gear TECHNOLOGY INDIA

VOLUME 1, ISSUE 3,
QUARTER 3, 2023

www.geartechnologyindia.com

Shifting Gears: ENRX Drives the Transition to a Greener Future in Gear Manufacturing

Induction heating is a cornerstone of manufacturing, and ENRX is a frontrunner in the realm of sustainable industrial practices

Bevel Gears India's Role in Chandrayaan's Success

Mushtaq & Sulaiman Jamal spoke about being a part of the lunar mission, the technical challenges they faced, and more

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Anitha Raghunath
Director
Virgo Communications and Exhibitions Pvt.Ltd

Dear Readers'

As we all know, the manufacturing sector is the backbone of any industry. It plays a pivotal role in numerous sectors like aerospace, defence, industrial machinery and more. India has emerged as a noteworthy player in the global gear market due to its technological advancements which has enhanced its efficiency, precision, and production capabilities.

In yet another pride-worthy moment for the country was its history-making lunar mission recently; thus it's suffice to confidently state that the manufacturing industry is not only making significant strides on Earth, but also is a force to reckon with in space.

In this issue, we took a look at the heat treatment process, which is a critical aspect of the gear manufacturing.

A plethora of engaging technical articles such as getting a closer look at case-hardening to ENRX driving the transition to a greener future, while Bevel Gears India played a part in this historic lunar mission and more awaits you, and. Other articles covered include the retrofitting of gearboxes, technology advancements in the EV sector, and an in-depth view of performance polymers for lowering gear oil temperature among others.

We are also pleased to announce that our first-ever webinar on the maintenance and troubleshooting of gearboxes that took place in August was well-received. Our upcoming webinar on the servicing of gears and gearboxes is scheduled on September 22. If you haven't registered, yet, what are you waiting for?

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

We invite you to share your expertise and knowledge and leverage this growing opportunity in this niche industry.

Happy reading!

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

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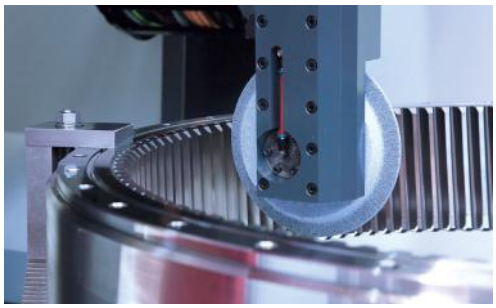


IGW's Stefaan Dewaele Eyes Expansion through Transmission and Motor Gear Acquisitions

Stefaan Dewaele, CEO, IGW

With 70 years of experience in gear manufacturing, Belgium's IGW history began in 1949 when a 20-year-old ambitious entrepreneur, Mr. Alfons Watteeuw, founded his one-man business in gear technology that is now known today as IGW.

IGW is steadfastly dedicated to making gears coupled with its unparalleled execution in manufacturing with international standards, best machines, and constant commitment to innovation and excellence, and skills of passionate people.

CEO Stefaan Dewaele spoke to *Gear Technology India* about IGW, the unique challenges and opportunities in the Indian market, and what lies ahead for IGW among others.

What types of gears and sizes does IGW specialize in manufacturing, and which industries do you primarily serve?

Global customers rely on IGW for a wide variety of products in the drive lines of their critical parts. IGW supplies various parts such as gears, assembly & sub-assembly and prismatic parts to global customers. IGW caters to several markets such as automotive, compressor, agriculture, construction, rail, industrial machinery, medical and semiconductor, and so on. Global customers rely on IGW for their toughest projects, design insight, innovative solutions, manufacturing and technical expertise.

Do you offer custom gear design and manufacturing for specific applications?

Yes. IGW takes pride in offering custom gear design and manufacturing services to cater to specific applications.

We have a world class engineering team who possess a deep understanding of gear technology and its applications across various industries.

We have exceptionally trained CAD (Computer-Aided Design), CAM (Computer-Aided Manufacturing), KISS software trained engineers.

We work closely with our clients to gather detailed insights into their specific requirements taking into account factors like load, speed, torque, and environmental conditions among many other things such as metallurgy etc.

What manufacturing technologies and equipment do you utilize for gear cutting, shaping, grinding, heat treatment and others?

IGW has state-of-the-art manufacturing facilities in Belgium, Romania, India (Pune) & China.

In our manufacturing process, we utilize a range of advanced technologies and equipment to ensure precision, quality, and efficiency.

We have tremendous customer intimacy and therefore we have always created future-ready infrastructure with machines from international brands in entire processes like gear cutting, shaping, hobbing machine, gear shapers, gear skiving machines, gear grinding machines, profile grinding machines, and in-house heat treatment facilities (Ipsen & Aichelin SQFs).

How does IGW ensure quality and precision in gear manufacturing particularly for demanding applications?

We believe in quality check / assurance throughout the manufacturing processes deploying high precision measuring instruments with the latest technology.

We have invested in not only high-class quality testing equipment but trained our people as well to the fullest extent.

Together with the best testing machines and continuous training of people has ensured that we deliver high quality output.

What considerations does IGW keep in mind when looking at selecting materials for different gear types and applications?

Material for gear making is selected based on several quality criteria keeping end application in mind by the customers.

Usually, material is a choice made by the OEM and we adhere to the same requirement with our state-of-the-art testing facilities.

What separates IGW from other gear manufacturing companies?

What separates IGW from the rest of the gear manufacturing is that it strongly believes in developing employees and their skills.

It continuously focuses on problem solving, improvement techniques, using digital tools, customer focus, leadership, lean management, 5S, teamwork, communication, knowledge sharing among group companies adopting best practices. We are present in each continent with manufacturing plants. Wherever the customer wants us to deliver gears, we do that from the plant close to the customer.

How do you manage factors like gear noise reduction, vibration control, and heat treatment distortion?

Noise reduction is important. To achieve robust gears that are more resistant to wear and no micropitting under high loads, gear honing, fine grinding comes into play. Gear honing ensures quieter gear shifting. Gear honing is also relevant when noise optimization is very important as it is in case of the construction of electric & hybrid engines.

With the growth of electric and hybrid technology, this is becoming necessary. Fine grinding with special stones also helps in reduction of noise. Especially in automotive, if the torque is too low, rattle noise emerges, and if the torque is too high, that will result in gear whine noise. Idler gears are placed between a driving and a driven gear to transfer motion without change of direction or gear ratio. This also helps to reduce noise and vibrations. For heat treatment, there are stringent quality criteria to ensure there is no distortion.

What are your impressions of the overall Indian gear manufacturing market? Please elaborate on some of the common challenges and opportunities that you have faced.

Over the years we have seen that Indian gear manufacturing is a significant and dynamic sector within the broader manufacturing industry. It plays a crucial role in various sectors automotive, off-highway, industrial needs and also catering to export. At the same time, the industry faces some of the challenges.

a) Technical Upgradation: One of the challenges in the gear manufacturing market, like in many manufacturing sectors, is the constant need to upgrade and adopt new technologies.
Staying up-to-date with advancements in gear design, production techniques, and materials can be a challenge.

b) Skilled Labor: The industry often faces a shortage of skilled labor particularly when it comes to specialized tasks like precision gear machining and quality control. This can impact both production efficiency and product quality.

c) Quality Assurance: Maintaining consistent quality is vital in gear manufacturing due to the critical role's gears play in various applications. Ensuring dimensional accuracy, surface finish, and proper tooth profile is a challenge that manufacturers need to address

d) Global Competition: The Indian gear manufacturing market faces competition from both domestic and international players. In the globalized economy, companies remain competitive 360 degree -cost, quality & reliability, innovation following safe practices. Technology and robust industrial infrastructure is the backbone of developed countries, and India too has been improved in the context and on the right path.

e) Cost: Conventional gear requirement is facing cost challenges being conventional manufacturing routes and requirements of customers. Price is the major criteria in such businesses.

Opportunities

a) Growing Industrial Sectors: With the growth of industries such as automotive, off-highway and overall, the demand for high-quality gears is increasing. This presents an opportunity for gear manufacturers to expand their customer base and diversify their offerings. India's infrastructure development efforts, such as road construction, metro rail projects, and wind energy installations, have increased the demand for gears as well. India's aerospace and defense sectors have also driven demand for high-precision gears used in aircraft, helicopters, and defence equipment.

b) Technology Adoption: The adoption of advanced manufacturing technologies like CNC machining, 3D printing, and digital simulation tools can enhance the precision and efficiency of gear manufacturing processes.

c) Local Sourcing: Many industries are looking for local suppliers to ensure supply chain stability. This can be an advantage for Indian gear manufacturers who can provide high-quality products and reliable delivery schedules. IGW India is established very well and brought in global IGW technologies – global player at your doorstep.

d) R&D and Innovation: Investing in research and development can lead to innovative gear designs, improved materials, and more efficient production methods. This can give manufacturers a competitive edge.

e) Collaboration: Collaborations among players can build good, innovative solutions and products and better use of skills and competence.

What trends have you seen in the Indian gear manufacturing industry over the last 5-10 years?

Sustainability is no longer a buzzword. OEMs and all global players want to have products which are sustainable. The entire manufacturing process needs to be sustainable keeping the environment in mind. We see this shaping up a lot in gear manufacturing as well. We create internal targets to achieve sustainability. Apart from global competitiveness, automation, digitalization is now an integral part of the manufacturing landscape.

What lies ahead for IGW in terms of expansion?

IGW entered the Indian market in 2015 by acquiring a controlling stake in a Pune-based gear manufacturing company and completed the 100% acquisition in 2020. Now, the business is established very well on the foundation of "One Team One Goal" focusing on safety, quality, delivery, cost, agility and continually investing in state-of-the-art technologies come up with "speed of new product development" as one of the key strengths.

Having built a successful business, it now looks to expand to the gear manufacturing business in India. We continuously look for acquisition opportunities in transmission gears and motor gears.

Typically, companies with 200 crores of revenue are our interest, and we are open to look at good and niche companies below this threshold, too.

We will continue to keep building business through more strategic opportunities in the Indian market. I think globally consolidation has happened, and the Indian market will not be an exception.

For joint ventures and acquisition opportunities, companies can reach out to: sumit.chuttar@igwpower.com

Visit IGW: https://igwpower.com/

Gearwheel Manufacturing in 34-second Cycle

Gearwheel manufacture in 34-second cycle © Martin Witzsch

Minimising production times to ensure competitiveness is one of the most important challenges in the automotive industry — Henry Ford already recognised this over a century ago.

After decades of optimisation, it is difficult to reduce machining times even further while maintaining the same level of quality.

Nevertheless, the company Volkswagen (VW), near the German town of Kassel, has managed to achieve this in gearbox production using KAPP NILES gear grinding machines.

The Volkswagen plant in the small town of Baunatal is one of the larger German locations of the enterprise with a workforce of about 17,000. Its production focuses mainly on passenger car gearboxes in ten different series at present.

Gearing centres of KAPP NILES are being deployed on 50% of the manufacturing lines. The company, based in Coburg, Bavaria, is primarily known as a specialist for generating gear grinding with dressable tools — a process combining productivity and quality.

880 gearboxes per day

KAPP NILES machines are also applied in the production of the DL 382 dual clutch gearbox for Audi. A total of sixteen gearings is required to shift the seven gears with this type of gearbox — ten ground and six honed.

The production unit runs 24 hours a day, 5 - 6 days per week, depending on demand. VW strives to achieve an EPEI value of 1 day in the production unit.

EPEI stands for "every part every interval“, meaning that all components can be produced on each day for the aforementioned gearbox.

This type of streamlined production requires seamless processes and a high degree of flexibility. Technical clerk, Christian Hahn, is in charge of the production process of the DL 382 dual clutch gearbox (Fig. 1).

Figure 1: Christian Hahn oversees production of the DL 382 dual clutch gearbox © Martin Witzsch

He describes the production process: "We have five gearing centres by KAPP NILES in the wheel production unit and two more in the shaft production unit.

In order to achieve an EPEI value of 1 day, we change over the machine in the wheel production unit twice a day. This way, we can produce ten different wheels per day."

The challenge with flexible production was the short cycle times; with an output of 880 gearboxes per day, one machine in wheel production must produce 1,760 parts per day.

Including all set-up times and failures, this yields a line cycle time of 34 seconds. An average line cycle time is about 39 - 40 seconds. Bernd Kümpel, application technician at KAPP NILES, analyses these figures:

"Saving 5 - 6 seconds per cycle does not sound like a lot at first, but together it can be up to a 15% reduction.

If I consider that at least 40% of segments cannot be influenced, I have to reduce the actual process time by 30-40%. Seen in this way, 34 seconds a real challenge."

Saving precious seconds during changeover, dressing and measuring

A total of seven KAPP NILES machines are being deployed which, with their low space requirement, are ideally suited for the highly automated production at Volkswagen. These include: Three KX 100 DYNAMIC (Fig. 2), two KX 260 TWIN in wheel production and two KX 160 TWIN in shaft production (Fig. 3).

Figure 2: In wheel production: The KX 100 DYNAMIC © Martin Witzsch

Christian Hahn and Bernd Kümpel agreed from the very beginning that the desired cycle time could only be achieved with a combination of several measures. In order to minimise the daily set-up effort, Christian Hahn makes sure that the wheels that are to be produced on one machine have bore holes of the same size. Thus, he has to changeover the machine, but not the clamping tools. The remaining set-up time is minimised by the intelligent set-up concept of the KX 100 DYNAMIC. For one machine, he needs just 20-25 minutes.

Figure 3: In shaft production: The KX 160 TWIN © Martin Witzsch

"The semi-automatic set-up makes the KX 100 DYNAMIC extremely user-friendly," says Bernd Kümpel, describing the process.

"All you need is an Allen key for the entire set-up operation. With it, you operate the hydro-expansion clamping chuck of the dresser roll. Everything else is connected without any screws via HSK interfaces (HSK= hollow shaft cone)".

An additional visual aid is available in the form of a menu-guided and easy-to-understand cycle on the machine controller. By completing the step-by-step process and the acknowledgement screen the operator ensures that no work steps are executed incorrectly or, in fact, forgotten. High-cost failures are prevented in this way.

The tools are dressed using full profile rolls, allowing all threads of the cylindrical worm to be approached and moulded simultaneously.
Thus, with a 5-pass full profile roll, the dressing time can be reduced by more than half without compromising on quality (Fig. 4).

Figure 4: With a 5-pass full profile roll, the dressing time can be reduced by more than half without compromising on quality © KAPP NILES

The integrated measurement system is another important time-saver. Christian Hahn explains the advantage,"After each changeover, a quality measurement has to be made outside the machine.

In fact, we continue to require this, but I can already check the basic, quality-related parameters with the integrated measurement sensor in the machine itself. It saves a lot of time since we can start production before the results of the external measurement are available."

The integrated measurement system of the KAPP NILES machines thus accelerates the restart process considerably. The external measurement merely checks more teeth and generates the measurement report to monitor the gear.

Open for new machine tool technology

The search for optimisation potential also includes the actual grinding process. CubitronTM II machine tools by 3MTM show a highly promising approach, with geometrically specific — triangular shaped — cutter heads, compared to conventionally dressable grinding wheels.Christian Hahn enumerates the benefits of these machine tools; "With these, you can step it up a notch, to say it plainly. That is, remove more material in one thread, and remove it faster."

For this purpose, KAPP NILES provided relevant preparatory work with a large number of grinding tests in-house to be able to use the benefits of this machine tool with the DL 382 components.

Bernd Kümpel, "With CII, you can remove a considerable amount of shavings without any thermal damage to the component. This way, we reduce time consumption by a solid 30% compared to other grinders, depending on the component."

Saving space and money

Production is characterised by a belt chaining (or linkage) which goes through the entire hall (Fig. 5).

Figure 5: The 34 seconds cycle provides for traffic on the highway © Martin Witzsch

Figure 6: Loading to and unloading from the conveyor belt is done by a transfer unit © Martin Witzsch

Among the employees, it has gained the nickname "highway". The available space is limited. Hence, the highly compact KX 100 DYNAMIC machines are the preferred choice.

This machine type has two separate rotatable mounted columns, each with vertically movable pick-up axes with one workpiece spindle.

While a workpiece is being machined, the other pick-up axis places the machined workpiece and loads a non-machined part onto the workpiece spindle. The workpiece is aligned outside the work area.

This allows the workpiece spindle, already accelerated to machining speed, to be swivelled in the work area. Non-production times are thus reduced to a minimum.

A transfer unit (Fig. 6) does the loading to and unloading from the conveyor belt.

Bernd Kümpel tells us, "We usually move with the belt directly below the machine. However, this was not possible here. With the transfer unit, we compensate for height and distance from the belt to the machine." This solution is not only compact, but also cost-effective.

"An integrated automation solution would have been significantly more expensive, at about 25% of the price of the machine," adds Bernd Kümpel. "A simple transfer unit costs less than 10% of the machine price."

Planned success

The time for conversions and commissioning is, in most cases, very limited. But the highly ambitious goals have been achieved. Christian Hahn takes stock, "Throughout the process, I have been very satisfied with the on-site support and the local service.

We were convinced by the machine concept and managed to overcome any obstacles together. The cycle time, in particular, was a critical aspect. But, we did it." And for this, they faced a lot of time

constraints. The commissioning which included the machine capability analysis, where 100 components of each type are produced and measured a 100%, took place in the summer of 2016.

Production commenced right in the first week of September.

Apart from the cycle time, other difficulties were overcome in the shaft production (Fig. 7).

Figure 7: The long shafts are hollow and thus comparatively unstable, making the grinding process particularly challenging © Martin Witzsch

Christian Hahn describes it as follows: "The shafts are hollow and thus, comparatively unstable. This called for a special clamping technique and a machine that can absorb the unavoidable vibrations in the grinding process.

The KX 160 TWIN can do this due to its solid design and construction which in turn helps to achieve better grinding quality."

Should immediate service be required, KAPP NILES has stationed an employee in Kassel who only provides support to the Volkswagen plant.

Bernd Kümpel says, "Our highest priority is to ensure production, regardless of the problems that occur." Exceptional support that is very much appreciated by VW (Fig. 8).

Figure 8: A well-rehearsed team: Bernd Kümpel and Christian Hahn © Martin Witzsch

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

Fatigue Characteristics of Case-Hardened Gears

The overall design of the gear must take into account the stress systems and minimize the effect on the integrity of the gear. Fatigue strength is one the key areas

By: KP Soundarajan

Introduction

An efficient and reliable transmission of power involves the interaction of forces which are transmitted by a carefully developed set of components. These components must withstand various complex stresses produced by the forces involved. Gear teeth transmit loads through a process of sliding, rolling, and negative sliding of contacting surfaces.

The contact is responsible for the development of bending stresses at the root of the gear tooth and contact stresses at flanks. These are basic yet important life aspects of loaded gears which are of case-hardened ones.

By calling the fatigue properties of such gears, the influencing features are many that contribute to fatigue. With the help of a simple diagram, these are shown in blocks in serialising order of A, B, C, D, E, F, G and H. Each of these blocks contain the respective engineering principles or facts.

The gear teeth transmit load/s through a complex process of positive sliding, rolling, and negative sliding of contact surfaces. This is the cause of development of bending stresses at the root and contact stresses in the meshing involute flanks. Here, we look at each block individually.

A: Bending Stresses

These occur at the root of the tooth due to transfer of load from one gear to the other.

The bending stresses are cyclic by nature which can lead to crack i.e., fatigue crack initiation at the root. This zone itself is a stress concentrator and the fatigue cracks are fractures in their position and role when these undergo alternating load peaks.

As everyone knows, per the Lewis calculation of stress developed in the root and his approach to the model, it is a notched beam in bending approximating to a parabola. It is fundamentally right even today, and gear geometry calculation and bending load still begin the understanding from here.

The stress concentrators were brought out by detailed explanation by researchers Broghamer and Dolan. The calculation of stresses was done in 2D analysis later by Aida and Terrauchi. These put together gave a good understanding of the importance of the tooth root stress. Around 2,000 Andrews came up with finite element analysis.

The bending fatigue is governed by gear geometry, the loading magnitude and material characteristics. So, elements like the parameter module have been connected to the endurance of the material to the bending strength to fix the module in accordance with the famous Maag approach. Many descriptions have been known and read as well as practised more often with gear geometry, but more precisely the metallurgical factors are to be correlated too.

B: Tooth Root Stress

The interference zone contains the fillet where the true or modified form of active profile blends with the root region. The quality, the magnitude and finish in the fillet blend is a key area for stress concentration. The unfavourable intensity here is directly connected to the fatigue performance.

The radius is limited by any formation of undercut as a function of pressure angle and nr of teeth, root thickness ratio (this is termed as kf from the X factor), the hob or the gear cutting tool edge radius to form the fillet corner and the proportion of whole depth based on finishing.

The fillet formed by the generating rack or hob or tool is a trochoid, and should blend at either end smoothly. In gear cutting like hobbing, it is often guided to look for chip thickness size from the knowledge/ program and employ feed rate; the corresponding finish in the fillet area contributes to the stress after hardening.

The root diameter and the fillet radius are together the parameters for bending root stress effect in a fatigue performance evaluation.

The form diameter at the root region gets its position and relevance depending on where and how effectively the active profile for use begins. The tool geometry is calculated for the form diameters values and position with regard to the fillet. In short, the interference zone is very sensitive in values and finishes for fatigue performance.

The 'tooth root chord' in critical section (sfn) and a quantity stress correction factor Ys are load capacity based geometrical values which contain the fillet radius as their influencing factor.

Consequently, say for low cycle fatigue (where the uniform loading in the line of action) of case-hardened gear steel takes 3× 10^6 as reference to segregate those with higher nr of load cycles or lower to enable fix on life factor become interlinked.

For higher order load cycles, linear elastic finite element comes up to evaluate the fatigue effect from the nr of stress cycles.

More often the surface finish in the profile zone in pre-finishing and finishing are different on account of axial feed employed and the limitation of true involute portion to finishing leaving the pre-cut root region untouched. So, the favourable performance and fatigue life on this count depends on how the fillet area has been dealt in pre-cut. Shaving or hardening, grinding or hard skiving or honing, all face the above situation with regard to 'the fillet region pre-cutting situation' towards fatigue life.

C: Contact Stress

These are out of loaded flanks experiencing the Hertzian pressures and the induced elastic deformation and some plastic zones based on the type of load, the surface heat production by friction, the component of sliding speed, and the summation of rolling velocities between the pinion and the gear.

The friction is a combination of both mechanical and hydrostatic friction, and depends on the heat flux created, the thermal conductivity of the surfaces, the micro depth of affected place all to add to the under substrate — stress values to indicate the fatigue.

By 3D mapping of slip as percentage, a principle analogous to slide roll ratio, entrainment speed for lubrication oil and the friction coefficient, it indicates the interlinked phenomenon of the three parameters on stress progression in the contact zone.

The plastic zones can be recognised through the film thickness and load equations, and can be in the order of a few microns in micro asperities contact.

