion by 2026.

3D Printing

One of the most significant recent advances in gear technology is the use of 3D printing. With this technology, gears can be designed and produced with much greater precision and complexity than traditional manufacturing methods. This allows for more efficient and compact gear designs that can lead to significant energy savings in power plants.

Additive manufacturing has also enabled the creation of lighter, stronger, and more durable gear components, which can improve efficiency and reduce maintenance costs in power generation systems.

The ability to create customized gears using 3D printing has led to improved performance and reduced downtime in power generation systems.

Advanced Materials

Materials like the use of carbon fiber and ceramics have also contributed to the gear development technology.

These materials offer significant advantages over traditional metals in terms of weight, strength, and durability. This allows for the creation of lighter and more efficient gear designs that can handle higher loads and operate at higher speeds.

Nanoparticle-based lubricants are being developed for gear applications, providing improved lubrication and reducing friction, which can result in higher efficiency and longer gear life.

Software and Simulation Tools

With these tools, engineers can model and test gear designs in virtual environments that allows for more efficient and cost-effective design iterations. This can lead to faster development cycles, lower costs, and higher overall performance.

Trends

In addition to these technological advances, there has also been a growing trend towards more sustainable and environmentally friendly gear designs in the power sector.

For example, the use of regenerative braking systems in wind turbines and electric vehicles can help to reduce energy waste and improve overall efficiency.

The power sector has also embraced digitalization and the Internet of Things (IoT), which has led to the development of smart gears that can monitor and optimize performance in real time.

Conclusion

Looking ahead, it's clear that gear technology will continue to play a critical role in the power sector.

As new sources of renewable energy are developed and the demand for clean, efficient power continues to grow, the need for advanced gear designs and manufacturing methods will only increase.

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