There can be two plastic regions by continuous change of sliding and rolling due to different phenomena. The first one is a flank surface layer due to macro contact. The second one is due to micro asperities contact as mentioned above.

The depth of stress intensifying can be within about 50 microns where the surface roughness of the tooth flank plays a role on account of difference of entrainment velocity and asperities contact velocity. So, we can say that the friction has a role on the contact length.

The type of lubrication determines the film thickness in the zone of contact length.

The contact along the helix in helical gears with an overlap ratio of ebeta greater than 1 and transverse contact ratio of ealpha less than equal to 2 roughly ends up with the length of all contact oblique lines to ealpha times the face width.

Just a calculation of load along the face to see the influence of the load trapezium inclined to helical elastic yield. The above is a related but additional point of view.

The ratio of the surface asperities speed to the mean rolling speed in the continuous run impacts the oil

FLOW CHART REPRESENTING THE ENGINEERING PRINCPLES

- Occur at root of the tooth
- Cyclic in nature
- Root crack initiation
- Lewis
- Broghamer - "stress concentration"
- 2D analysis / Terrauchi
- FEM by Andrew

A Bending Stress

B Tooth Root Stress

- Fillet radius
- Root diameter
- Form diameters' relevance
- Surface finish

C Contact Stress

D Retained Austenite

- Transformation to Martensite-plain strain in load life
- Nr. of load cycles load-life relation
- Low cycle fatigue & high cycle fatigue
- Micro tensile stresses

- 2 different from rolling & sliding
- Sliding friction
- Hertzian pressure
- Asperities
- Compression of surf-ampli due to fatigue loss tensile / compress stresses
- TFF / TIFF

E Metallurgical Points To Fatigue

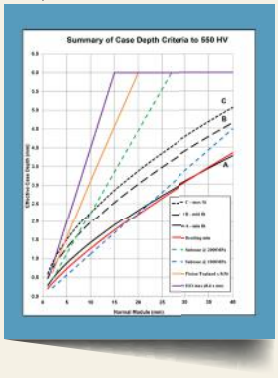
F Case - Core Properties

- Core strength importance
- TIFF can occur inside case or cose / core boundary

G Case Depth

H Cryogenic

- Need for hardness uniformity
- Case depth bending strength / contact fatigue
- Characteristics
- Critical parts diffrential depths, two components composite



- Role of cryogenic in contact fatigue
- Bending fatigue

film entry and compression of surface amplitude to affect the film thickness fluctuation.

This is complex due to the EHL phenomenon; the resultant heat flux gets to the surface or below based on friction factor. What was found with popular case hardening alloy steels is that a coefficient greater than 0.3 can bring the fatigue fracture in course of time at the surface.

A new analysis in gear grinding is monitoring and managing the grinding parameters to restrict the heat development in contact depth zone in case depth; this can cause additional heat burn thermal stress.

D: Retained Austenite

A 'mechanism by which austenitic structure' of case hardening steel during heat treatment when raised up to this elevated temp range based on carbon and quenching after a while to form martensite has been dealt in the tech literature.

So, we do not go to the type of alloying elements responsible for retention of austenite on cooling and how carbon has the larger effect and so on; similarly, the iron carbon equilibrium, temperature, time and transformation is ignored.

Researchers like Krauss, Zaccone, and those who measured the volumetric expansions and transformed micro structures/ properties to retain austenite etc., have shown the inter relationship between the fatigue performance and the retention of austenite.

In terms of austenite – the martensite transformation at the tip of a proceeding crack shows how beneficial it is to fatigue resistance and its mechanism.

Large amounts of retained austenite are accepted in terms of low cycle fatigue where the 'plastic strains' induce strain-hardening from austenite to martensite and the development of favourable residual stresses.

The plastic strain needed to transform is directly proportional to prior-austenitic grain size and size or morphology of austenitic packets before transformation.

In high cycle fatigue, the relatively low plastic strain does not quickly allow the transformation. The magnitude of such strain depends to a great extent on the fine grain structure. These structures will be able to transform the low amounts of strain into martensite, hence it can resist the crack progression.

There are several aspects in each of these mechanisms, and as mentioned earlier, the linear elastic finite element model helps to know better.

In a way, my learning is limited in progressive developments in this area but know that no systematic evidence has been out there with regards to outlining the nature, magnitude and micro stresses etc., on different case hardening steels and alloys as each is specific.

For example, sufficient details have been made available in some hot hardness steels with many alloys (like 9310 steel or AMS 6365) on their performance especially at elevated operating temperature fatigue failure tests based on research at Illinois Institute of Technology in the late 90s and early 2000s.

With this, we can look for E in some metallurgical influencing factors alone without going much into crystallography or metallography.

E: Metallurgical Aspects

These factors depend on the composition of material used and its heat treatment. Additionally on their post heat treatment transformation in service is the structure change as said earlier by load impacted plastic strain.

The residual stresses and the effect of residual stresses and quasi stationary stresses change based on the surface load of the tooth flanks.

Loads on both flanks as in the case of reverse idler and torque at that speed are tackled by coarser pitch and longer face width.

Some designs consider residual stress induction in grinding the teeth through the final process using a non-dressable CBN grinding wheel to induce tangential compressive stresses in the substrate up to 20 to 30 microns.

These stresses increase the load carrying capacity on the flanks. They are measurable by X-ray diffraction using the Sin^2 phi method. Yet these stresses sit closer to the tooth flank surface in the substrate but not deep.

This was brought out by Prof Yokagawa in 1992 in a power transmission and gearing conference as an effect of CBN grinding. There are companies in the gearing field that carry on this technical phenomenon in the late ‘90s.

A corollary of this is at heavy commercial vehicle transmission- gear grinding in generating grinding process with an option of profile grinding and indexing for reverse idler.

There are German solutions that employ a cluster of these spur gears in an arbor type exchangeable fixture into a fixture base body with collet type clamping on a profile grinder.

Some of the other metallurgical factors are oxidation, decarburization, super carburization, carbide

formation, grain boundary segregation, type and size or density of inclusions present, micro crack formation along with residual stresses which affect the fatigue performance significantly.

F: Case-Core Property

The core strength is of significant importance in fatigue resistance. This is because core strength has a direct impact on residual stress. The differential volume expansion between the case and core is responsible for the magnitude and polarity of the residual stresses developed.

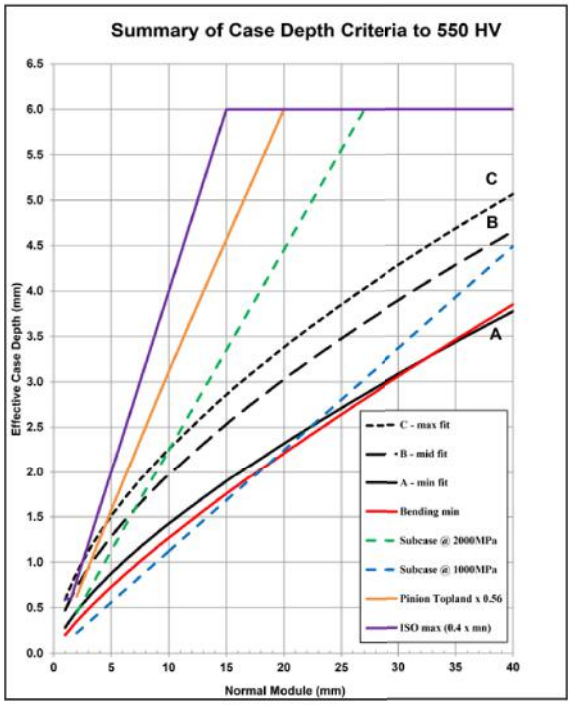
When the difference is big enough, so is the residual stress. The carburized structure is a two-component composite and each has different elastic and plasticity properties.

When the stress levels are below the material yield point in both case and core, no significant overall stress state difference from the expected homogeneity. However, when load increases and the stress levels go beyond the yield stress, the core can behave plastically while the case still is elastic.

Due to different Poisson's ratio for elastic behaviour the contracting tendencies vary; so transverse stresses are created in the interface region. This is the tensile bi-axial stress state.

The development of compressive transverse stresses lead to the higher ductility of the carburized part which helps to resist the applied stress. The presence of any inclusion in the case affects the case core transit plane and creates tooth internal fracture under fatigue.

G: Case Depth



The improved ductility of the carburized component compared to through hardened parts is by the development of compressive transverse stresses in the case. Volumetric expansion on transforming to martensite when straining can reduce the bi-axiality of the stress condition in the case.

A deep case may be seen to increase the degree of bi-axiality in the case-core interface while it restricts the ductility of the case. Some research in recent times has found that the nickel-chrome-molybdenum case hardening steel performs better than a normal 20MnCr5 type.

Case depth selected on the basis of contact fatigue perhaps may not necessarily perform at optimum for bending; at the same time, maximising for bending fatigue is usually overshadowed by the need for contact resistance.

To an extent, it can be said that even dual case depth is done in critically loaded parts for optimum fatigue strength in special gearing.

To influence the macro geometry in terms of optimum case hardening depth (up to a target hardness level), the formula used per standards gets split between that for contact zone alone or a maximum when both bending and contact stress are together considered by suitably changing the numerical factor in the formulae.

These can be seen in the enclosure along the bottom and top sides of the graph below where the module is in X axis and case depth on the ordinate. This is fine for TFF (Tooth Fatigue Fracture) as well.

There is a phenomenon WEA (White Etching Area) where the material structure is exposed to strong hydrodynamic pressure and sheer stress at the same time.

The origin of WEA beneath the surface results due to the presence of a mechanically thermodynamic state induced – high tensions where the sheer resistance of the material is exceeded.

The crack initiation can run in the direction of the greatest sheer stress where the flanks are heated in a short time.

In the process, carbides dissolve and carbon enters the gamma matrix. After cooling by itself there can be an oversaturated martensite due to the surrounding structures at relatively lower temperatures.

H: Cryogenics

This is not an essential process for all case-hardened gears but applicable where the stress limits even the thermal of operating gears are at unfavourable environments; maybe at an altitude where the oil viscosity or the fluid flow inside a loaded heavy

planetary gear undergoes a momentum ratio in penetrating the air medium to strike the tooth surface for lubrication; that results in an unfavourable Weber cross flow number.

Besides, the air density in such an environment would be sub atmospheric condition while the temperature matches with the typical operating value of the gear box system.

When the ratio of the pitch line velocity to the oil jet velocity changes to an unfavourable one, the gears have to "sustain their structure and overall stresses including heat energy to the target level in design in a time bound level before fracture." Such gears also are those that require special treatment.

The effect of cryogenic treatment with respect to deduction of retained austenite, and if the belief of retained austenite can be there for transforming on straining, the overall applicability of cryogenics can have multiple but opposing views as well.

So, the necessity of its use has to be tested for specific conditions of material rather than a common statement.

Generally, the reduction of retained austenite for better fatigue properties and fracture toughness of the carburized parts due to development of residual tensile micro stresses require the process "cryogenic" as an essential practice.

In both the described conditions, the cryogenic treatment helps by adopting the gears to sub-zero temperature by suitable medium, mostly liquid nitrogen, it is practised where the "bending and contact fatigue properties" are to be sustained at adverse conditions of operation.

While the fresh tensile micro stresses induced are seen to be active for the purpose, there are opinions from certain users that these stresses are not favourable in the remaining austenite region.

Therefore, there are some applications where cryogenically treated gears showed a decreased fatigue performance in both bending and surface fatigues when tested. But by changing the base steel or compositions and cryogenizing in aerospace parts have been shown.

Conclusion

We can summarize the steps from A to H to briefly describe the main aspects of fatigue performance of case hardened (including ground gears) in service. Areas of material composites, design of gears and the best engineering practices contribute to better S-N properties for longer survival.

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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.

Basic Grades of Carbon Steel Used in Various Applications and Gears

Raw materials are the bedrock of any gear manufacturing process. Using quality raw materials ensures the reliability and efficiency of gears. In this article, we look at the different grades of carbon steel that are used in different applications in gear manufacturing.

What is Low-Carbon Steel?

Low-carbon steel, also known as mild steel, has a comparatively low ratio of carbon to iron compared to other steel types.

Typically, its carbon content is within the range of 0.05% and 0.32% by weight. This gives low-carbon steel low strength while making it more malleable and ductile compared to high-carbon steel.

One of the major benefits of mild steel is its cost-effectiveness. As it requires less carbon and other alloying elements, it's normally less expensive than other types of steel.

Moreover, it's more readily available and simpler to work with than higher-carbon steels, which makes it a popular choice for a wide range of applications.

What are the Uses of Low-Carbon Steel?

Despite its low strength compared to other steel types, low-carbon steel is still strong enough for use in structural applications. It's also used for machinery parts, as it helps to reduce machining costs.

Low-Carbon Steel Properties

Property	Value
Density	0.103 – 0.292 lb/in^3
Tensile Strength, Yield	20300 - 347000 psi
Fracture Toughness	30.0 – 105 ksi-in½
Shear Modulus	10200 – 11600 ksi
Melting Point	2600°F
Thermal Conductivity	176 – 645 BTU-in/hr-ft^2-°F

What is Medium-Carbon Steel?

Medium-carbon steel has a carbon content typically ranging between 0.3% and 0.6%.

This category of steel offers a balance between the ductility and formability of low-carbon steel and the strength and hardness of high-carbon steel.

Medium-carbon steels are stronger and harder than low-carbon steels. This is due to their increased carbon content, but it also means they're less ductile and more difficult to form and weld.

They often require heat treatment, such as quenching and tempering, to achieve desired mechanical properties. This is possible with its manganese content, which ranges between 0.30% to 0.60%.

What are the Uses of Medium-Carbon Steel?

Medium-carbon steels are commonly used in applications where higher strength and toughness are needed, as shown in the table below.

Medium-Carbon Steel Types

Common types of medium-carbon steel and their applications include:

Type	Industry	Application
Medium-carbon structural steel	Construction, Manufacturing	Buildings, bridges, heavy-duty equipment
Medium-carbon sheet and strip steel	Sheet Metal Work	Machinery parts, automotive parts
Medium-carbon tubing and piping steel	Construction, Automotive, Heavy Equipment	Mechanical tubes, pipes for fluid
Medium-carbon pressure vessel steel	Oil and Gas, Food and Beverage, Pharmaceutical	Pressure vessels
Medium-carbon alloy steel	Automotive, Heavy Machinery	Gears, shafts, axles, connecting rods
Medium-carbon quenched and tempered steel	Automotive, Construction, Heavy Machinery	Gears, axles, transmissions, crane booms, excavation arms

Grades of Medium-Carbon Steel

Products made from medium-carbon steel adhere to specific standards. Within those standards are grades. Commonly used grades of medium-carbon steel — and the standard they fall under — include:

Standard	Grade	Application
SAE J403	1045	Gears, shafts, machine parts
SAE J404	4140	Gears, axles, aircraft landing gears, and drilling equipment
ASTM A29	1045	Axles, bolts, studs, and other machinery parts
ASTM A576	1045	Bolts, studs, couplings, bushings, shafts and gears
ASTM A29	4140	Gears, axles, and shafts
ASTM A434	Class BD (AISI/SAE 4140)	Bolts and other fasteners, connecting rods, gears and shafts
ASTM A829	4140	Gears, axles, and drilling equipment

Medium-Carbon Steel Properties

Each grade has its own properties that distinguishes it from other medium-carbon steel grades.
The table below gives you a range of values for medium-carbon-steel properties.

Property	Value
Density	0.280 – 0.285 lb/in^3
Tensile Strength, Yield	35500 – 252000 psi
Fracture Toughness	73.7 – 130 ksi-in½
Shear Modulus	10400 – 11900 ksi
Melting Point	2597– 2800°F
Thermal Conductivity	152 – 361 BTU-in/hr-ft^2-°F

What is High-Carbon Steel?

High-carbon steel contains a carbon content ranging between 0.60% – 1.5%. It's the most corrosion resistant of the steels due to its high amount of carbon. This increased carbon significantly enhances the steel's hardness, tensile strength, and wear resistance. In turn, this makes it suitable for applications that demand high strength and wear resistance.

However, the higher carbon content also makes these steels more brittle and less ductile, which makes it more susceptible to cracking under certain conditions. High-carbon steel is also more challenging to weld than lower-carbon-content steels,

due to the risk of cracking and brittleness in the heat-affected zone.

What are the Uses of High-Carbon Steel?

High-carbon-steel uses include anything needing wear resistance and durability, as shown in the table below. High-carbon steel is often used to manufacture springs.

A note about plain high-carbon steel, which is often used to mean high-carbon steel.

They are different. Plain high-carbon steel consists mostly of carbon and iron, without any significant amounts of alloying elements.

Grades of High-Carbon Steel

Grades of all carbon steels are subsets of specific standards. Some of the most commonly used grades of high-carbon steel include the following:

Standard	Grade	Application
ASTM A29/A29M	AISI/SAE 1060	Springs, gears, axles, heavy-duty machinery components
ASTM A29/A29M	AISI/SAE 1065	Springs, cutting tools, industrial knives and blades
ASTM A29/A29M	AISI/SAE 1070	Springs, automotive suspension components, agricultural machinery parts
ASTM A29/A29M	AISI/SAE 1080	Heavy-duty springs, automotive components, heavy machinery parts
ASTM A295	AISI/SAE 52100	Bearing steel used in the manufacture of ball and roller bearings
ASTM A600	AISI/SAE M2	High-speed tool steel used for cutting tools, drills, and taps
ASTM A686	AISI/SAE W2	Water-hardening tool steel used for cutting tools, dies, punches, and woodworking tools

Properties of High-Carbon Steel

Property	Value
Density	0.0163 – 0.298 lb/in^3
Tensile Strength, Yield	39900 – 484000 psi
Fracture Toughness	12.0 – 150 ksi-in½
Shear Modulus	11300 – 12000 ksi
Melting Point	2,800-2,900°F
Thermal Conductivity	1132 – 361 BTU-in/hr-ft^2-°F

Low, Medium and High-Carbon Steel Differences

The essential difference lies in the steels' carbon content, each of which reflects different characteristics.

	Low-Carbon Steel	Medium-Carbon Steel	High-Carbon Steel
Carbon Content	0.05% to 0.32%	0.30% to 0.60%	0.60% to 1.5%
Characteristics	1. Ductile 2. Malleable 3. Tough 4. Easily joined and welded 5. Poor corrosion resistance	1. Stronger 2. Harder 3. Less ductile 4. Less malleability 5. Good corrosion resistance	1.Very strong 2.Very hard 3. Poor ductility 4. Poor malleability 5. Better corrosion resistance

Basic Raw Materials Used for Gears

Grey Cast Iron:

This material is used for gears where there is slow speed operation areas.

Depending on the load, grades can be varied from FG200/FG250/FG260

Phosphor Bronze:

This material is exclusively used for worm wheels

Cast Steel:

This material is used for open gearing with higher loads

Carbon Steel for Surface Hardening C45, C60E, EN8:

These materials are used for output shafts of gearboxes with normalized condition.

Direct Hardening Alloy Steels EN19, EN24, 42CrNiMo6:

These materials are used for gears with through hardening as well as surface hardening.

In the above materials, we can maintain hardness value, and as below by hardening and tempering. These gears can be supplied with cut and profile grinding finish.

En 24 (upto 450 BHN), En 19 (upto 350BHN) and En 9/C60E (up to 280BHN).

We can achieve higher hardness of 58 -62 HRC through gas nitriding, and sursulf nitriding with a case depth of 0.5mm and less. We can achieve higher case depth via induction hardening.

Case hardened steels EN36C, EN353, SAE 8620H, 16MnCr5, 20MnCr5, 18CrNiMo7-6:

These are all case-hardened steels. They require gas carburising and hardening to get a higher surface hardness with good case depth.

The above materials can maintain a surface hardness value of 58-62 HRC core hardness and 28-32-40 HRC depending on material used. These gears will be supplied case hardened and profile ground.

Conclusion

The differences between the various types of materials used for different applications including gear manufacturing have been elucidated above.

If we select the appropriate material to achieve the correct heat treatment processes, we can get good results.

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

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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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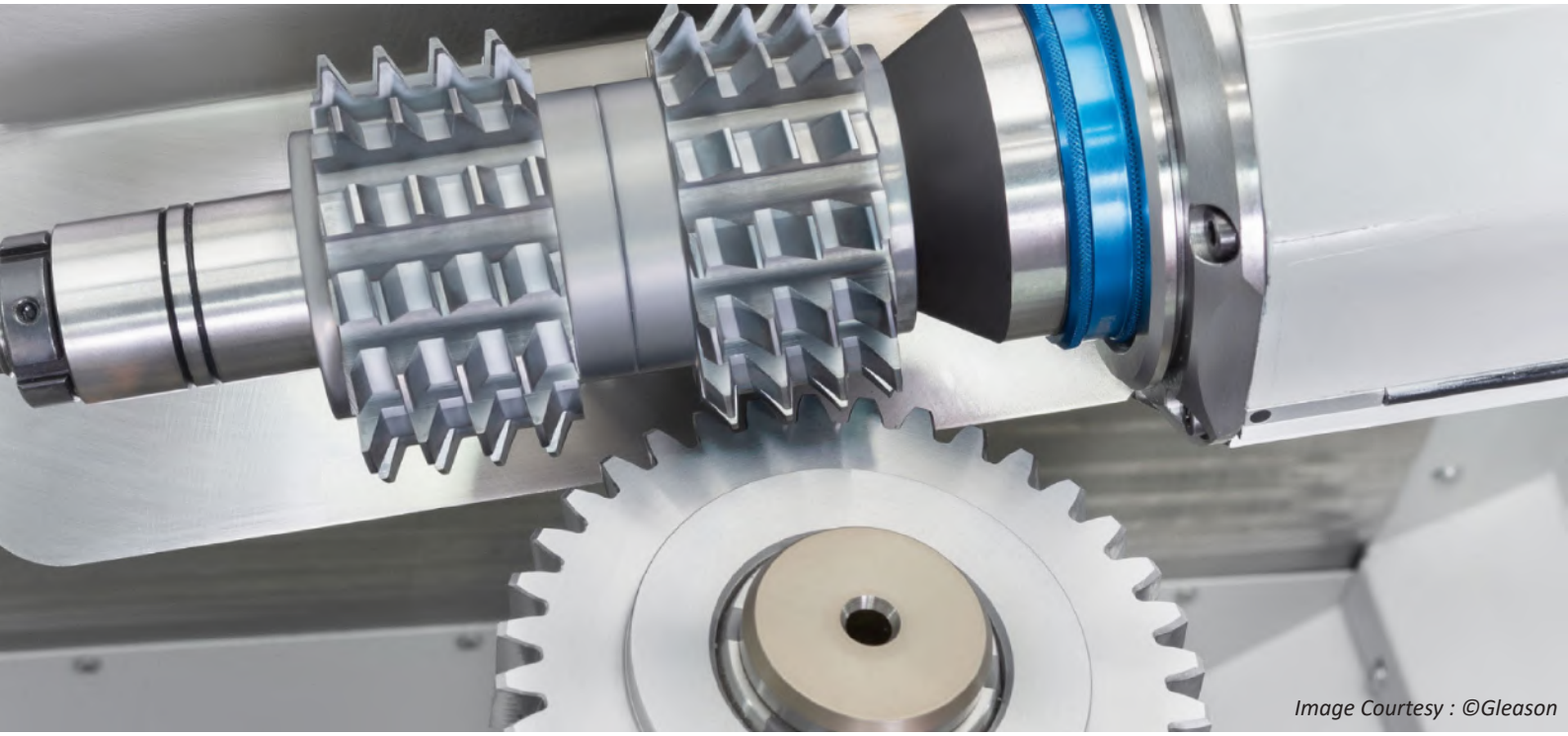

Image Courtesy : ©Gleason

Gleason's Gear Hobbing Redefines Precision and Quality

Gleason Works India is part of the multinational Gleason Corporation, headquartered in Rochester, New York, USA. Gleason is a global leader in gear technology.

Gleason's "Total Gear Solutions'" range from gear and transmission design software to the development and production of gear manufacturing machines and related accessories, gear metrology equipment and automation systems.

Gleason Works India Pvt. Ltd. was founded on April 1, 1996 in Bangalore to manufacture bevel gear cutting tools for the local Indian market.

In June 2017, Gleason India completed the construction of its ultra-modern 65,000-square-feet manufacturing and office facility with solar-powered rooftop, climate-controlled shop floor and full ISO certification.

Manufacturing Capabilities & Product Offerings

Today, Gleason India manufactures a full line of bevel gear cutting tools, gear hob cutters, shaving cutters, and the respective services for tool resharpening and reconditioning, including the resharpening of gear hobs.

Machine building activities include the manufacture of Genesis 130H, 210H and 280H CNC Hobbing Machines, 200SVP Gear Shaving Machine, 685Q Quenching Press, as well as machine upgrading and rebuilding services.

Gleason India manufactures cylindrical workholding systems for Gleason and other manufacturers' machines.

Last but not least, Gleason India supports customers with application engineering services for bevel and cylindrical gears and offers extensive field service and aftersales support with sales and service centers located in Chennai, Kolkata, Mumbai, Delhi and Pune.

Industries

Our products are used by customers in the automotive, commercial vehicle, aerospace, agricultural, mining, energy, construction, power tool, marine and many other industrial equipment markets. Basically, wherever and whenever a gear is turning, it is likely Gleason technology is somehow involved.

IoT Facilities

Gleason set milestones in connectivity back in the 90s such as remote connection modules and the first machine diagnostics and analysis systems.

Today, Gleason offers specific systems as well as the general IoT services available in the marketplace.

Gleason's "Fingerprint" system in combination with Gleason's Condition Monitoring Services has tremendously helped customers during the pandemic and the related travel restrictions to perform machine diagnostics and analysis remotely.

Gleason does not limit IoT solutions to the machine itself, but extends its systems to reach further with AR video systems, cloud services, and e-catalogs for spare and wear parts to name a few.

Sales and Service Networks

Gleason Works India supports customers from design to manufacture and finally inspection including design software and support, manufacturing machines and metrology systems, workholding, tools and all related services.

Gleason's support team is formed by well-trained and highly experienced staff including application (bevel & cylindrical) customer service, and technology trainers with offices in Delhi, Mumbai, Pune, Bangalore and Chennai, and — of course — including the product support team in the head office in Bangalore.

Gleason Works India also provides cylindrical and bevel gear design support employing KISSsoft gear and transmission design software and Gleason's GEMS Bevel Gear Engineering and Manufacturing System.

Automation

Image Courtesy : ©Gleason

Gleason offers a wide array of fast and flexible automation systems including fully integrated automation modules made by Gleason inhouse. Gleason machines are easily integrated into existing workflows with vertical or horizontal orientation.

Loading systems for horizontal and vertical workpiece change can be fitted with different functions and specific auxiliary operations.

Next to typical third-party automation, Gleason offers fully integrated loaders and/or robotic systems which cater to conveyor, tray, or basket-based workpiece storage and transport systems.

The universal nature of Gleason machines and automation modules allows to integrate additional processing steps up or downstream of the actual gear manufacturing process like chamfering/deburring, pre-positioning of workpieces, coolant spin-off, brushing, roll testing and/or inspection, laser-marking or engraving. Many other functions are available on request.

Digitalization

Image Courtesy : ©Gleason

Digitalization extends to all areas of Gleason activities, in new product developments, processes we promote, as well as in daily work life. Constant networking of information and data exchange is necessary to make effective decisions based on all required facts.

Gear designs can now be checked for their manufacturability by creating digital twins that allow to simulate gear manufacture and expected results, feeding back changes to update the theoretical design without having made one cut or a single scrap part produced.

Closed Loop manufacture and digital networking of manufacturing and inspection equipment allows for in-process, detailed gear inspection and analysis and manufacturing process adaption in real time – without a single piece of paper or operator interference.

In service, for example, entire processes are redefined, service requests are recorded digitally and processing is automated to solve service cases quickly and learn for future occasions and interventions.

Manufacturing machines are supported by digitalized tools to identify quality issues before they become critical. Tooling is scanned and confirmed before its use to avoid wrong application or to scale lifetime to avoid extensive wear. In short, there are many applications of digitization within Gleason, that it is difficult to name them all, in general, there is hardly a process or product which is not affected.

Multiple Operation Machines

Gleason machines can include many additional functions like chamfering and deburring, chamfer rolling or cutting, turning, brushing, inspection or

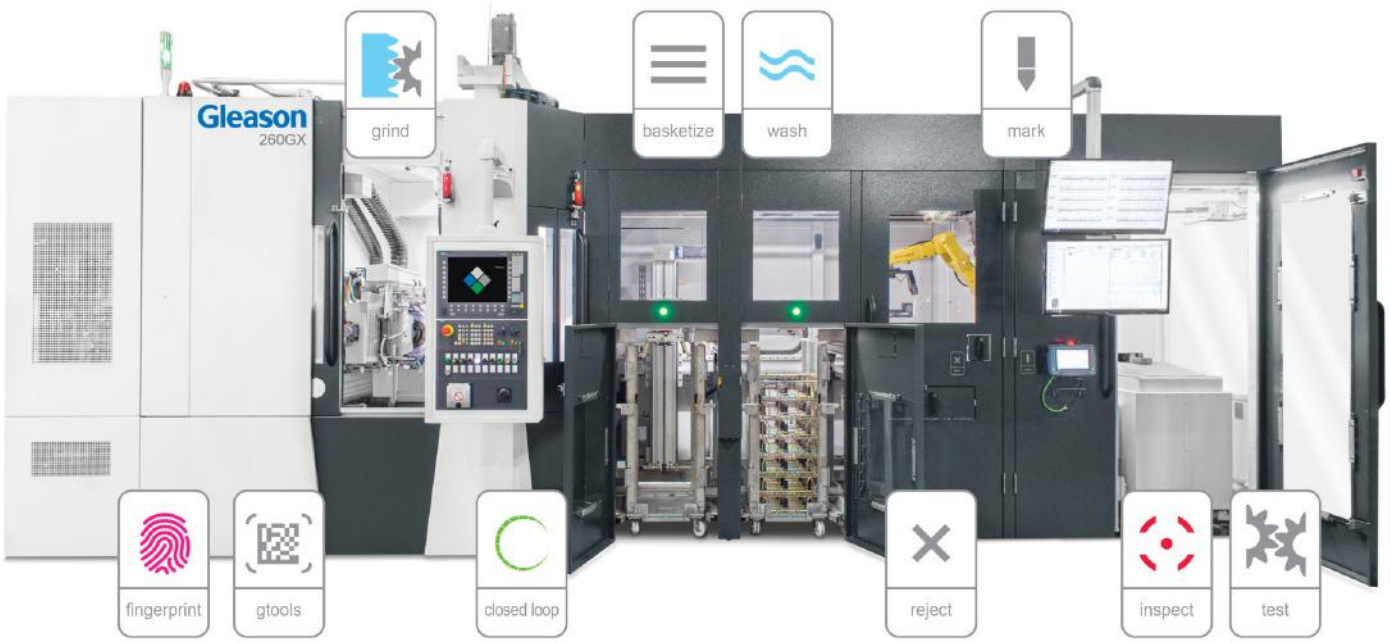

Image Courtesy : ©Gleason

testing, marking, tool resharpening and many more. Depending on the actual product and application, these processes can be installed in parallel to the main manufacturing process or in sequence.

Gleason's USP

We offer many different products and each product has its own USPs. Gleason products are developed to be on the top of their game incorporating latest technological developments.

An important USP of Gleason is the system supplier approach: Customers can purchase single machines, workholding, tools and services, but they can also acquire a complete manufacturing system from one source making sure that all products fit perfectly together and are optimized within the system.

One of the latest technology highlights developed by Gleason is the revolutionary GRSL in-process inspection, supported by non-contact laser scanning and double flank roll testing. Cycle times for optical pitch and profile inspection are reduced to a few seconds, enabling 100% analytical inspection of applications with high quality demands.

Closed Loop capability allows to drive the connected hard finishing machine(s) and adapt machine settings to keep quality within the required tolerances.

This revolutionary system integrates state-of-the-art Advanced Waviness Analysis and KTEPS to thoroughly evaluate gears regarding their NVH behavior.

Another strength of Gleason is its global footprint with its sales and service network distributed around the globe, making sure that global players receive global support while maintaining a very local and accessible service to smaller and mid-sized customers.

Machine Condition Monitoring

Image Courtesy : ©Gleason

Thanks to today's control technology and software systems, machine condition monitoring can be implemented effectively. Gleason's "Fingerprint" condition monitoring system records machine status over time and compares actual and target data.

This regular process captures machine data including measurement of physical parameters such as power consumption and vibration behavior of various machine axes.

Data obtained by means of the machine's digital and physical "Fingerprint" is analyzed by Gleason specialists and evaluated accurately to understand trending deviations and impending wear.

Gleason's Fingerprint is pre-installed on many Gleason machine models with the option to extend to the full Condition Monitoring Service offered by Gleason.

Technology Upgradation & Online Diagnosis

In general, the goal is to make online services available on older machines, for example remote service and maintenance. For this purpose, Gleason offers its “Gleason Connect Box” in two different executions: one for mobile use, and one for fixed installation depending on customers’ requirements.

After digitalization of the machine, diagnostics can be performed via remote connection, including the installation of required updates.

Gleason offers software updates as a stand-alone service, but always recommends purchasing a more comprehensive service program to ensure customers fully benefit from the available maintenance options.

Gleason & Aerospace Sector

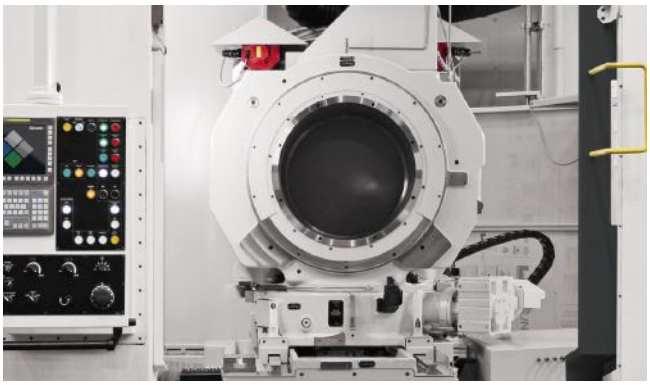

Image Courtesy : ©Gleason

Gleason has many customers in aerospace like HAL & its various units in India for helicopter and jet engine components providing cylindrical and bevel gear design, manufacturing and inspection solutions, like Curvic Gear manufacturing including bevel gear cutting and grinding, gear metrology, Curvic Gear cutting, cylindrical gear hobbing and quenching.

Gleason also supplies workholding and cutting tools to produce demanding aerospace components. Apart from HAL, there are private players in the aerospace sector who use Gleason equipment for domestic and export markets.

Gleason is certain that the Indian aerospace market will continue to grow with major investments coming from the Indian government itself as well as increased activity from domestic aviation companies and higher demand from export markets.

Sustainability

Gleason is committed to a long-term sustainable business model that involves every Gleason employee worldwide, implementing best practices for waste reduction and energy efficiency in all global operations, as well as sustainable product design and processes.

Image Courtesy : ©Gleason

New machines come readily equipped with energy monitoring and specific procedures to avoid idling spindles and limit energy consumption to times when it is actually required.

We also offer energy-saver packages for retrofits. Talking about retrofits, Gleason understands machine remanufacturing and recontrol, as well as component and spindle refurbishment as an important support to green initiatives, saving resources and reducing scrap.

Green thinking is also part of the daily service life at Gleason, with every remote maintenance and VR support completed, we actively avoid travel and minimize the related CO2 footprint.

(Left) Christian Albrecht, Chief Marketing Officer, (Right) Pardeep Kumar Aggarwal, General Manager, Gleason Works India

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Hypoid Gears Efficiency

By: Sushmita Das

In the domain of mechanical power transmission, innovation never ceases. One such innovation that has quietly transformed industries is the advent of hypoid gears. In this article, we delve into the intriguing world of hypoid gears and their efficiency, exploring their unique design, advantages, and applications.

In the intricate tapestry of mechanical engineering, gears are the unsung heroes that transfer power seamlessly from one component to another. Traditionally, spur and helical gears have been the go-to choices for power transmission due to their simplicity and reliability. But amidst this landscape, there's a silent revolutionary – the hypoid gear – which challenges conventions and raises the bar for efficiency in power transmission systems.

The Unconventional Design

Hypoid gears may not be as recognizable as their more common counterparts, but their design is nothing short of fascinating. Unlike traditional gears, which mesh on the same plane, hypoid gears feature an offset orientation. This unique design allows the pinion gear to engage with the larger ring gear at a distinct angle. This seemingly simple modification carries profound implications for mechanical efficiency.

Efficiency Unleashed

The efficiency of a mechanical system hinges on its ability to transmit power with minimal losses. Hypoid gears shine in this regard due to their offset engagement. Traditional gears often suffer from high sliding friction as teeth engage directly, leading to energy loss in the form of heat and wear. Hypoid gears, with their spiral engagement, distribute the load across a larger contact area, reducing friction and heat generation. This characteristic translates to higher efficiency and less wear and tear.

Advantages That Reshape Industries

Hypoid gears, with their unique design and characteristics, bring about a range of advantages that reverberate through various industries, fundamentally reshaping the landscape of mechanical applications:

Powerful Torque Transfer:
The exceptional torque transfer capability of hypoid gears stands as a cornerstone of their advantages. This is particularly vital in scenarios requiring substantial power output, such as heavy machinery and industrial equipment. Unlike conventional gears, the offset arrangement of hypoid gears enables a greater number of teeth to engage simultaneously along the gear profile. This distribution of load evenly across the tooth engagement surface minimizes the occurrence of stress concentration points. As a result, the gears are adept at handling significant torque loads without compromising structural integrity.

Compactness and Versatility:
The inherent design of hypoid gears not only enhances their efficiency but also allows for the creation of more compact gearbox configurations. This compactness serves as a boon in situations where spatial constraints are a concern, enabling the development of machinery and systems that occupy less physical space. This new-found versatility is a game-changer across industries, permitting the integration of powerful gear systems into environments where traditional gear arrangements might have posed limitations.

Noise Reduction:
One of the remarkable advantages that hypoid gears introduce is the reduction in operational noise. The larger contact area between the gear teeth and the spiral engagement pattern result in smoother and quieter gear meshing compared to traditional straight-cut gears. This noise reduction attribute holds immense value in industries where noise levels are a critical consideration, such as automotive applications or precision machinery. The subdued acoustic signature of hypoid gears contributes to enhanced user comfort and quieter operational environments.

Angular Flexibility:
The offset angle characteristic of hypoid gears provides a unique advantage in terms of angular flexibility. This design enables efficient power transmission between non-parallel shafts, a feature that finds applications in various industrial settings. The ability to transmit torque across non-collinear axes opens doors for innovative engineering solutions. Industries ranging from robotics to automotive engineering can leverage this feature to devise more intricate and adaptable mechanisms.

Durability and Longevity:
The reduction in friction and wear inherent to hypoid gear operation directly translates to increased gear longevity. This is particularly beneficial in heavy-duty applications where continuous and demanding use is the norm. Industries like construction, mining, and heavy manufacturing stand to gain significantly from the prolonged operational lifespan that hypoid gears offer. The diminished wear and friction ensure consistent performance over extended periods, thereby reducing maintenance requirements and associated downtime.

Applications Across Industries

The versatility and effectiveness of hypoid gears have propelled their integration into a wide array of industries, revolutionizing the way mechanical power is harnessed and transmitted:

Automotive Industry:
Hypoid gears have established a significant presence in the automotive sector, particularly within rear-wheel-drive vehicles. For automobiles, where the efficient transfer of power is paramount, hypoid gears shine.

By seamlessly channelling high torque from the engine to the wheels, these gears play a pivotal role in enhancing vehicle performance and stability.

The robust torque-handling capacity of hypoid gears contributes to improved acceleration and towing capabilities, making them an essential component in ensuring a smooth and dynamic driving experience.

Manufacturing and Robotics:
Industries that demand precision, reliability, and compactness have found a dependable ally in hypoid gears. Manufacturing processes, where intricate mechanisms require seamless motion control, benefit from the gear's exceptional torque transmission capabilities.

Additionally, robotics relies on precision and adaptability, both of which are bolstered by the angular flexibility and compact design of hypoid gears.

Their ability to operate quietly while maintaining efficiency aligns perfectly with the precision-oriented nature of these industries.

Power Generation:
The power generation sector hinges on the efficient conversion of rotational energy into electricity. Hypoid gears excel in this arena, facilitating smooth and efficient power transmission.

The durability of these gears ensures reliable operation in generators and turbines, where consistent and uninterrupted performance is critical.

Their capability to handle substantial loads while minimizing wear and friction contributes to the overall reliability and longevity of power generation systems.

Agricultural Machinery:
Agriculture reaps the benefits of hypoid gears in various machinery, such as tractors and harvesters. The gear's angular flexibility is of particular value in these applications, as it enables power transmission between non-parallel axes commonly found in agricultural machinery.

This adaptability streamlines the operation of equipment, enhancing efficiency and productivity in the field.

The durability of hypoid gears also aligns well with the demanding nature of agricultural work, where machinery is subjected to challenging environments and heavy workloads.

A Future Redefined:
As industries continue to evolve, demanding higher levels of efficiency, performance, and adaptability, hypoid gears stand as an embodiment of innovation and progress.

Their design, which combines unique attributes like powerful torque transfer, compactness, noise reduction, and angular flexibility, positions them as a technology that can reshape the future of mechanical power transmission.

The versatility of hypoid gears makes them capable contenders in addressing the diverse and evolving needs of a gear-driven world, paving the way for enhanced machinery performance and industry advancements.

Guiding Principles for Defining Gear Hobbing Processes in New Part Development

In recent times, gear hobbing machines have updated themselves with modern features like backlash free drives, high dynamic rigidity, auto tool changer, CNC controls, increased machine power, improved cutter materials and cutter coatings.

Therefore, it becomes imperative to consider all these features, so as to obtain least cost per piece.

The following guidelines attempt to systemize the modern knowledge of hobbing, and to assist gear process engineers in the selection and determination of various hobbing parameters for cutting gears efficiently.

Of course, it is not possible to consider all the variables influencing the hobbing operation.

There can be differences of opinions regarding the best methods to hob gears.

Nevertheless, these guidelines can effectively serve as a beginning for a various number of applications.

A: SELECTION OF HOB

1. Selection of Number of Starts

This depends on the module, the number of teeth in a workpiece, the stage of manufacturing program, the required gear quality, and the divisibility of the number of starts with the number of teeth on the workpiece to be cut.

Generally, productivity increases when hobs with greater number of starts are used.

The following table refers to the multi-start hobbing limitations with respect to module and number of workpieces to be cut.

MULTI-START HOBBING LIMITATIONS

Number of Hob Start	Maximum Module NDP	Minimum Number of Teeth
2	5.5	13
3	4.5	17
4	3	20
5	2.5	25

The table below also factors in additional limitations with respect to the DIN quality class desired.

DIN Quality Level	4	5	6	7	8	9	10
Maximum Number of Starts	1	1	1	2	2	3	3

2. Selection of Number of Gashes

As evident, the more the number of gashes there are, the more cutting edges are engaged in the cut which results in lower cutting loads and less wear.

The greater number of gashes increases the number of enveloping cuts which make the involute smoother. This is especially important when cutting gears with small numbers of teeth.

Number of Starts	1	2	3	4	5
Minimum Number of Gashes	9-12	12-13	13-17	17-19	17-21

3. Selection of Hob Diameter

A small hob diameter usually results in less cutting time since a higher hob RPM is obtained. Furthermore, it cuts down the total hobbing traverse by decreasing the approach and overrun distances.

However, the limiting factors for reducing the hob diameters are usually the minimum number of gashes and the hob lead angle.

The maximum lead angles for the hobs with straight gashes are usually within 6 degrees.

4. Hob Accuracy Class Selection

The hob accuracy selection is based on the required DIN gear quality, stage of manufacturing, and number of starts.

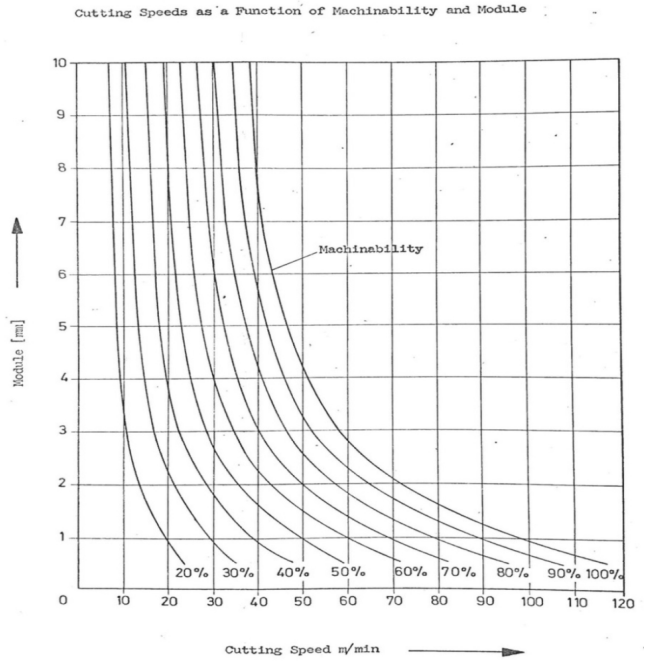
Class AA hobs are recommended for finish hobbing of parts that require DIN 7 or 6. Class A hobs can be used for parts that will subsequently go for gear grinding.

B: SELECTION OF MACHINING DATA

1. Number of Cuts

The selection of the number of cuts is influenced by pitch, number of teeth in the workpiece, stage of manufacturing, surface finish, and gear quality.

A two-cut cycle can be selected for gears with a module greater than 3. For small numbers of teeth, less than 12 pitch, and a module greater than 3 is when a two-cut cycle should be used.



ATTAINABLE CUTTING SPEEDS

Resistance of Steel	Cutting Speed in m/min		
N/ sqmm	HSS Wet Cutting	Carbide Dry Cutting	Carbide Wet Cutting
600	120	320	305
700	110	290	280
800	100	270	240
900	85	240	200
1000	70	210	180
1100	60	180	160

2. Cutting Speed

This is usually selected based on cutter material, coating as well as workpiece material, hardness and module. Similarly, hob speed is also usually selected based on cutter material, coating, workpiece material, hardness, and module. For coated hobs, the speeds can be increased to 10 ~ 15 %.

For gears above 3 mm module, the greater the module of the gear, the more the cutting speed is to be reduced. The above table reflects the guidelines and data to be used with caution.

Module Range (mm)	Roughing Before Grinding or 1st Cut (mm/wr)	Roughing Before Shaving (mm/wr)	Finishing or 2nd Cut (mm/wr)
0.5 - 1.25	-	-	0.8
1.25 - 2.5	1.5 - 2.5	1.4	1
2.5 - 4.0	1.8 - 3.0	1.6	1.2
4.0 - 6.0	2.0 - 3.0	1.8	1.4
6.0 - 10.0	2.0 - 3.0	1.8	1.6
10.0 - 12.0	2.0 - 3.0	2	1.6
12.0 - 16.0	2.0 - 3.0	2	1.8
16 - 20	2.0 - 3.0	2	1.8

3. Feed

NOTE:

- *The above hobbing feeds are the medium values for single start hob.*
- *The possibility to use higher feeds is to be found out in trials. This depends upon accuracy of gear, machinability of material and surface finish required.*
- *Gear sizes up to module 4 can be hobbed in a single cut.*
- *Higher modules will need a two-cut cycle.*
- *For two start or three start, multiply above feeds by 0.6 to 0.8 or 0.4 to 0.5 approximately.*
- *For helical gears the feed rate is applied as feed direction parallel to the workpiece axis.*
- *The actual feed rate will be above feeds divided by cosine of helix angle.*

C: SELECTION OF HOBBING CYCLE

There are numerous cycles that can be used. The selection of the hobbing cycle depends upon workpiece configuration, work holding fixture design, hob size, surface finish, and ultimately gear quality desired.

These hobbing cycles are mainly governed by the feed direction employed. They are classified as follows:

- Radial hobbing
- Axial hobbing
- Tangential hobbing
- Radial-Axial hobbing
- Axial-Tangential hobbing

D: DETERMINING THE HOBBING CYCLE TIME

The cutting time for axial hobbing is calculated, for a one-cut cycle, is as follows:

$$T = \frac{Z2 \times (A+b+O)}{n1 \times Z1 \times Sz}$$

Where:

T=Hobbing time; Z2=Number of teeth in the workpiece; Z1=Number of starts in the hob; n1=Hob rpm; Sz=Feed per work revolution; A=approach; b=face or width of stack of workpiece(s); O=Hob overrun

Hob approach travel is calculated, for spur gears, is as follows:

$$A = \sqrt{(h2 \times dk1)}$$

Where:

h2=whole depth of cut; dk1=hob diameter

For helical gears, the calculation is:

$$A=\sqrt{\{h2\ [(dk1+dk2) \times \tan^2 \eta = dk2]\}}$$

Where:

dk2=workpiece diameter; η=hob head swivel angle

Hob overrun is calculated as:

$$O = \frac{h2 \times \cos\beta \times \tan\eta}{\tan\alpha}$$

Where:

β = helix angle of the workpiece; α = normal pressure angle

Conclusion

There can be many other criteria that might arise to be considered like machine selection, sourcing of workpiece as presented to the hobbing machine, part inspection, material handling and movement. However, with the knowledge of the above guidelines, it will help the gear manufacturing engineer to plan the process very well in advance.

It will give an insight in the procurement of hob cutter, development of workholding fixture, adopting a suitable hobbing cycle and target the overall stages of gear production leading to desired quality and productivity.

This will also help estimate the hob tool cost per piece based on the procurement cost, sharpening and coating costs.

Further, based on the machine hour rate and productivity achieved, one can estimate the machining cost per piece, and in totality the overall cost per piece.

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

Advantages, Disadvantages & Strategies for Reverse Engineering in Gear Manufacturing

Innovative manufacturing relies on techniques like reverse engineering to enhance products. We explore its benefits in gear manufacturing: improved design understanding, rapid prototyping, competitor analysis, and legacy equipment maintenance.

By: Sushmita Das

In the dynamic landscape of contemporary manufacturing, achieving excellence is intricately tied to pioneering innovation and operational efficiency. Among the techniques that have emerged, reverse engineering has steadily ascended to the forefront.

This method meticulously revolves around dismantling a product to unveil the intricacies of its design and operational mechanisms

Here, we look at the numerous advantages that this approach offers, including a profound understanding of gear design, expedited prototyping capabilities, insights from competitor analysis, and the sustenance of legacy equipment. Equally, it doesn't shy away from addressing the inherent drawbacks of this method.

These encompass thorny issues like intellectual property concerns, the potential for incomplete data leading to inaccuracies, cost considerations, and the critical aspect of maintaining precision.

In addition, we look at the strategies employed that can foster the efficacious deployment of reverse engineering including delineating clear objectives, upholding ethical practices, robust data acquisition, fostering collaborative expertise, and judicious technological investment.

The article underscores the pivotal equilibrium between fostering innovation and upholding ethical considerations, a nexus crucial for steering modern gear manufacturing toward a prosperous future.

Advantages

Design Understanding and Improvement:
Reverse engineering allows manufacturers to gain comprehensive insights into the design and construction of existing gear products.

This understanding paves the way for potential improvements in terms of efficiency, performance, and durability.

By dissecting and analyzing the gear's geometry and material composition, engineers can identify areas for enhancement that may not have been apparent otherwise.

Rapid Prototyping:
It facilitates the creation of precise and functional prototypes. Engineers can replicate gears with precision by analyzing the existing components.

This is particularly valuable for manufacturers aiming to develop new products that are compatible with existing systems or for those seeking to replace outdated parts in a timely manner.

Competitor Analysis:
In a highly competitive industry, understanding the strategies and technologies employed by competitors is crucial.

Reverse engineering enables manufacturers to dissect rival gear products, decipher their strengths, and identify potential weaknesses. This knowledge can be used to develop innovative features that give a competitive edge.

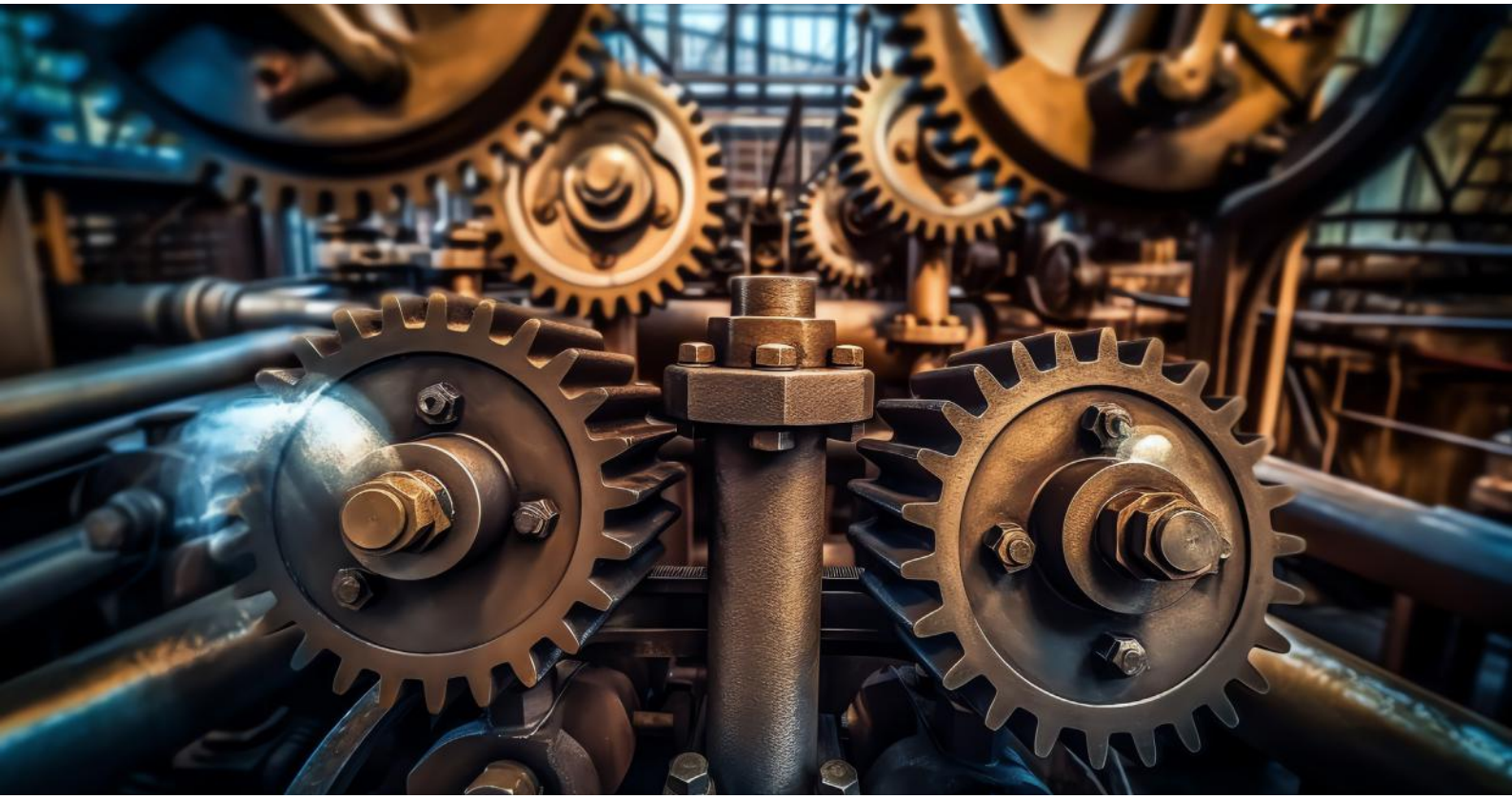
Legacy Equipment Maintenance:
Many industries rely on machinery and equipment that have been in operation for years. Reverse engineering assists in the maintenance of these legacy systems by recreating obsolete or hard-to-find components. This prolongs the life of equipment and reduces downtime.

Disadvantages

Intellectual Property Concerns:
Reverse engineering raises ethical and legal questions regarding intellectual property rights.

Manufacturers who invest substantial resources into research and development may be at risk of having their designs copied by competitors. Striking a balance between innovation and protecting intellectual property is essential.

Incomplete Data:
In some cases, the product being reverse-engineered may not be available in its entirety, leading to incomplete data.



This can result in inaccurate or insufficient conclusions about the gear's design, functionality, or material properties.

Cost and Time:
Reverse engineering can be a resource-intensive process requiring specialized equipment and skilled engineers. The time and financial investment needed to accurately reverse engineer a gear can sometimes outweigh the benefits, especially for smaller manufacturers with limited resources.

Precision Challenges:
Achieving the same level of precision as the original manufacturer can be challenging. Even minor deviations from the original design can have significant impacts on performance and compatibility of the machines.

Effective Strategies

Clear Objectives:
Manufacturers must define clear objectives for the reverse engineering process. Whether it's improving performance, ensuring compatibility, or creating a replacement part, having a well-defined goal guides the entire process.

Ethical Considerations:
Address intellectual property concerns by adhering to ethical practices. If reverse engineering is conducted on a competitor's product, ensure that its compliant with relevant laws and regulations.
Collaboration or licensing agreements could also be explored to avoid legal conflicts.

Accurate Data Collection:
Collect as much accurate data as possible. This might involve using advanced scanning techniques like 3D laser scanning or CT scanning to capture precise geometries and dimensions.

Collaboration:
Reverse engineering often requires multidisciplinary expertise. Collaborate with engineers, designers, material scientists, and legal experts to ensure a comprehensive and successful outcome.

Invest in Technology:
Investing in cutting-edge technology and software for reverse engineering can streamline the process and improve accuracy. Computer-aided design (CAD) software, simulation tools, and additive manufacturing techniques can be valuable assets.

Conclusion

Reverse engineering has emerged as a double-edged sword in the domain of gear manufacturing. While it offers unparalleled insights, rapid prototyping capabilities, and competitive advantages, manufacturers must also grapple with potential ethical dilemmas, precision challenges, and resource implications.

As technology continues to evolve, figuring out the right balance between innovation and responsibility will remain a critical aspect of modern gear manufacturing.

Critical Heat Treatment Factors for Gear Longevity

By: C.Selvaraj

Heat treatment is one of the critical process in gear manufacturing. In this article, we address the crucial factors that need to be addressed. These are as follows:

- Raw material selection
- Segregation of different materials and gears based on case depth
- Fixturing of components
- Calibration of furnaces
- Laboratory facility
- Testing and traceability of components

Raw Material Selection

During the design stage based on the application and gearbox rating, design engineers decide the raw material grade that is to be used for the gears. To achieve the correcting rating and get the required service factors, they design the gear tooth parameters like module, helix angle, gear face width, and so on. According to the gear modules, they calculate the desired case depth. Additionaly, based on the raw material selection, the design engineer takes into account the type of heat treatment process, a gear will undergo such as hardening, case hardening, induction hardening, or gas nitriding to name a few.

Segregation of Different Materials

At any heat treatment facilty, different types of gears arrive for the heat treatment process. Various types of components together may be available during this stage. The concerened heat treatment personnel first seggregate the components based on the type of heat treatment to be carried out on the components like case hardening or nitriding or through hardening components.

In case of case-hardened components, further segregation is required based on the case depths wherein the carbon inducing process time will vary. Thus, the need for segregation. For instance, we can't load a 1mm case depth component and 2mm case depth component together in one batch.

Fixturing of Components

Fixturing of components play a crucial role in the heat treatment process; this depends on the furnace capacity fixture to be designed. To avoid distortion,

proper bushes are prepared for bore type components, so the components do not hit each other. The fixture is prepared accordingly to ensure a gap between the components remain. Similarly, based on the weight of the components and fixture, lifting bolts are fixed. Additionally, necessary test pieces are prepared and fixed along with the components. It is important that the test piece materials should be of same specification as the components. This is done for inspection purposes where post the carburising process, test pieces have the correct case depth.

Calibration of Furnace

The calibration of furnaces help maintain uniform heating, and leads to energy-saving measures. Similarly, rectifying a furnace also helps avoid energy losses. Using flow meter calibration, gas wastage can be minimized, too. The calibration of hardness testers, and microscope offer error-free readings for case depth and hardness values.

Laboratory Facility

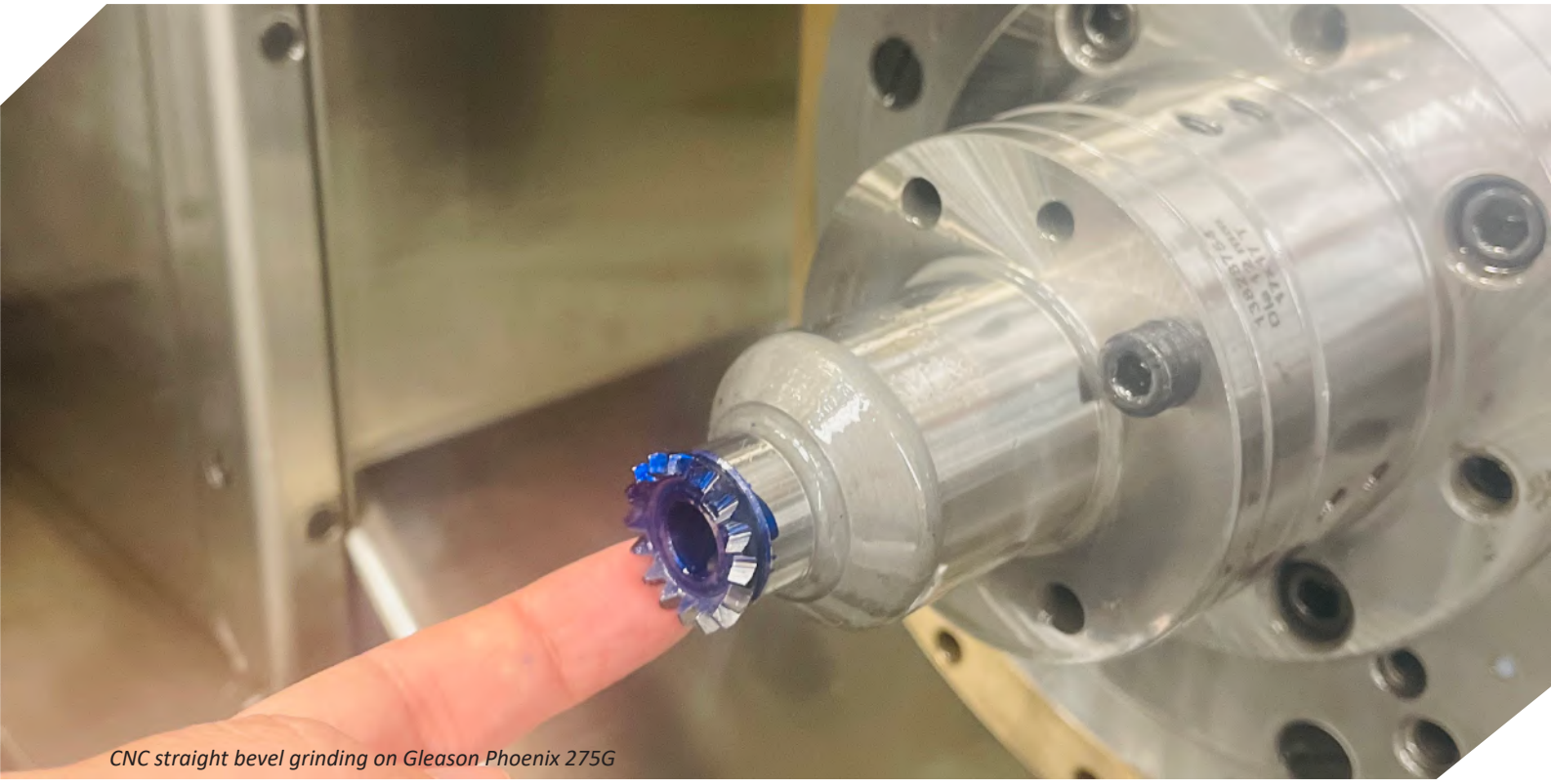
Any good heat treatment shop is well-equipped with a laboratory facility, and has the necessary instruments. To ensure carbon potential, a laboratory should have a carbon analysis facility.

Other laboratorial equipment includes a hardness and microstructure analyser instrument, a SKADA control with software to control aecton and methanol flow rates. A hydraulic press is required for pinion shaft bend removal. Every component history need to be maintained as traceability is a critical area in heat treatment.

Conclusion

For better results, the above-mentioned factors are to be meticulously followed. Additionally, attention must be paid towards quenching oil quality and cleanliness. By doing so, good components post heat treatment can be achieved.

Bevel Gears India's Role in Chandrayaan's Success



CNC straight bevel grinding on Gleason Phoenix 275G

India recently made waves when Chandrayaan-3 successfully landed on the south pole of the Moon. Behind this tremendous feat, is a gear manufacturing company who played a part in this historic lunar mission.

Gear Technology India had an email interview with Mushtaq Jamal, Director, Engineering & Business Development, Bevel Gears India and Sulaiman Jamal, Managing Director, about the experience, technical challenges, and more.

How did Bevel Gears India come to be involved in the project, and how long a process has this been?

Bevel Gears India has been honing its capabilities and investing in new bevel technology for several years.

Presently, these technological upgrades include cutting edge Gleason and Klingelnberg CNC spiral bevel grinding machines, CNC bevel gear cutting and CNC inspection.

These technological advancements are continually conveyed to both new and potential customers, and this was shared at various vendor meets with the government organizations.

Once the Indian Space Research Organization (ISRO) was made aware of our capabilities, they contacted us. It took 12 months for our company to be approved, and thereafter over two years to supply prototypes and the final products.

Can you share aspects of the technical specifications of the gears (i.e., material, design standards, production methods)?

As with most programs of this nature, details are shared selectively. As you would imagine with anything space related, the requirement was the parts had to be low in weight with a specific emphasis on precision and accuracy.

Thus, in the manufacturing process, we were chasing microns (one micron is a thousandth of a millimeter) and not production cycle time as you would in high volume manufacturing. These particular bevel gears played a critical role in the Pragyan rover's drivetrain and had to be fail-safe.

Special steel grades were used and the bevel gears had many critical processes along every step of the way. Demanding topography requirements had to be maintained, too.

A big part of the reason for our selection in this project was our ability to not only manufacture but to make machine setting summaries in house and measure very small bevel gears.

We had installed a brand-new state-of-the-art CNC Gleason 475 GMS measuring center, and this piece of equipment certainly gave the customer peace of mind. Today, we make and measure some of the smaller bevel gears in the country going down to 0.4 module.

Were you asked to both help with the design and production?

Our role was primarily to execute to a specified design. However, any suggestions on improvements were well received. That is also testament to ISRO's team because they were very receptive to areas of improvement.

What were some of the biggest technical challenges you and your team faced? What were some of the central constraints to which you had to find solutions?

One of the challenges was the material we needed to work with. The material was difficult to machine and wore out the tools rapidly.

This, in turn, affected the ability to maintain the close tolerances the parts required, so we had to modify our machining strategy. It is fair to say it took far longer than anticipated to machine the prototypes.

0.5 module gear measurement on Gleason 475 GMS

Oerlikon G27 CNC bevel grinder

However, this modified strategy helped immensely in the final part production.

Given that the lunar landscape has its own set of challenges, how have your gears performed under those circumstances?

The lunar landscape imposes constraints that render some of our basic everyday assumptions invalid. The south pole of the moon experience immense temperature variations, and the parts and sub-assemblies all had to weather these extremes for as long as possible.

From all accounts, the program has been a great success and all the tasks assigned to the rover were completed successfully. Now, we have to wait and see if the rover can "wake up" and be mobilized once the south pole of the moon sees the sun again.

Can you tell us what it's like being involved in such a momentous project for your company and your country, but also for the benefit of the world at large?

Like any other project, it is always team work; not only within our company, but also with the customer. First, we have to understand that this is unchartered territory, and yet the product must be absolutely "fail safe."

It's only the success that is known, but a number of times one has to fail to understand the concept of success in these cases. Finally, it is like doing a trapeze act without a net.

The audience being not only India but the world at large. Therefore, the serious commitment to ensure that there is no chance of failure was prime.
In this case, it was a combination of our talent,

and the right kind of high-end machines that ensured the result.

In many such cases, we do our best to ensure that India has the talent to do such jobs. An important point to note is that just as the saying goes: "talent is nothing without opportunity", we are grateful to ISRO for giving us this opportunity to prove our and the country's capabilities.

On a global level, this makes a huge statement for us and our country. A recognition for us being a manufacturer who has the capability to take on "fail safe" products, and the world to know that India is second to none.

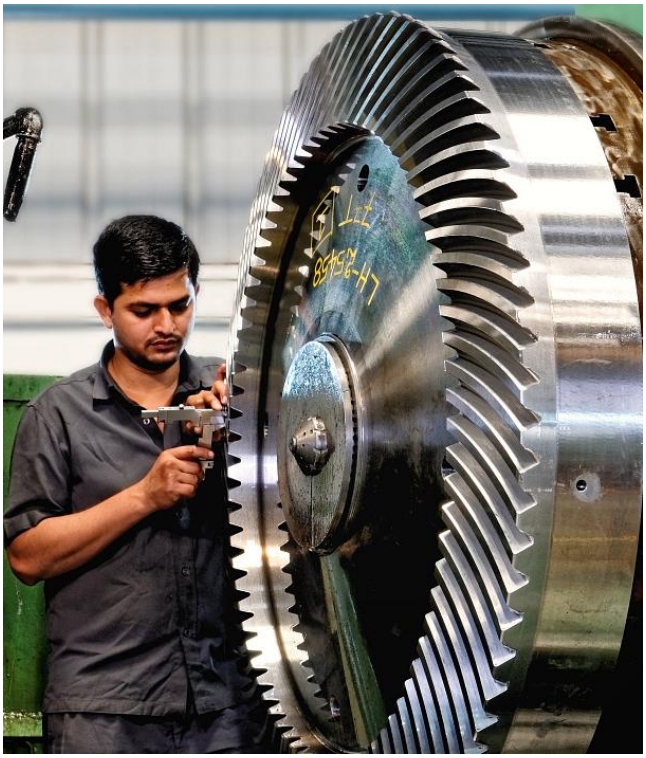
The import of such parts will no longer be required and, on the contrary, we can look forward to exporting such critical parts. Our ship has arrived in the true spirit of *AatmaNirbhar Bharat*.

What are your thoughts about the prospect of gear technology and space explorations for the future?

Emerging technologies such as 3D metal printing will play increasingly significant roles.

The ability to print the parts you need onsite without holding any inventory is immensely appealing and practical. Nanotechnology is an extremely exciting space to watch as well.

We have seen how the transition to EVs accelerated the adoption of higher specification gears, albeit, fewer per assembly. Similarly, in other aspects of space and airborne vehicles, gears will certainly play a relative role though probably not as much as it has in the past.



Large Spiral Bevel

About Bevel Gears India

Bevel Gears India Team : (L) Mushtaq Jamal, (C) Sulaiman Jamal, and (R) Abdulla Jamal

Founded by Sulaiman Jamal in 1976, Bevel Gears India Pvt Ltd (BGI), specializes in the manufacturing of high precision bevel gears across an internationally broad spectrum from 5mm to 1,800mm.

It covers a number of applications under one roof like robotics, automation, aerospace, high speed machine tools, performance motorsport, aggregate, steel, mining, and space programs.

Their USP is high mix-low volume that allows them to address their customers' requirements across international markets.

They also have the unique ability to manufacture both Gleason and Klingenberg bevel tooth forms and cover all manner of bevel gears – straight, ground spiral, angular bevels and high ratio hypoids (HRH) as well as selective bevel gearbox projects.

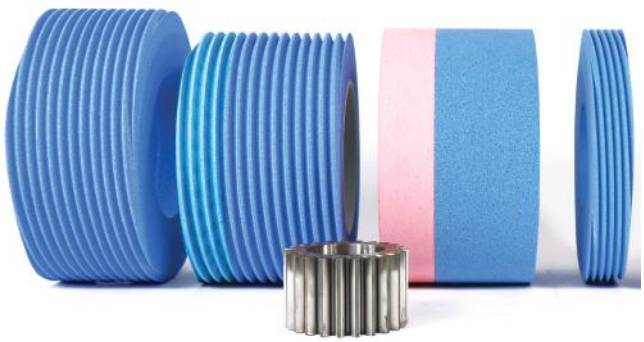
BGI is the first private company in India to install multiple CNC bevel grinding machines. These include both Klingenberg and Gleason bevel grinders.

Additionally, they are the only company to have CNC straight bevel grinding in the country. Another niche of theirs is curvic coupling grinding.

This is a result of the leadership team focusing on investing in bevel gear technology to stay relevant on a global scale.

KREBS

KREBS & RIEDEL



INNOVATIVE GRINDING TECHNOLOGY SINCE 1895

Krebs & Riedel Abrasives India Pvt. Ltd.

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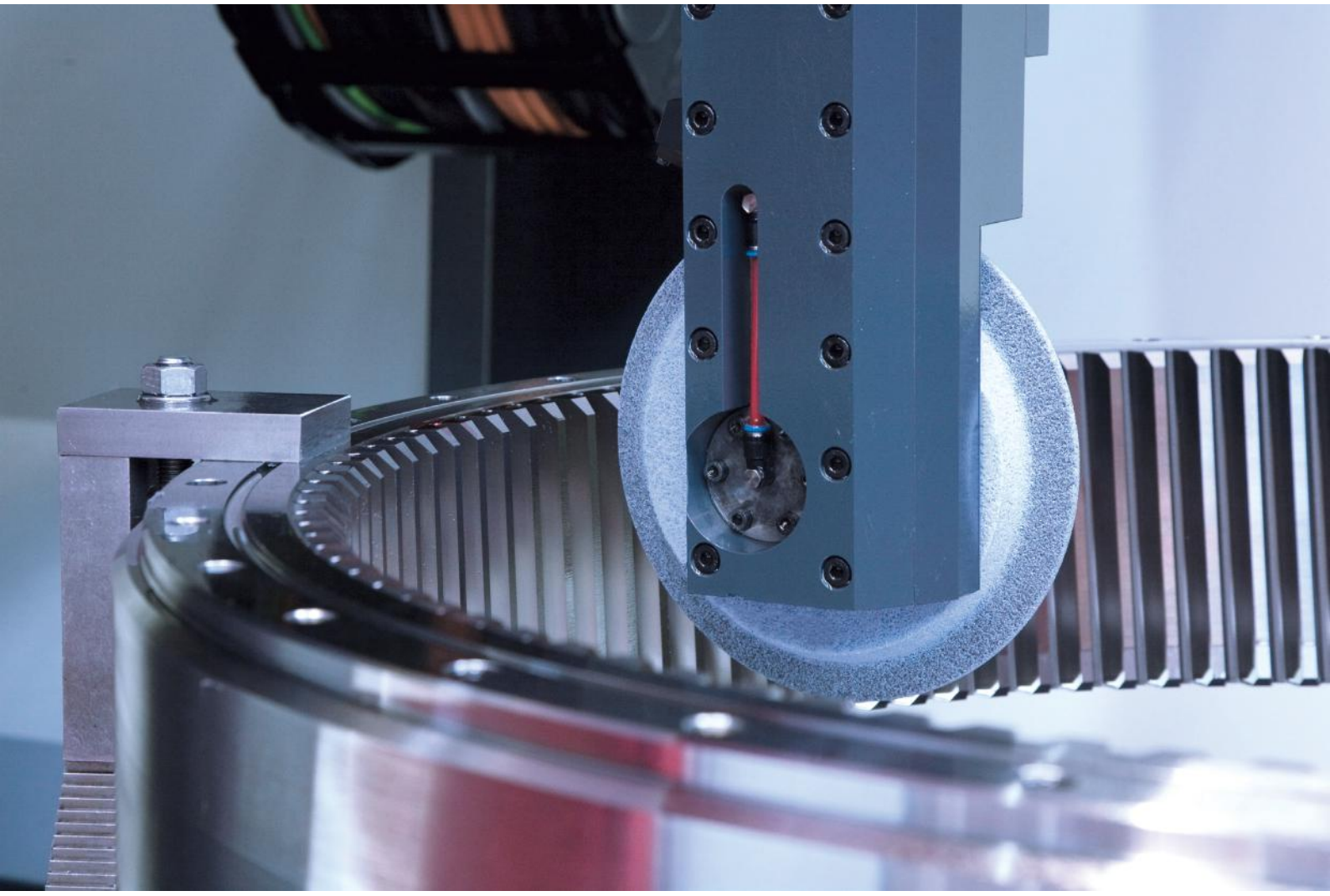


Grind ‘em Cool: Premium Solution for Grinding Large Gears

Blue Moon™ TZ is the new premium grinding wheel from Krebs & Riedel. It is a precision-shaped abrasive grain with a high process reliability which is very useful for the serial production of large gears that require a high level of quality, excellence and continuity in production

In recent years, wind power has been an important factor in reducing CO2 emissions. Wind turbines are getting bigger and more powerful, while production costs have to be reduced. This requires production methods that can produce the gears cost-effectively and in high quality, even with complex flank modifications.

Gear sizes in wind power typically range from 800 to 4,000 mm. Some gears can even reach a diameter of 8,000 mm and weigh up to 100 tonnes. The most common size in the field of external gears is 1,200 mm in diameter and ranges from module 12 to module 52. The profile grinding wheels typically have a diameter of 100-450 mm.

Synergy Between the Grinding Machine, the Grinding Process and a Premium Grinding Wheel is Very Important

Only a perfectly ground gear geometry ensures optimum power transmission for high wind turbine efficiency and smooth running. Grinding burn must be avoided under any circumstances because the forces in the gearbox are very high and tooth breakage is very expansive.

High-precision gear quality is a matter of course at Klingelnberg and Krebs & Riedel. It increases the service life of the individual gear components and makes a significant contribution in reducing maintenance and production costs.

To achieve maximum synergy between the grinding machine and the grinding wheel, Krebs & Riedel optimizes the process with application support at customers sites around the world, and offers the Blue Moon™ TZ, a new premium grinding wheel with a precision-shaped abrasive grain.

Grind 'em Cool: Precision-shaped Abrasive Grain Ensures a Very Cool Grind

Blue Moon™ TZ is characterized by a very high cutting performance and a very high material removal rate.

"In some trials, the material removal rate (Q'w) was more than 30 mm³/mms," says Sigurd De Ridder, Senior Application Engineer at Krebs & Riedel, who conducts trials and process optimization for customers worldwide.

He says: "Precision-shaped abrasive grains are state of the art today. Blue Moon™ TZ is comparable in performance to other precision-shaped abrasive grains in the market. It is self-sharpening, very sharp-edged, microcrystalline, and has an elongated trapezoidal shape."

The homogeneous pore structure of Blue Moon™ TZ contributes to an extreme improvement of the entire cooling system during the grinding process. Due to the open structure, the entire grinding wheel is immediately flooded by the cooling liquid. Even with extreme material removal rate, the chip is transported away from the contact surface. This avoids heat input that could lead to thermal damage to the gear.

Grinding Large Gears in Serial Production with the Highest Quality while Reducing Production Time

On average of all tests on the Klingelnberg Höfler Rapid 2500 machines, Sigurd De Ridder had the following grinding results: A cooler grind and a longer tool life combined with up to 20% faster grinding time compared to standard grinding wheels.

The longer tool life and higher grinding performance helps reduce costs while achieving the same, or even better quality of the gear.

With respect to dressing tests, on average, Sigurd De Ridder achieved the following results: 20% longer dressing intervals, 30% less infeed, which also leads to a longer tool life of the dressing wheel. Another advantage is that the machines have a lower power consumption after optimization.

Huge Profile Grinding Machines with Absolute Precision, Speed, and Flexibility

The profile grinding machines of the RAPID series for large workpiece sizes are designed for component diameters up to 8,000 mm. Depending on the individual requirements, they are equipped with an extended stroke range (L variant) and are also available in two variants.

In addition to the standard configuration, the machine is also available with a small grinding head to accommodate very small grinding wheel diameters of 300-20 mm (K variant).

In all configurations, machines of the RAPID series can be converted from external to internal gears in a very short time by means of optional internal gear grinding arms.

In addition, the special arrangement of the machine axes, a thermally stable and almost vibration-free machine bed made of mineral casting, as well as wear-free torque drives in the machine table and the grinding head for 5-axis grinding contribute to the proven precision, consistent quality and enormous flexibility.

Thanks to the highly flexible grinding head with an integrated 3D probe and adjustment of the helix angle during the grinding process, gears can be topologically modified in 1-flank grinding or 2-flank grinding depending on the permissible deviations.

The measurements with the optionally available testing devices ensure a controlled grinding result already during the grinding process.

Choose a Premium Grinding Wheel for Large Gears

Serial production of large gears requires many hours of workpiece set-up, programming, grinding, dressing and quality control. It is important to use a premium grinding wheel with precision-shaped abrasive grain.

The dressing and grinding processes should be perfectly set up on the grinding machine and optimized by application support.

The Blue Moon™ TZ premium grinding wheels have not only proven themselves in the grinding of planetary gears, spur gears and IR outer and inner rings.

They have also led to a reduction in production costs when grinding drive shafts, automotive gears and conveyor screws.

After several successful trials on various Klingelnberg Höfler Rapid grinding machines carried out by Krebs & Riedel with customers in their production facilities, Krebs & Riedel has received several large orders for grinding large gears from abroad and has introduced the new premium grinding wheels with high process reliability. Krebs & Riedel is one of the world's leading manufacturers of grinding wheels for gear grinding in the automotive and EV sector. The family-owned company is also expanding into other sectors where large gears are manufactured with the new Blue Moon™ TZ premium product range.

Philipp Bötte, Marketing & Communications, Krebs & Riedel

Closer Look at Case Hardening in the Heat Treatment Process

Case hardening is an important heat treatment process that provides steel gears and other transmission components with a hard surface and a comparably soft core.

This enables them to resist high surface pressures while ensuring a long fatigue life. Yogesh Patil, General Manager of the Ovako Group, India, explains how it works.

Case hardening is used to produce a hard, highly resistant surface layer and a tough core.

After case hardening, the surface layer contains substantial compressive stresses.

The process is often used for applications like gears where the loading produces high surface pressure in combination with fatigue stresses.

Case hardening consists of two separate treatment stages. Sometimes, they are performed in direct succession. In the first stage, some form of carbon is added to the surface layer of the material. In the second stage, hardening is performed.

The article covers different stages of cases hardening through various techniques.

Carburizing Techniques for Surface Carbon Addition in Steel Alloys

Low-alloyed steel is often used in case hardening, typically featuring a carbon content ranging from 0.15 to 0.25%. In principle, any steel with less than approximately 0.8% carbon content can undergo case hardening.

However, it's essential to note that beyond this threshold, many of the benefits associated with case hardening start to disappear. Carburizing involves the addition of carbon to the surface layer of the material.

The thickness of the carburized surface layer is controlled by the diffusion of the carbon in the austenite, which is the face-centred cubic (FCC) crystalline structure of the material at the carburizing temperature (850 to 950°C). The diffusion speed is roughly dependent on temperature and time.

The carburizing depth attained can be calculated approximately as:
$X = k.\sqrt{t}$

Where:
X = case-hardening depth (mm); t = time in hours;
k = is determined by the temperature.

As an example:

Temp. ºC	k
875	0.34
900	0.41
925	0.52

After carburizing, the carbon content varies as seen in Figure 1, and after hardening, the hardness achieved is therefore a function of the distance from the surface.

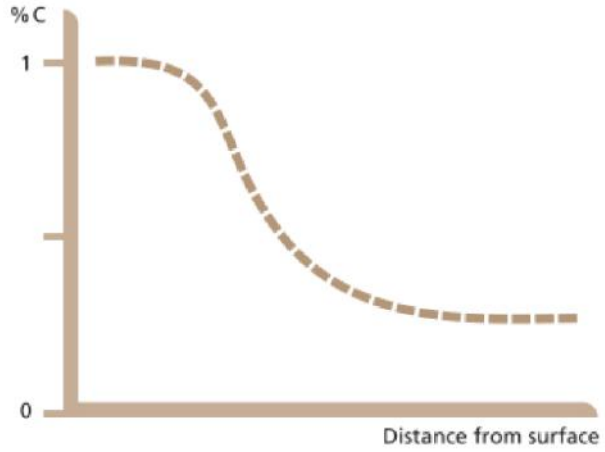


Figure 1: Relationship between carbon content and distance from the surface

The load the component will be subjected to determines how deep the in-carbonization depth (depth of hardness after hardening) needs to be.

The tooth face of a cog, for example, transfers a certain load undergoes a strain that varies with the depth under the surface as shown in Figure 2.

The case-hardened layer must then be provided with a strength profile which at every point from the surface to the core corresponds to the load applied.

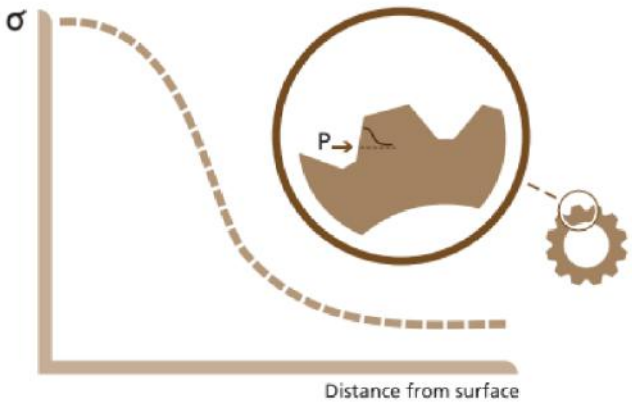


Figure 2: Shows how the stress varies according to distance from the component's surface distance.

Carburizing

The processing stage in which carbon is added to the surface of the material is called carburizing or in-carbonization.

In-carbonization occurs at high temperatures which can result in substantial grain growth. This grain growth can be effectively counteracted by using fine-grain treated material.

Occasionally, the material is normalized after carburizing. At present, three different methods are used to add carbon. Common to all of them is that the material used to envelope the material has a relatively high carbon content of about 1%.

Methods of Carburizing

Gas carburizing: It is the most common method used on an industrial scale and it offers major advantages from the standpoint of productivity and control.

Salt bath carburizing: It is performed in a cyanide salt environment and is primarily utilized when there is a need for a relatively small in-carbonization depth.

Powder carburizing: It is done by placing the component in a container packed with powder which is made up of a combination of wood carbon and barium carbonate. The process requires extensive manual handling.

The carbon in the surrounding atmosphere is absorbed relatively fast by the surface at the carburizing temperature, and the carbon then diffuses from the surface towards the core.

The term "gas carburizing" can be misleading since carburizing inherently involves a gas phase. Instead, "gas carburizing" refers to the method where the carbon-releasing agent is introduced into the furnace in gaseous form.

Various approaches can be employed for this purpose. One method involves producing a gas rich in carbon monoxide (CO) through the complete combustion of certain hydrocarbon materials.

Alternatively, some hydrocarbon that evaporates can be introduced into the furnace to achieve the desired effect.

Hardening

There are three different ways of hardening carburized material, and there are also variations in these methods.

Direct hardening: This involves hardening the material directly from the carburizing temperature.

Consequently, the austenitizing temperature is high, resulting in a coarse structure, especially in the high-carbon-content surface. It's important to note that this method is rarely employed.

Direct hardening can also entail the rapid cooling of the material to suitable austenitizing temperatures for the high carbon content surface zone (620 to 850°C) after carburizing.

The temperature is allowed to become uniform throughout the component, and it is subsequently hardened to martensite.

This means that the core material does not receive the correct austenitizing process.

Direct hardening is very common among component manufacturers such as in the automotive industry.

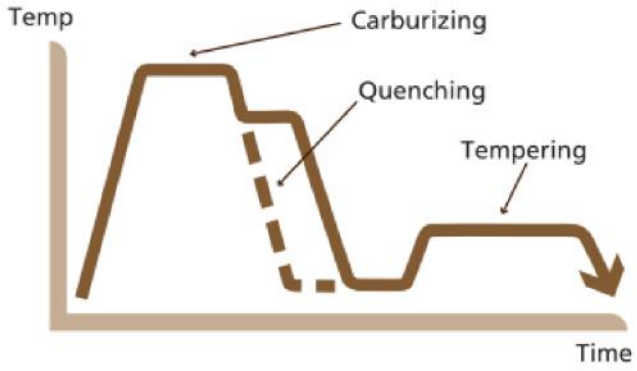


Figure 3: Direct hardening

Single hardening: It implies that the material is cooled to room temperature without permitting martensite to form.

Afterwards, conventional austenitizing and martensite hardening are performed. Austenitizing is undertaken to attain optimum results in the surface zone.

Double hardening: This signifies that the material undergoes direct hardening immediately after carburization, followed by conventional martensite hardening.

In general, case hardening results in higher degrees of residual martensite than through hardening.

Direct hardening, following the adaptation of the hardening temperature, has become increasingly common and imposes considerable demands on the grain growth of the material.

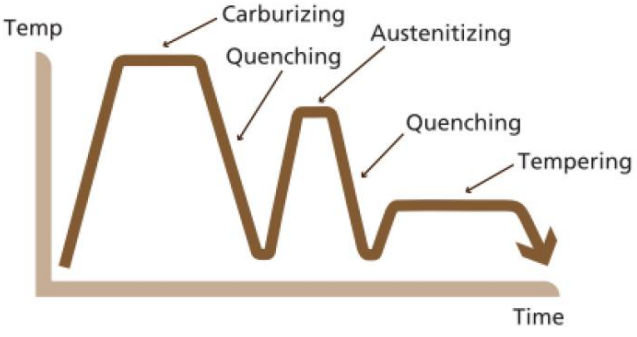


Figure 4: Single hardening

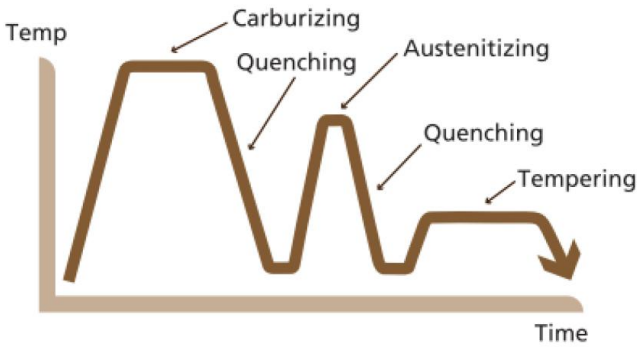


Figure 5: Double hardening

Steel Grade and Heat Treatment Relationship

While there is a strong relationship between a steel grade and how it can be heat treated, often the same type of heat treatment can be used on many different steel grades.

It is not possible to case-harden ball-bearing steel but both ball-bearing steel and hardened and tempered steel can be tough hardened.

However, it is easy to case-harden structural steel and hardened and tempered steel as well as carburizing-steel.

Therefore, the choice of steel grade combined with heat treatment provides some degree of freedom while designing the transmission components.

There is a singular crucial factor to consider: achieving the lowest cost for both the material and its heat treatment, all while ensuring that the final product meets all its specifications.

Ovako's Innovative Heat Treatment Guide

Ovako has created an online heat treatment guide to help design engineers evaluate the mechanical properties after quenching and tempering of any grade of steel that contains the 13 most common alloying elements.

This tool makes it possible to compare the heat treatment and tempering performance of thousands of steel alloys without the need for extensive desk research, calculations or testing.

While Ovako produces around 500–600 grades available as standard, there are many more specialist steel grades on the market. In theory, the number of grades is almost endless as steel properties vary depending on the alloying elements and their quantities.

Leveraging a neural network to simulate the performance of specific steel grades, comprehensive documentation exists regarding their hardenability throughout heat treatment and tempering.
This valuable insight has been made possible through extensive laboratory testing, resulting in a repository of properties for widely recognized grades.

You can access Ovako's heat treatment guide through its online platform, Steel Navigator here:

https://www.ovako.com/en/services/digital-tools/steel-navigator/

Yogesh Patil,
General Manager, Ovako Group. He is a metallurgist with an expertise in alloy steel, and is a reliable guide for the selection & application of steel.

HIGHLIGHT

Case hardening is used to produce a hard, highly resistant surface layer and a tough core. After case hardening, the surface layer contains substantial compressive stresses.

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

By: Ravi Naik

A fundamental process for gear manufacturing, gear hobbing is a precise and accurate way to generate a gear tooth profile through a machine. Therefore, to achieve good quality in gear hobbing, these are the basic parameters that must be taken into consideration.

Material - Input Condition of CNC Blank

1.Blank face runout with respect to bore should be less than 25um. Direct relation of blank face runout for controlling

a.Lead angular error b. PCD run out.

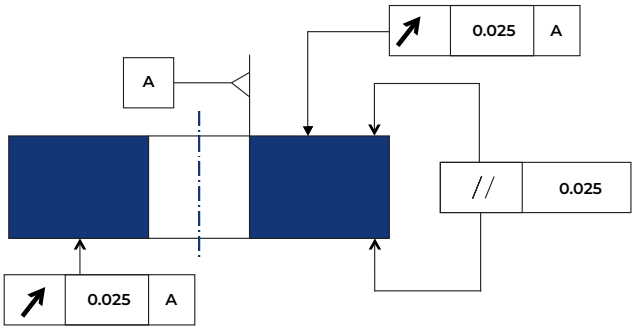
2.Face parallelism should be less than 25um.

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

4.CNC Blank Hardness must be 150-180BHN for better hobbing quality and better hob life. If hardness is less, then hob glazing and excess bluntage takes place.

5.Both sides of the CNC blank bore should be free from dents and damages.

6.CNC blanks should have well separated pearlite and ferrite microstructure, and free from bainite structure for better tool life and distortion control.



Hobbing Fixture

1.Clamping with collet clamping or hydraulic expansion fixtures for zero clearance between part bore and clamping fixture. This takes care of controlling PCD runout and span size variation.

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

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

4.Tail stock clamping force needs to be fixed as per part configuration.

5. Collet life to be monitored and replaced as per decided frequency.

6. Fixture resting plate and clamping cap runout needs to be checked every day and maintained. Doing so, will take care of the lead errors.

7. Runout master component must be checked during set up and at set frequency.

8. Fixture resting face, tail stock clamping cap, and collet must be cleaned after every shift.

Tool-Hob

1.Hob collar runout both side - Mounting side and clamping side should be less than <8um. This will the control Fh-alpa variation.

2.With respect to bad sector teeth, those should be correctly marked and included in the program to avoid bad sector runs during cycle.

3.Hob should thoroughly clean and demagnetized every time after removing from the machine.

4.Hob should be handled carefully and kept in the box provided by tool supplier after every use.

5.The hob rake angle should be checked after every resharpening to ensure that the original rake angle is maintained. This is done before putting it on to the machine, so that the required profile angular error on part (Fh-alpa) is maintained.

6.The hob should have the required protuberance amount as per shaving operation stock or gear grinding operation stock per flank, otherwise it leads to step at SAP.

7.The hob should be with AA/AAA class of accuracies for shaving finish or hobbing finish gears.

8.In hob resharpening, bluntage amount should be checked correctly and resharpened the same amount.

9.Follow the right hob coatings be it alcronpro or altensa.

10.Profile form error controls with hob quality

D-Machine

1.Machine conditions like the spindle runouts and alignments must be in accordance per the machine geometrical accuracy charts.

2.Machine levelling should be ensured. If this doesn't happen, this leads to profile form error.

3.X axis repeatability must be checked. This leads to span size.

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

5.Dry hobbing chip suction hood should be mounted behind the hob and air blow pipes need to mounted at the right location and in the right direction for chip cleaning.

6.Dry hobbing machines must be thoroughly cleaned. To prevent rust formation on machine slides, spindle bore and hob collet, oil must be applied.

7.Machine JH condition monitoring and actions need to be followed for the machine's basic health condition.

8.Preventive maintenance schedule and critical spare parts planning must be followed.

Conclusion

Part hobbing quality affects teeth finishing, gear quality shaving process, teeth honing process, and to some extent, the teeth gear processed part quality. Therefore, if we take care of the above-mentioned parameters, the component quality during gear hobbing will help achieve the required finish gear quality. Additionally, this will help get the desired gear profile accuracy in the gear profile grinding operation.

HIGHLIGHT

By carefully monitoring these key basic conditions, gear manufacturers can achieve the desired high-quality finish gear component with precise tooth profiles, excellent surface finish, and minimal deviations.

Lowering the Temperature of Gear Oils with Performance Polymer Technology

By: Shubhamita Basu

Companies that depend on industrial enclosed gears and open-gear systems are always searching for the best way to keep those systems lubricated while keeping the oil cooler.

Higher operating temperatures can be detrimental for the quality of oil which can, in turn, cause gearbox durability issues.

Reducing temperatures while maintaining adequate protection is paramount, as these gears are part of intricate operations that can cost significant time and money should they wear down or break.

While mineral oil based fluids used to be the standard, operators are increasingly looking for the better protection offered by synthetic oils using Polyalphaolefin (PAO)-based formulations.

PAO-based oils do perform well in these heavy-duty applications, but they can be significantly more expensive than their mineral oil counterparts.

For lubricant manufacturers, the challenge is to create synthetic industrial gear oils (IGOs) and open gear lubricants (OGLs) that can offer the appropriate protection while keeping costs reasonable.

Tests performed on lubricants with performance polymers (PPs) have shown their ability to achieve both of those goals.

In this article, we will examine the history of IGOs and OGLs, what a PP is, how lubricants with PPs perform under real-world conditions and what advantages they provide for IGO and OGL end users.

The History of Industrial Gear Oils and Open Gear Lubricants

Both IGOs and OGLs have undergone significant changes over the past 50 years. Engineering advancement has led to the development of much smaller enclosed gearboxes that are capable of producing higher power throughput compared to their mammoth forebears.

These compact and more powerful gearboxes need a much smaller volume of IGOs leading to incomparable stress on the oil. OGLs have also evolved significantly. Historically, OGLs were made of asphaltic bases without significant additive treatments, and there was no differentiation for OGLs based on end usage.

Over time, OGLs have become more complex as scientists began to recognize that different open gear applications required different types of lubricants.

To address the shortcomings of conventional IGOs and OGLs in mineral oils, synthetic formulations are typically used.

Using PPs can lead to the development of a new way to formulate synthetic IGOs and OGLs. In both cases, new and improved PPs offer specific advantages over traditional formulations.

What is a Performance Polymer?

PPs are a versatile class of polymers with unique architecture that offer superior thickening efficiencies, low traction coefficients and high shear stability.

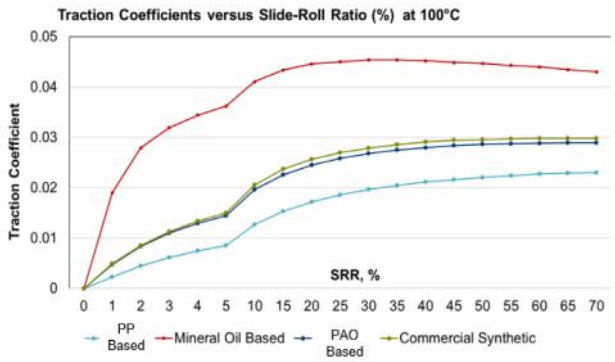


Fig 1: Traction Coefficient

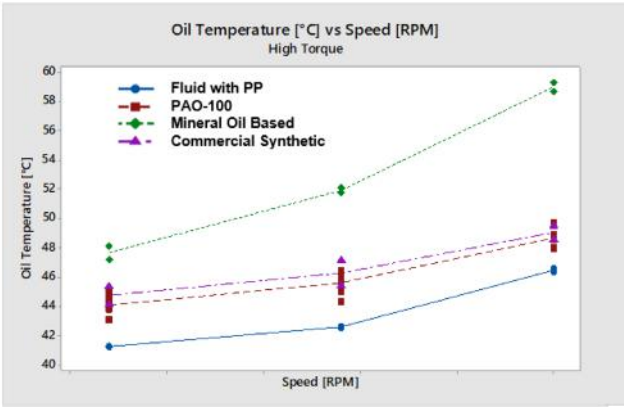


Fig 2: Temperature reduction by worm gear

Depending on the end use applications, PPs can be used both as viscosity modifiers as well as base oils. They also exhibit excellent thermal and oxidative stability and can be used in incidental food contact applications and are NSF HX-1 certified.

The versatile nature of PPs allows them to be used with PAO base oils as well as with mineral oils.

When added to more conventional base oils, PPs can elevate the performance of the resulting fluids by lowering the traction coefficients and operating temperatures while increasing overall energy efficiency—and these advantages are demonstrated in extensive statistically validated laboratory testing.

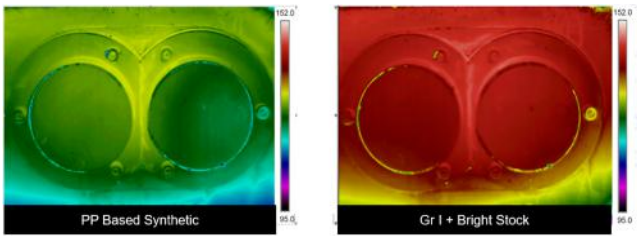


Fig 3: Temperature reduction by FZG rig shows that IGO formulated with PP runs 17 °C cooler compared to conventional mineral oil based formula

Experimental Design to Test PP in IGO Formulations

One of the greatest threats to industrial gear systems is the high temperatures under which they operate. After all, higher operating temperatures can cause durability issues and lead to poor film thickness in many applications.

The goal of the laboratory test was to determine whether PPs could reduce temperatures enough to protect bearings while preventing micropitting and white etching cracks.

In the laboratory, four different fluids were tested:

1. Mineral oil based IGO.
2. Commercial synthetic oil.
3. Synthetic IGO with heavier PAO in PAO base oil.
4. Synthetic IGO with a PP in PAO base oil.

Mineral oil based IGO and the commercial IGO were the poor and good reference oils used in the study.

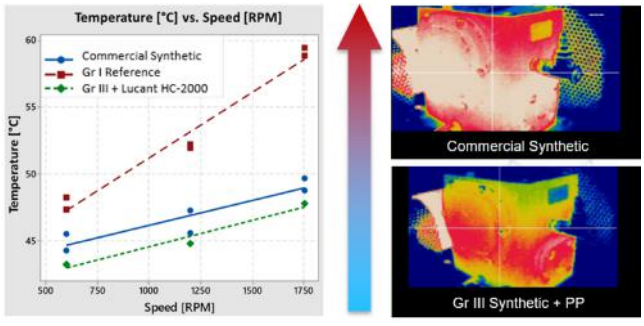


Fig 4: Gr III Synthetic with PP vs. PAO Synthetic

Both of the test fluids—PP-based and conventional synthetic with heavier PAO—used the same performance IGO additive at 1.8% weight.

The four fluids were tested to measure their traction coefficients, temperature reduction and energy efficiency. Temperature reduction was measured using an in-house worm gear efficiency rig as well as an FZG rig.

What Do These Tests Reveal?

The charts above showcase that IGOs formulated with PPs can demonstrate lower traction coefficient compared to even standard PAO-based synthetic IGO, which can reduce the gearbox operating temperature significantly. Temperature reduction by the FZG rig shows that IGO formulated with PP runs 17 C cooler compared to conventional mineral oil based formula.

PPs can be used with Group III base oil to generate performance similar to or slightly better than conventional PAO-based synthetic IGO, and this offers a more cost-effective way of formulating synthetic IGOs.

The results of those tests reveal that PPs perform equally well in the less expensive oil as a base. This means that IGOs with PPs can offer the same protection as the more expensive PAO-based synthetics and can provide a cost-effective alternative.

Experimental Design to Test PP in OGL Formulations

Open gears can range in size and be up to 90 feet in diameter. They take 12 months to manufacture and cost nearly $1 million, so keeping them in appropriate working order is paramount. OGLs must be designed for boundary and mixed lubrication as well as high viscosity for full-film lubrication.

To see how PPs perform in OGLs in the real world, three different fluids were tested:

- Grease-type OGLs.
- HV PIB-mineral type OGL.
- Fluids formulated with PPs.

A basic performance test was performed on the fluids to determine the kinematic viscosity at different temperatures, low temperature fluidity or pumpability, theorical film thickness in typical gear sets at operational temperatures, temperature reduction and energy efficiency.

The results reveal that OGLs with PPs provide superior lubricant film thickness at initial and operational temperatures that are lower than their more traditional counterparts.

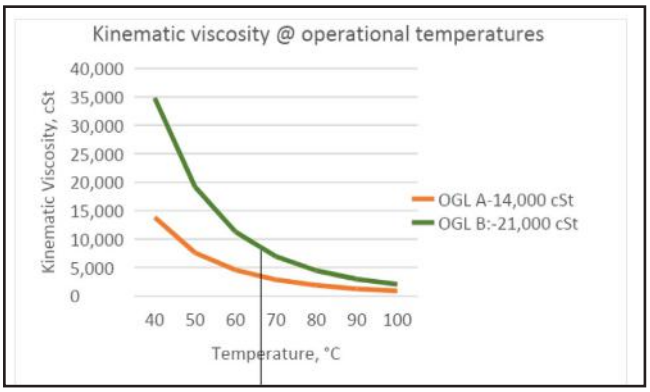


Fig 5: Viscosity of Lubrizol's OGLs with PP technology at different temperatures

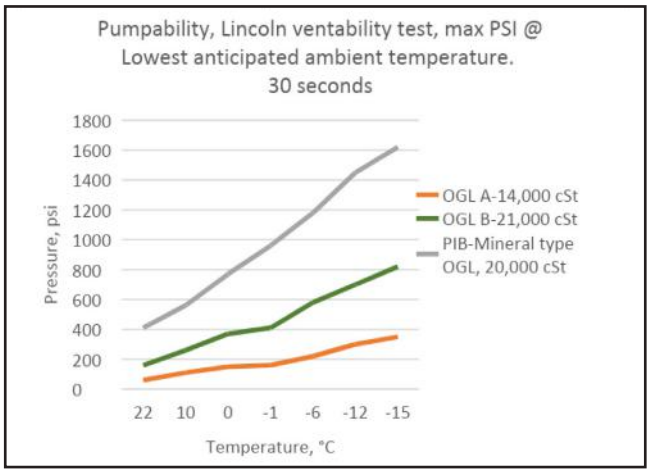


Figure 6: Residual pressure at lowest testing temperature

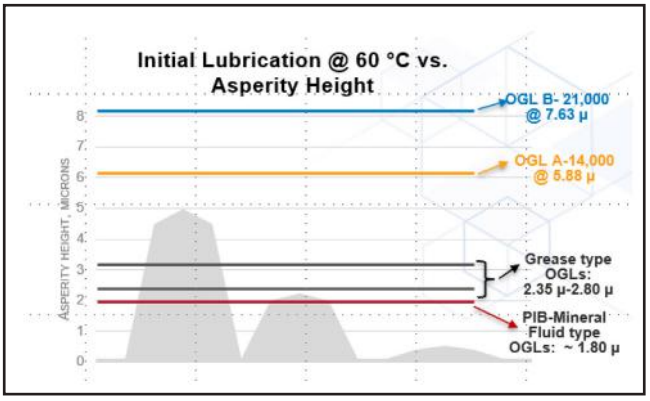


Fig 7: Comparing different OGL tiers film thickness at typical operational temperature

These factors improve the overall performance of the OGL and provide more protection for the systems in which they are used.

Our View

Synthetic IGOs formulated with PP as the viscosity modifier can offer reduced operating temperature, higher energy efficiency and low traction coefficient while reducing the total formulation cost by 20%-40% compared to a conventional synthetic formula.

This newer formulation approach can extend oil drain interval and offer a more sustainable solution to IGO development. In OGL, the performance polymer provides versatility as a base fluid. It also provides improved performance characteristics to OGL used in the mining, cement and sugar cane industries. Finally, it provides product sustainability, as well as reduces lubricant consumption and energy usage.

Fig 8: Lubrizol OGLs with PP technology shows better performance in temperature reduction in FZG rig

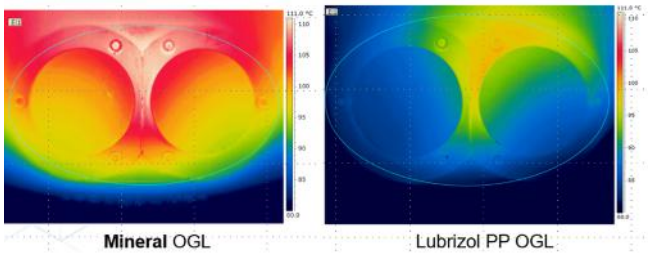


Fig 9: Significant temperature reduction between general market mineral OGL and Lubrizol OGL with PP technology

Fig 10: Lubrizol OGL with PP technology shows better performance in energy consumption in FZG rig

For more information on industrial gear oils, open gear lubricants and performance polymer technology, please contact your Lubrizol representative.

Dr. Shubhamita Basu is the North America Product Manager for Industrial Oils at Lubrizol, where she manages the hydraulic fluid, industrial gear oil and turbine oil portfolio. Dr. Basu has worked extensively in developing new molecules, engine oils and limited slip-gear oil applications, as well as formulating hydraulic fluid and industrial gear oils. She has also led an energy efficiency initiative and spearheaded environmentally acceptable lubricant development.

(Retro)Fit for the Second Stage in Life

Quite often machines run in multiple-shift operation for two to three decades, and have processed millions of workpieces when they finally become focussed by production or maintenance managers. A retrofit offers a worthwhile alternative to a new machine.

There are various reasons why managers turn their attention to machines that are at the end of their life cycle (fig.1):

Some feel they are outdated and unsightly, others focus on the facts and notice that these machines are lagging behind today's machining times resulting in increasing time and money expenditures.

Worst case, it is no longer possible to find qualified personnel or suitable spare and wear parts to keep them operational.

Figure 1: Machine before retrofit

The cost-benefit issue is a crucial question when considering selling a machine. The same applies if said machine can still be used for supplying spare parts.

It should be considered if the previous options are the only ones for a machine that has been running reliably to date? KAPP NILES offers an alternative in case the current monetary situation does not allow a new investment.

KAPP NILES scores with retrofits

KAPP NILES corporate group has recognised the production problem in handling older machines and thus offers specialization on retrofit modernisation measures.

At the beginning customers raised the question whether this is the right approach since the machine tool builder has the world's largest product portfolio in the field of gear and profile grinding machines and covers all customer requirements. Though, the advantages cannot yet be dismissed.

- The newly installed hardware and software are state-of-the-art, which means restoring and often even increasing precision and performance.
- State-of-the-art control system components enable cycle time reductions in the machining process and reduce the maintenance cost.
- The software is graphically processed and thereby facilitates the operation; moreover, additional functions are offered that considerably speed up the editing and the input of grinding programmes.
- Additionally, due to its upgraded control system and installed interfaces, the retrofit machine is now ready for the “challenge” of industry 4.0. Thus, every retrofit machine comes with the latest remote maintenance technology.

Safety and availability as a matter of course

The most important electronic components of the old machine are no longer available today and remaining stocks are gradually declining.

Hence, the customer receives a material availability of at least ten years in addition to a new warranty for newly installed spare and wear parts with their retrofit.

A glance at safety standards of older machines shows that these do not comply with any current guidelines. Therefore, the safety concept on the newly installed (electronic) drive and control system is adjusted to the highest degree.

Reaction times shrink to a minimum, providing machine protection and in particular reducing personal injuries significantly.

Integration into production

If a retrofit is being carried out, the machine must be fully integrated into each existing production process - visually and technically.

In other words, the space requirements for a machine overhaul should not be altered significantly, as the machine is removed from an existing production line, modernized and then reinstalled in its original position.

Due to the new electrical cabinet technology, the set-up area of the entire equipment can be also reduced, creating additional surface area.

Finally, the optical processing as well as the positioning of all functional areas (hydraulic, pneumatic and lubrication) make the machine shine in the new KAPP NILES look (fig. 2).

Figure 2: Machine after retrofit

German mechanical engineering as an essential basis

A retrofit uses the solid construction work of "good old mechanical engineering". Components and assemblies that no longer meet today's quality requirements but are still acceptable from a mechanical point of view are used as the basis for this modernisation.

They are overhauled and then reinserted into the machine. In addition to considerable cost savings compared to a new machine, this approach also offers the advantage that the customer's existing inventories can be used.

Irreparably damaged or economically useless mechanical parts are replaced by new and more efficient ones.

The beds made of cast iron have long been set up and have extremely robust hydrostatic guide rails, which are reprocessed. This gives the machine its original precision and stability in the machining process.

However, these measures do not necessarily have to be carried out on your own machines, even if this would undoubtedly extend their lifespan.

KAPP NILES already has used machines enabling a retrofit being carried out within four weeks by simply exchanging machines.

This step offers further high savings potential for the customer and should therefore be examined as part of this modernization measure.

Retrofit – the worthwhile alternative to a new machine

Specific solutions based on the current product line are and will continue to be the core business of KAPP NILES as they individually address customer requirements with a broad range of machining processes.

Also, the company's after-sales area is a flexible one, allowing the company to react to customer requirements for every retrofit.

Currently, KAPP NILES overhauls four to five machines annually with increasing frequency, thus offering customers a cost-efficient alternative to a new machine of comparable quality.

Since retrofit is regarded as a maintenance and modernization measure and is not subject to budget for new machines, our experience suggests investment proposals can be implemented more successfully.

In the best case, these expenditures can even be amortized within a year.

Initial experience shows that these benefits should not be underestimated. From an economic point of view, they were at times the crucial reasons why customers have opted for a retrofit in the past.

All required work is performed either in-house, (including dismantling, transport and re- installation) or on-site at the customer's premises.

This special service from KAPP NILES makes customer machines fit for the second stage of their life cycle.

The author is Kevín Geißendörfer of the Department Industrial Services / Spare Parts / Tooling at KAPP NILES.

Best Practices in Dealing with Thermal Expansion and Contraction in CNC Machining

By: Sushmita Das

Computer Numerical Control (CNC) machining has revolutionized the manufacturing industry by providing unmatched precision and efficiency in the production of complex parts.

However, as CNC machines operate under varying environmental conditions, a fundamental challenge that manufacturers encounter is thermal expansion and contraction.

These phenomena can introduce errors, affect dimensional accuracy, and compromise the integrity of machined parts.

By understanding the science behind this, and implementing effective strategies, CNC machining operations can achieve higher precision, reduced scrap rates, and improve efficiency.

The Science of Thermal Expansion and Contraction

Thermal expansion and contraction are physical phenomena that result from changes in temperature. When a material is heated, its particles gain energy and vibrate more, causing the material to expand. Conversely, when the material cools down, its particles lose energy and move closer together, leading to contraction. This behavior is consistent across various materials, and its effects are particularly pronounced in metals and other materials commonly used in CNC machining.

Impact of Thermal Variation on CNC Machining

In CNC machining, precision is paramount. Even slight variations in dimensions can lead to defective parts and costly rework. Thermal expansion and contraction can jeopardize this precision by causing the following issues:

Dimensional Inaccuracy:
Parts machined at different temperatures than the design temperature can deviate from the intended dimensions. This can lead to assemblies not fitting together correctly or products failing to meet quality standards.

Residual Stress:
Rapid temperature changes during machining can induce residual stress in the material, affecting its mechanical properties. This can lead to premature part failure and reduced product lifespan.

Tool Alignment:
Temperature fluctuations can impact the alignment of CNC machine tools, leading to misalignment and reduced machining accuracy.

Surface Finish: Thermal variations can cause uneven expansion and contraction across the material's surface, resulting in poor surface finish and aesthetics.

Strategies for Mitigating Thermal Effects in CNC Machining

1. Thoughtful Material Selection and Pre-conditioning

The selection of materials plays a pivotal role in combating the adverse effects of thermal expansion and contraction.

Opting for materials with inherently low coefficients of thermal expansion provides an initial advantage, as these substances are naturally less susceptible to dimensional changes with temperature fluctuations.

Moreover, a strategic approach involves subjecting raw materials to a preparatory phase of controlled heating and cooling cycles prior to machining.

By gradually introducing materials to the anticipated operational temperature range, their molecular structure becomes acclimatized, resulting in a stabilized state that minimizes undesirable deformations during the machining process.

2. Operating within Temperature-Controlled Environments

The surrounding environment in which CNC machines operate wields a significant influence on the stability of machining operations. By maintaining a controlled temperature setting, manufacturers can significantly reduce the impact of external temperature variations.

This control involves insulating the machining area to create a buffer against temperature fluctuations, installing sophisticated Heating, Ventilation, and Air Conditioning (HVAC) systems to ensure a consistent ambient temperature, and employing specialized thermal shields that serve as barriers between the machine and any external temperature changes.

This trifecta of measures collectively fosters an environment where thermal expansion and contraction are minimized, allowing for precise and reliable machining outcomes.

3. Precision-enhancing Tool Compensation and Probing

In the dynamic realm of CNC machining, real-time adaptation is paramount to counteract the effects of thermal expansion and contraction.

The implementation of tool length compensation and probing systems empowers CNC machines with the ability to continually monitor and fine-tune tool lengths during machining operations.

As temperature fluctuations induce dimensional changes in the material and subsequently impact machining accuracy, these systems make instantaneous adjustments, ensuring that the final dimensions of the machined part adhere to the design specifications.

This level of precision enhancement is invaluable in mitigating the challenges presented by thermal effects, culminating in products that meet the highest standards of quality.

4. Strategic Optimization of Tool Paths

Tool path optimization emerges as a strategic manoeuvre in the battle against uneven thermal expansion.

By skilfully mapping out the trajectory that the cutting tool will follow across the workpiece, machinists can strategically manage the distribution of heat buildup.

Concentrated heat in specific regions of the material can exacerbate thermal expansion imbalances. In contrast, an even distribution of heat allows for a more controlled and predictable expansion pattern.

By pre-emptively considering thermal effects in the tool path planning phase, manufacturers set the stage for harmonious material response, resulting in dimensional consistency even in the face of fluctuating temperatures.

5. Deliberate Avoidance of Rapid Temperature Changes

The manufacturing arena is rife with complexities, and one aspect that warrants prudent attention is the avoidance of abrupt temperature changes.

Rapid temperature fluctuations can trigger swift and uneven thermal expansion or contraction, leading to potential distortions, and defects in machined parts. A more judicious approach involves orchestrating controlled temperature transitions.

By allowing materials to acclimate gradually to changing temperatures, the risk of sudden shifts in dimensional integrity is significantly diminished.

This deliberate pace in temperature modulation safeguards the structural coherence of the material, reinforcing the reliability of CNC machining outcomes.

6. Diligent Machine Calibration and Maintenance

The precision of CNC machining is underpinned by meticulous calibration and ongoing maintenance. Regular calibration routines ensure that the machine's

measurements and movements align accurately with the intended specifications.

Given the challenges posed by thermal expansion and contraction, this aspect becomes even more critical.

Calibration geared towards accommodating potential thermal effects equips the machine with the ability to dynamically adjust its operations, compensating for the dimensional variations induced by temperature fluctuations.

Furthermore, a steadfast commitment to machine maintenance ensures that all components function optimally, reinforcing the machine's resilience in the face of thermal challenges.

7. Harnessing Simulation through Finite Element Analysis (FEA)

The advent of technological prowess brings forth the remarkable capability of Finite Element Analysis (FEA) software.
This tool enables manufacturers to simulate and comprehend the intricate thermal behavior of materials under varying temperature conditions.

By subjecting digital representations of materials to simulated temperature fluctuations, FEA reveals potential issues in advance of actual machining.

This foresight empowers manufacturers to strategize and make informed decisions, proactively mitigating challenges arising from thermal expansion and contraction. The integration of FEA as a predictive tool fosters a paradigm shift in how CNC machining operations pre-emptively address thermal effects, fostering an environment of enhanced precision and reduced operational uncertainties.

8. Thorough Post-Machining Inspection and Precise Compensation

The culmination of CNC machining is marked by the creation of machined parts – products that bear the culmination of precision engineering efforts.

To ensure the dimensional accuracy and quality of these parts, it is imperative to conduct comprehensive inspections once they have cooled down to ambient room temperature.

During the machining process, thermal expansion and contraction may have introduced subtle deviations from the intended dimensions.

By subjecting the machined parts to thorough scrutiny, manufacturers can detect any deviations attributed to thermal effects.

The subsequent precise compensation adjustments, informed by the inspection results, restore the dimensions to their intended specifications, yielding machined parts that meet the highest standards of excellence.

Technology Advancements in EV Inspection

Electric vehicles provide new challenges as well as opportunities

By: Matthew Jaster

Different component characteristics in electric vehicles lead to higher noise and load requirements in the automotive industry. E-mobility to a certain degree is changing how gear analysis and inspection is carried out. Dissecting noise issues in gears and gearboxes requires an analytical approach like a detective. The problem could stem from the design itself, tolerancing or tip/root relief issues, tooth flank form deviations like waviness or perhaps crowning issues that directly impact noise. Every aspect of gear production needs to be examined to provide the most accurate results.

Solutions for Evolving Gear Inspection Needs

"How is the production machine influencing gear noise? Does other equipment nearby cause additional vibrations? These are questions that need to be answered to better understand gear noise," said Klaus Deininger, international sales manager, Gleason Metrology Systems. "The constantly increasing power density of gears and the growing importance of noise behavior are leading to increasingly tight tolerances, thus placing an even greater burden on gear inspection technologies," Deininger said.

Even when all the measurements are in tolerance, components still fail due to bad noise behavior. Gleason offers two software applications to evaluate gear noise including low frequency noise, medium frequency noise and high frequency noise (crowning, tooth mesh irregularities and waviness):GAM A's KTEPS (Kinematic Transmission Error Prediction Software) analyses the plane of contact for an entire gear rotation by deploying tooth topography measurements. Based on surface deviations transmission errors can be calculated and evaluated by FFT analysis. In a second step the operator can evaluate suspicious harmonics by extracting only the topography data representing the questionable harmonics.

This data is being presented in a false color picture, making it much easier to understand the source of the waviness. This unique way of gear evaluation is an ideal tool for ghost noise studies whilst correlating with End of Line single flank testing. Topography measurement is a relatively slow process, so customers want to obtain waviness measurements faster and more efficiently than they have in the past.

Gleason has created Advanced Waviness Analysis to detect and mitigate critical noise behavior caused by hardtofind tooth form irregularities. Advanced Waviness Analysis Software can be seamlessly connected with KISSsoft's Gear Design Software for Loaded TCA to provide multisensor inspection gear noise analysis based on standard profile, lead and pitch inspection, which can be tactile, optical or a combination of both.

"This is going to be a faster way to get the measurements customers need in today's production environment. There's no additional time for analysis, once the measurement is completed, you'll have results," Deininger said. The 300GMS nano is an example of a new inspection system that is suited to support automotive e-drive production with minimum noise requirements. "This machine covers the full range of modern gear inspection capabilities,

The HFC Hard Finishing Cell from Gleason combines gear grinding, auxiliary processes and gear inspection, with fully robotized part handling. (Courtesy Gleason)

as well as fine pitch gear inspection and CMM measurement. With the 300GMS nano, users are now able to measure surface finish at sub-micron level with a skidless probe, analyze waviness for profile, lead and pitch, and execute noise analysis with sophisticated software tools," he added. The machine also integrates 3D measurement and analysis capabilities typically offered by a CMM. The 300GMS nano provides customers with a valuable tool for e-drive gear measurements.

For many decades, Gear Noise NVH Roll Testing has been a part of bevel gear production, but cylindrical roll testing markets require more sophisticated technology.

"In order to look at electric vehicles, we must examine NVH from low to high frequency levels and provide a variety of testing features and capabilities," Deininger points out. The GRSL (Gear Rolling System with Integrated Laser Technology) System from Gleason combines traditional roll testing with advanced non-contact laser technology. This vastly improves cycle time for index, lead and profile inspection, as well as gear noise evaluation, and provides analytical inspection of 100 percent of production output, even for the toughest gear applications.

Combining the GRSL with Advanced Waviness Analysis software offers the unique possibility to evaluate each gear produced regarding potential waviness on the tooth flanks, which is the ultimate contributor of high frequency noise in gear mesh. This means, no gears with questionable or bad noise behavior enter final assembly, which reduces the costly disassembly of gearboxes with bad noise behaviors dramatically. Today's gear inspection must also factor in the machine behavior itself.

How does the machine contribute to measurements? Why are there variations from machine to machine? How can Gleason provide the most accurate inspection results moving forward? Recently, the GRSL system was integrated into Gleason's Hard Finishing Cell (HFC). This automated system includes a robot that integrates a variety of

process modules including gear grinding, washing, laser marking, measuring and part handling. During the gear inspection, the laser scanner provides measurement characteristics for each tooth.

Deviations are fed back into the machine via a Closed Loop correction. The future of gear inspection is complete, in-process measuring with integrated gear noise analysis in a Closed Loop automated system, providing customers with all the necessary means to keep tolerances at all times, minimizing scrap and rework.

gleason.com

Klingelnberg Dissects Complex Inspection Requirements

Dr. Christof Gorgels, director, precision metrology at Klingelnberg, discussed the reduction of gear tolerances in the automotive industry in recent years. "The need for noise performance testing has increased and is an addition to the traditional geometric quality assessment. With the Gear Deviation Analysis (GDA) Klingelnberg has been offering a tool for many years to analyze the expected noise behavior of a gear based just on simple gear measurement," he said.

With Klingelnberg's hybrid approach, the company offers a solution for faster measurements without compromising on accuracy. In addition, the R 300 a roll testing solution can do a fast 100 percent noise assessment of gears within the production cycle. "Speed and flexibility both contribute to minimize the quality costs," Gorgels said. "With the combination of GDA, hybrid metrology and roll testing, Klingelnberg offers a solution for the different requirements of gears concerning geometrical quality and noise. There are two major differences in EV compared to conventional vehicles: "The most obvious is the lack of a masking noise of the engine bringing gear noise even more into focus.

Looking into load-carrying capacity, the electric motor has a different torque characteristic increasing load on the drive flanks. In addition, recuperation leads to high loads on the coast side that is new to the automotive industry. Combining higher load and noise requirements in combination with a highly loaded coast flank, the optimization of a gear flank design becomes much more complex," Gorgels said.

Klingelnberg's GDA software makes gear noise visible. It comprises the four modules View, Wave Analysis, Wave Production and Produce.

"For noise analysis we are evaluating the form error in a smarter way by looking not only for the amplitudes, but also for regular structures such as waviness. With our GDA software we offer a tool to our customers to rate this waviness and basically receiving order diagrams that can directly be compared to the end of line test. This ensures that the acoustics engineers and the manufacturing and quality engineers speak the same language," Gorgels added.

What is important today is the advanced grinding process simulation. If a gear is found to be noisy the next question arising is how to fix the issue? Finding technical solutions for noise issues is far more complex compared to correcting standard geometrical deviations.

"With the manufacturing simulation, different process deviations, like for instance a tumbling grinding tool

or a torsional vibration of the workpiece table, the result on flank waviness can be simulated and thus compared to real world measurement result. Besides making noise visible, we also help our customers to find the root cause," Gorgels said. He is seeing more tolerances for certain orders on customer's prints today. "These orders can be tooth mesh orders (and higher harmonics) as well as so called ghost orders. If these requirements show up on a printout, they should be measured in production.

This increases the demand for standard pro- duction solutions which we offer with the GDA analysis as well as the R 300 roll tester," Gorgels said. In the coming years the need to use these tools will increase. Standardization will become a major topic to ensure a common understanding between OEMs and their suppliers.

klingelnberg.com

Liebherr Points to Accuracy, Liability and Reliability for Gear Inspection Results

Gears in EVs have a particular higher demand on noise generation and consequently on the surface structure and waviness of the gears. Although the measuring principle for the inspection of involute gears is still valid, EV gears are pushing the limits for gear inspection today, according to Matthias Bruederle, product manager at Liebherr.

Liebherr's WGT 400 optimizes the precision and quality of the measurement of tools used to machine very small parts, including internal gears and gears with very small modules. The supply of data in real-time is one of the machine's benefits as well as its high measuring speed.

The WGT series of measuring technology closes the gap in the closed- loop sector. The four-axis measuring devices are equipped with high-precision mechanics and electronics, which are controlled by intelligent and user-friendly software. The combination of granite guides and air cushioning creates maximum precision with wear-free mechanics.

Liebherr's solution "Open Connect" offers a direct link between the grinding machine and the inspection center, providing a fast and reliable solution to shorten the response time to a deter- mined error of the gear's geometry. Data is transferred via standardized GDE interface and work with any grinding machine.

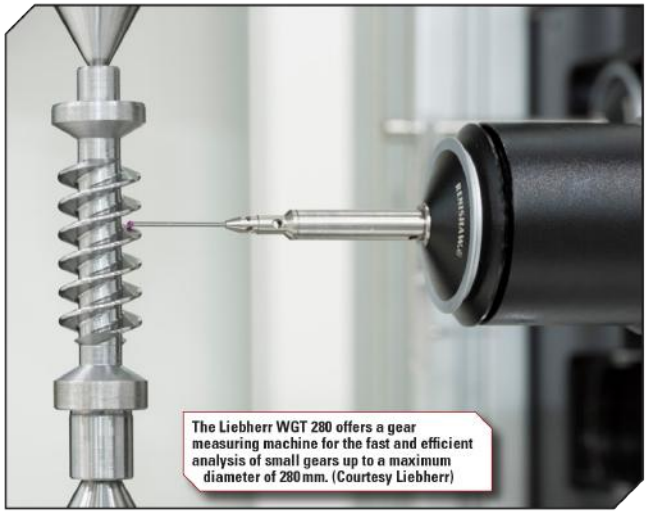
"The use of optical sensors seems to be an appropriate solution to improve performance and quality cost, however open questions regarding accessibility and accuracy, in particular on polished surfaces, are still preventing this to be a reliable solution applicable for the inspection in industrial environment," Bruederle said.

For the most effective gear production, Bruederle said that inspection results today must provide the highest accuracy, liability and reliability. "Measuring speed and accuracy may therefore exclude each other and depend on the gear geometry. The development of a specific measuring strategy—based on gear geometry and the production method is required."

E-mobility has expanded gear measuring solutions to meet automotive demands. "The development of new production methods like the polishing of gear teeth with and addition grinding process with the purpose of stochastic distribution of grinding marks on the tooth flank also known as silent shift grinding find their way in the development of hardware and software components on the inspection machines," he added.

Sensors and software extensions for evaluation of surface roughness (special sensor required), evaluation of dedicated end reliefs, and evaluation and analysis of waviness and undulation will continue to play a large role for the analysis of e-drive gears.

liebherr.com

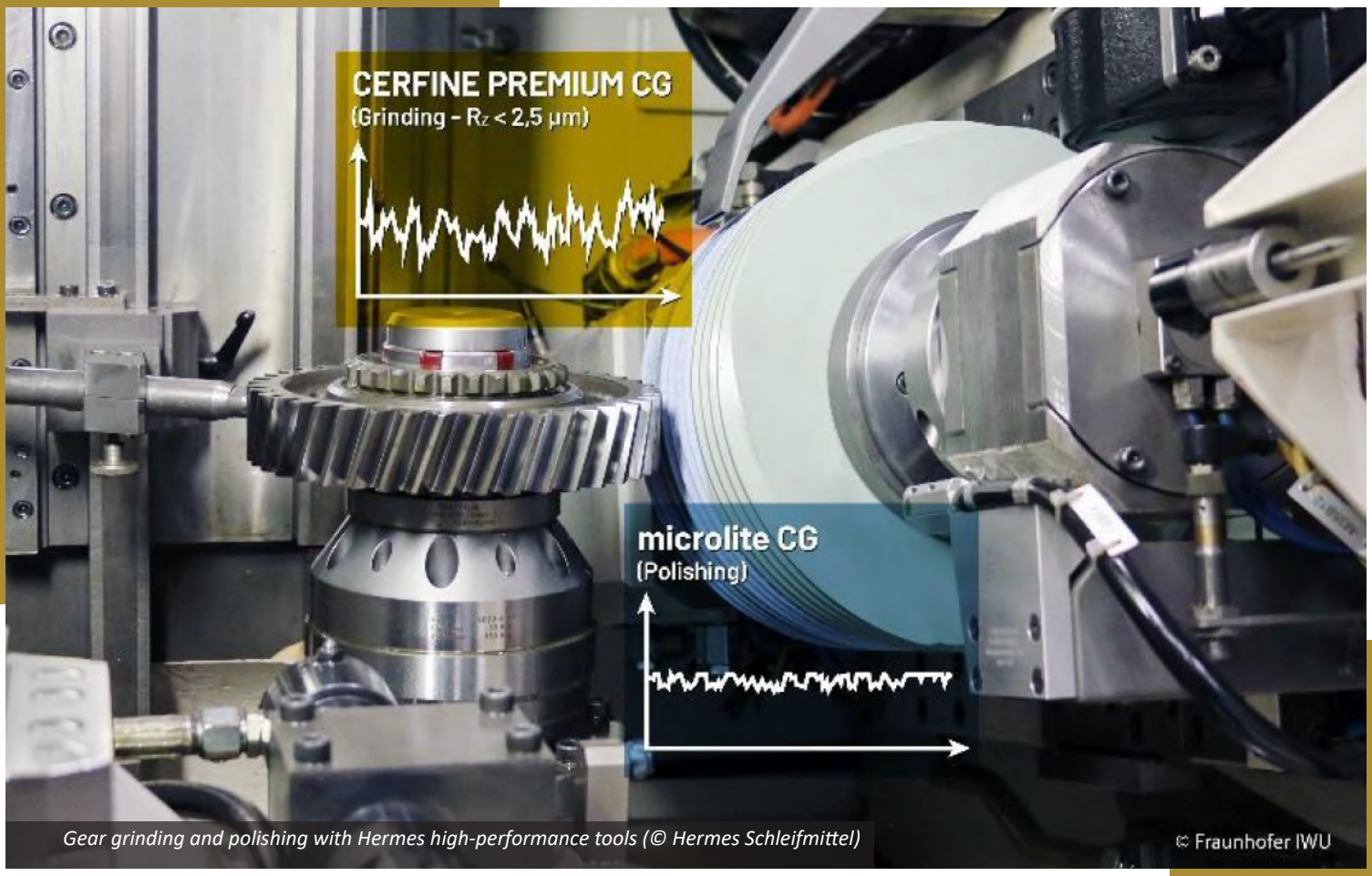


The Liebherr WGT 280 offers a gear measuring machine for the fast and efficient analysis of small gears up to a maximum diameter of 280 mm. (Courtesy Liebherr)

Higher Inspection Levels

Large scale transmission manufacturing requires a greater focus on noise behavior and quality for each gear in the powertrain.

Although the electric motor provides a variety of advantages for the future of transportation, it does very little to hide gear noise. New inspection equipment and technology, therefore, must provide the tools to bring comfort, reliability and precision to all future e-mobility applications.



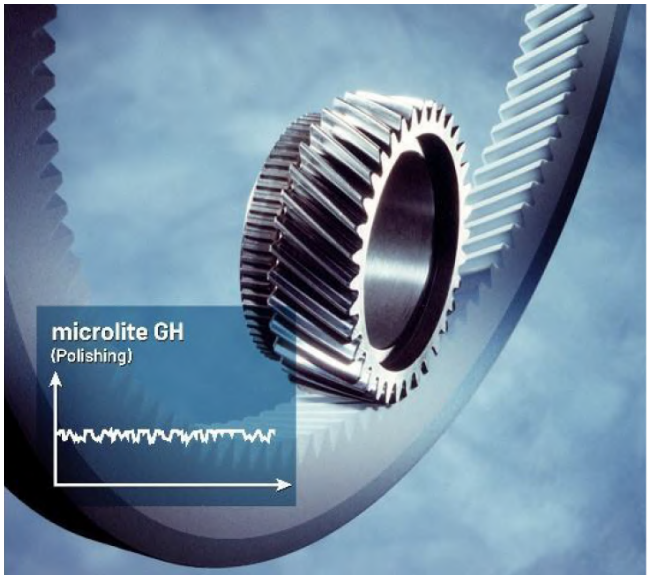
Gear grinding and polishing with Hermes high-performance tools (© Hermes Schleifmittel)

Pushing it to the Limit: High Speed Manufacturing of Gears with Excellent Surfaces

Gears are essential in many industries including automotive, machinery, marine, aerospace, medical, and food processing. Although the gears used in these industries have very different designs, they all need to be manufactured in a time and cost-efficient manner.

In addition, the demands on the required surface quality are constantly increasing in order to reduce friction losses, improve NVH (Noise, Vibration, Harshness) properties, and increase the flank load capacity and lifetime of the gears in the final transmission.

The best NVH results of two meshing gears are achieved when different surface patterns are present on the flanks of both gears. If similar surface patterns were present on both gears, periodic vibrations as



well as additional noise emissions could be caused, thus reducing the performance of the gears in the gearbox.

The surface structure of the gear flanks depends mainly on the utilized finishing process. Therefore, different finishing processes are recommended for the production of each of the two meshing gears.

However, the number of manufacturing processes capable of producing the required surface characteristics in a productive manner is very limited. Gear honing and continuous generating gear grinding are the most commonly used methods for industrial gear production.

Due to their very different process kinematics, both processes produce completely different surface patterns and can achieve very high surface qualities while being very economical compared to other manufacturing processes.

The main challenge for both processes is to find appropriate tool specifications and process parameters to achieve the most economical results while creating the desired surface finish.

Hermes Abrasives offers a wide range of different honing and grinding tools with the most competitive tool technology, i.e. the latest and most innovative VITRA-Bonding.

This technology makes it possible to achieve very high material removal rates while achieving the required surface quality.

In addition, the honing rings and grinding worms can both be made with Microlite, our first-class product for polishing of gear flanks.

This further enhances the surface quality and even allows to create reflective gear flanks! The individual tool design however strongly depends on the individual application case at the customer.

Hermes provides a wide range of customized tools combined with many years of experience and this allows to assist the customers with a special service in all aspects of gear grinding, from the process and tool design to the optimization of process parameters and the troubleshooting in case of bad gears.

If you need assistance with your honing or gear grinding process, please contact your nearest Hermes office or visit us at ***https://www.hermes-abrasives.com***

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Shifting Gears: ENRX Drives the Transition to a Greener Future in Gear Manufacturing

Induction heating, a process of remarkable precision, is ideal for gear manufacturing. In a world where environmental consciousness and efficiency are ever more important, ENRX is a frontrunner in the realm of sustainable industrial practices.

Thanks to its efficiency, versatility and meticulous control over hardness patterns, induction heating is the best choice for attaining optimal performance and enhanced durability in gear manufacturing.

Gear Technology India spoke with Director for Sales & Marketing in Asia, Mahesh Gupta, about ENRX, their offerings, digitalization and more.

Global Presence, Local Commitment

ENRX is the world's largest induction hardening equipment maker. With more than 70 years of experience, the company offers solutions that boosts throughput, cut costs, and help manufacturers around the world to reach their productivity targets as well as their sustainability goals.

With a global footprint encompassing America, Europe, and Asia, ENRX's influence spans continents. Their Indian base in Bengaluru KIADB aerospace park, coupled with sales and service hubs in Gurgaon and Pune, ensures a local touch for global excellence.

Clean, Safe and Energy Efficient

"When we harden gears with induction technology, we use induced heat and rapid cooling or quenching to increase the hardness and durability of the steel. It is a no-contact process that quickly produces

intense, localised, and controllable heat," Gupta explains, elaborating on the many benefits the technology has to offer.

"First of all, it is extremely fast. ENRX's patented simultaneous multi-frequency hardening process achieves true contour hardening of small gears in well under a second. Advanced coil design and process control software ensure short cycle times and precise repeatability."

Speeding Up the Journey

ENRX is formed by the recent merger of global industrial induction heating expert EFD Induction and the patent-dense wireless inductive charging and contactless power supply innovator IPT technology.

The company enjoys a strong backing from owner Arendals Fossekompani — a forward-looking investment company that focuses on energy and technology-related businesses for a greener economy.

"As a global green technology company on a mission to speed up the journey to a sustainable future, we offer inductive heating, charging, and power transfer with low or no carbon footprint," Gupta says. "These technologies provide value to manufacturing and mobility applications worldwide."

All of ENRX's products boast high energy efficiency and a minimum of waste whilst being safe and easy to use. "Energy efficiency is our forte," he underlines, "ENRX's commitment to a greener future is etched in every product, designed for optimal power utilization and efficiency."

Precision Meets Purpose

Gupta's observation that "induction heating is used to make everything from faucets to spaceships" captures the remarkable versatility of ENRX's technology.

Their applications extend to renewable energy production, where they are the world's leading supplier of heating solutions for wind farms and power stations.

Brazing, welding, hardening and shrink-fitting — induction reverberates across a diverse range of industrial applications.

With an array of induction heating equipment that seamlessly adapts to this myriad of applications, from standalone tools to integrated systems, ENRX delivers optimal performance and endurance.

From automotive giants to electrotechnical powerhouses, induction heating is a cornerstone of manufacturing, also for major tube and pipe

manufacturers, HVAC manufacturers and many other industrial segments worldwide

A surge in applications within renewable energy components further underlines its significance. "Notably, the shift from gas heating to induction heating in production processes significantly curbs carbon dioxide emissions," Gupta underscores.

Industry 4.0

The integration of Industrial Internet of Things (IIoT) facilities in gear manufacturing has transformed the industry by seamlessly enabling data-driven decision-making, process optimization, and enhanced productivity.

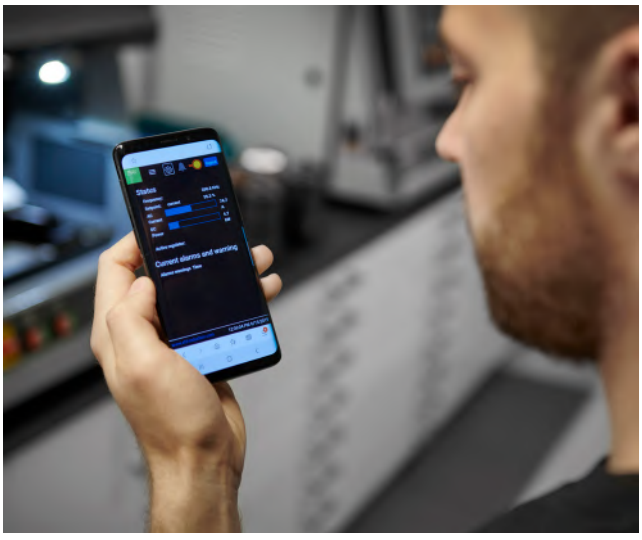
“All our machines and power sources are now fitted with programmable logic or micro controllers enabling real-time operation, process monitoring, and remote diagnostics,” Gupta says and elaborates, “We’ve made our products ready for Industry 4.0. The equipment can be connected for performance analysis, error diagnosis and software updates.”

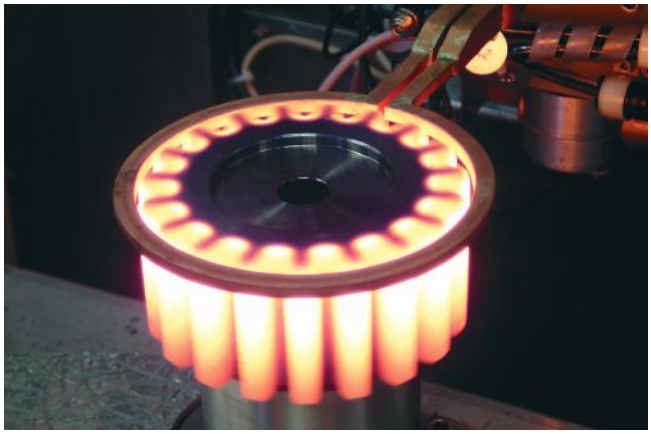
Digitalization Drive

ENRX's commitment to efficiency precision, and productivity finds its zenith in automation. "Our heating machines," Gupta reveals, "operate with a choreographed precision, whether handling individual components or orchestrating continuous processes. Our automation ensemble extends to robots, gantries, and more, all tailored to meet specific customer needs."

The quality of the induction heating process hinges on multiple variables such as power, frequency, voltage, and current, as well as cooling water flow and temperature. Each need to be accurately measured, compared against set limits, recorded, and controlled.

“Inputs for each manufactured component are digitized and fed into controllers for processing and





recording,” Gupta explains. “Components which vary from the safe zone are quarantined.” Power source control and diagnosis is also fully digitized.

Machine Condition Vigilance

Integrating data-driven insights into manufacturing is a crucial component that enables manufacturers to consistently produce high-quality products. “Most of the critical movements in our machine rely on servo motors and ball screws,” Gupta notes.

“We also use multiple pumps for cooling water and lubrication. We can measure the current and temperature of all motors in our machines to ascertain their working condition and setting pre-emptive warnings for assessment during preventive maintenance. In addition, we monitor end-of-life of tooling and proactively prompt operators for timely replacements.”

Enhanced Online Service

“ENRX will soon launch an online service and we are creating the necessary tools and software to ensure streamlined and efficient support and service.

This move is backed by our comprehensive shift to digital technology across our entire product lineup, including the provision of upgrade kits for older operational equipment on-site," Gupta says, adding that this endeavour includes the rollout of a customer portal for seamless case management and tracking, as well as the integration of Augmented reality (AR) and Virtual Reality (VR) systems to facilitate clear communication, remote product upgrades and equipment condition monitoring via the web.

Customers can conveniently view the condition and performance data of their equipment on any internet-connected devices.

Championing the Green Cause

“If we want to stay in business, we have to base our operations on long-term commitments,” Gupta states. “So, we design our equipment with energy, water, and space efficiency in mind.” ENRX offers an array of products and systems that encompass the

realms of heat, charge, and power, all designed to fuel eco-conscious industrial production and facilitate environmentally responsible transportation modes encompassing air, road, and rail.

“We take our Environmental, Social, and Governance (ESG) responsibilities very seriously,” he adds. “The global challenges we face today find resonance in the United Nations' seventeen sustainable development goals," he observes.

“While they are all interconnected, ENRX has chosen to focus on four that we think are the most relevant to our company and the business segments in which we operate: Promoting decent work and fostering economic growth, spearheading industry, innovation, and infrastructure, championing responsible consumption and production, and making substantial strides in climate action.”

Mahesh Gupta
Director – Sales & Marketing
(Asia) ENRX Private Ltd
(Formerly known as EFD Induction Private Ltd)

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Navigating the Challenges and Solutions of Heat Treatment in Gear Manufacturing

By: Sushmita Das

In the world of engineering, the phrase "heat treatment" might conjure images of forging swords in ancient times or crafting steel beams for modern skyscrapers.

Yet, beyond the historical and architectural realms, heat treatment plays a pivotal role in an industry that's crucial to our everyday lives: the gear manufacturing sector.

Gears, those silent yet robust components driving machines from watches to heavy industrial machinery, owe much of their strength and longevity to the heat treatment processes they undergo.

However, like any sophisticated process, heat treatment in the gear industry comes with its own set of challenges that must be deftly navigated to ensure the highest quality end product.

Crucible of Challenges

1. Uniformity of Heating: In the domain of gears, consistency is king. Achieving uniform heating across complex gear geometries can be a daunting task.

Uneven heating can lead to distortion, dimensional inaccuracies, and even catastrophic failure of the gear during operation.

2. Material Variation: The gear industry relies on a wide array of materials, each with its unique thermal properties. These materials respond differently to heat treatment, making it challenging to find a one-size-fits-all solution.

3. Residual Stresses: The heat treatment process can introduce residual stresses into the gears, potentially leading to performance issues or reduced fatigue life.

4. Distortion and Quenching Cracks: The rapid cooling during quenching, a critical step in heat treatment, can cause distortion or even cracks, undermining the integrity of the gears.

5. Surface Hardness Consistency: Ensuring consistent surface hardness across the gear is essential for uniform wear resistance. Any deviations could lead to premature failure of the gear teeth.

Forging Solutions

1. Advanced Simulation and Modeling: Modern technology comes to the rescue with advanced simulation and modeling tools.

These allow engineers to predict how a gear will react to heat treatment, which enables them to fine-tune the process for optimal results.

2. Tailored Heat Treatment: Instead of a one-size-fits-all approach, researchers are working on a tailored heat treatment processes for different gear materials. This involves adjusting heating and cooling rates based on the material's specific characteristics.

3. Pre- and Post-Heat Treatment Machining: Machining before heat treatment can mitigate distortion, while post-heat treatment machining can refine dimensions to their desired values.

4. Controlled Quenching: Implementing controlled quenching techniques, such as interrupted quenching or using different quenching media, can reduce distortion and cracking issues.

5. Surface Coatings: Applying surface coatings after heat treatment can enhance wear resistance without compromising the core material's properties.

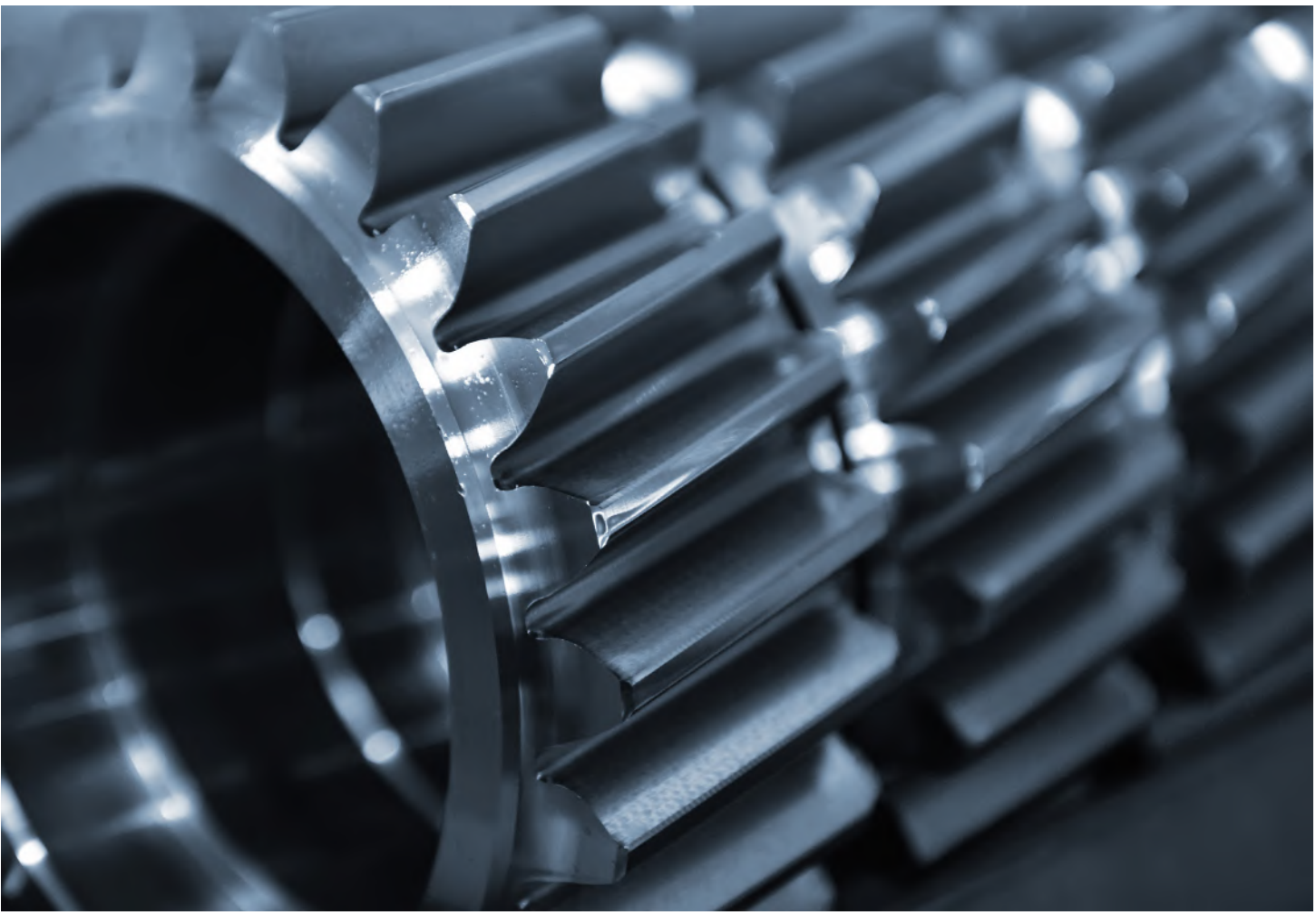
Shaping the Future

In an ever-evolving landscape, the gear industry continues to push boundaries. Researchers, engineers, and manufacturers are collaborating to develop innovative heat treatment solutions that overcome existing challenges and usher in a new era of gear technology.

Through a combination of computational advancements, tailored approaches, and meticulous process control, the industry is navigating the complex realm of heat treatment with renewed vigor.

The gear industry might remain hidden from the public eye, but its impact reverberates through numerous sectors from transportation to manufacturing. The challenges it faces today are not merely obstacles; they are stepping stones toward innovation and excellence.

As we look to the horizon of technology and machinery, we can be rest assured that the gears turning quietly behind the scenes are forged in the crucible of knowledge and perseverance ready to power the world into the future.



Multi-Tasking Hobbing Machines and Their Game-Changing Impact on Gear Manufacturing

Combining the traditional hobbing process with milling, drilling, and grinding capabilities, these integrated systems have redefined efficiency and versatility in the industry

By: Nishant Kashyap

Traditionally, gear production involved using separate machines for individual processes, leading to increased set-up times, additional handling, and higher production costs.

However, with the advent of multi-tasking hobbing machines, gear manufacturers can now consolidate multiple operations into a single set-up, eliminating the need for workpiece transfers between machines and reducing overall production cycle times.

The working principle of multi-tasking hobbing machines revolves around a CNC-driven process.

CNC technology empowers these machines with the ability to precisely control the cutting tools and workpiece movement that ensures consistent and accurate gear profiles. By integrating various cutting processes into one system, these machines can efficiently manufacture a wide range of gears including spur and helical gears, splines, and sprockets, which cater to diverse customer demands.

One of the key advantages of multi-tasking hobbing machines is their ability to produce gears with complex geometries and tight tolerances.

The integration of milling, drilling, and grinding processes allows for the creation of intricate gear profiles that may be challenging to achieve using traditional methods alone.

This capability opens up new possibilities for gear applications in industries like aerospace, automotive, and robotics, where customized gear designs are in high demand.

Image Source: Whoisjohngalt/Wikimedia Commons/CC BY-SA 4.0

These machines play a vital role in promoting smart manufacturing and Industry 4.0 initiatives.

With advanced sensors and real-time monitoring, multi-tasking hobbing machines provide valuable data insights that can be used for predictive maintenance, process optimization, and continuous improvement.

This data-driven approach optimizes production efficiency, minimizes downtime, and maximizes overall productivity.

Industry 4.0 and Smart Manufacturing

Incorporating Industry 4.0 principles and smart manufacturing capabilities, multi-tasking hobbing machines play a pivotal role in the modern manufacturing landscape.

These machines are equipped with advanced technologies and connectivity features that enable data-driven decision-making, process optimization, and enhanced automation leading to unprecedented levels of efficiency and productivity.

At the heart of Industry 4.0 integration lies the concept of connectivity. Multi-tasking hobbing machines are equipped with IoT-enabled sensors and communication protocols.

This allows them to gather real-time data on various aspects of the machining process. This data includes machine performance, tool wear, temperature, vibration, and other relevant parameters.

The seamless transfer of this data to centralized systems enables continuous monitoring and analysis of the production process.

With real-time monitoring and data analytics, manufacturers gain valuable insights into machine performance and production trends.

This information enables predictive maintenance where potential issues are detected early, minimizes unplanned downtime and prevents costly breakdowns. By addressing maintenance needs proactively, multi-tasking hobbing machines can operate at peak performance, ensuring consistent and high-quality gear production.

The integration of CNC technology in these machines further enhances automation and process control. CNC-driven operations ensure precise, repeatable machining, and reduces human errors and variability.

Moreover, CNC systems can be programmed to adjust machining parameters on the fly based on real-time data, optimizing cutting strategies for improved efficiency and accuracy.

Another significant benefit of Industry 4.0 integration is the seamless exchange of information across the entire production ecosystem.

Multi-tasking hobbing machines can communicate with other manufacturing equipment, ERP systems, and even customer order systems. This data exchange streamlines the flow of information, allowing for faster response times, just-in-time production, and efficient supply chain management.

By embracing smart manufacturing principles, gear manufacturers can embrace a proactive approach to production.

The data-driven insights obtained from multi-tasking hobbing machines enable continuous process improvement and optimization.

Manufacturers can identify inefficiencies, bottlenecks, and opportunities for improvement, leading to increased productivity, reduced waste, and improved resource utilization.

Advantages of Multi-Tasking Hobbing Machines

Enhanced Productivity: Multi-tasking machines streamline the manufacturing process, and reduces part handling and setup times.

With multiple operations performed in a single setup, productivity is significantly boosted, and leads to faster production rates and shorter lead times.

Improved Accuracy and Quality: These machines offer exceptional precision, which results in higher gear quality and consistency.

By minimizing human intervention and potential errors, multi-tasking hobbing machines ensure that gear specifications are consistently met, enhancing overall product reliability.

Cost Savings: Combining several processes into one machine results in reduced labor and maintenance costs, leading to a more economical manufacturing process.

Moreover, the elimination of workpiece transfers between different machines minimizes the risk of damage and rework, further reducing expenses.

Versatility and Flexibility: Manufacturers can easily switch between different processes and adapt to varying production requirements.

Whether it's helical gears, spur gears, splines, or sprockets, multi-tasking machines can handle diverse gear types, that makes them ideal for job shops and high-mix low-volume production.

Optimal Floor Space Utilization: As floor space in manufacturing facilities becomes increasingly valuable, the compact design of multi-tasking machines becomes a significant advantage.

Combining multiple processes into a single unit maximizes floor space efficiency and enhances overall shop floor organization.

Streamlined Workflow: The integration of various operations simplifies the workflow, reduces work-in-progress inventory and eliminates bottlenecks.

This not only saves time but also ensures smoother production schedules and faster response to customer demands.

Multi-tasking hobbing machines have ushered in a new era of gear manufacturing.

By merging hobbing with milling, drilling, and grinding processes, these integrated systems offer unparallel advantages in terms of productivity, precision, cost-effectiveness, and versatility.

As the industry continues to evolve, multi-tasking hobbing machines will undoubtedly remain at the forefront, and enables manufacturers to stay competitive and meet the demands of modern gear applications.

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Techno Gear Works Pvt. Ltd. Contribution to India's Lunar Mission

Techno Gear Works Pvt. Ltd. has been in the precision gear manufacturing business for more than 50 years. They also contributed to the recent and successful lunar landing where they provided their gear cutting services for critical precision machined parts for liquid engine assemblies (Vikas Engines) which are used in the rockets to carry satellites/any spacecrafts to the Earth's orbit.

Gear Technology India spoke with Mr. Kansara, Partner at Techno Gear Works Pvt. Ltd. about the company, their offerings, and more.

Please tell us a bit about your company's history in gear manufacturing, especially for precision machined parts used in liquid engine assemblies?

We have been in precision gear manufacturing business from more than 50 years. We started with four machines and now we have more than 150 machines at our workshop. We have manufactured many critical components for BARC research project, NPCIL commercial projects, indigenization of critical gears for Indian railway, and developed many gears for different defence applications. Additionally, we supply to many OEMs, and export to USA, Canada, Sweden and other countries.

What types of gear cutting services do you offer, and how do you ensure precision and accuracy in the production of critical parts?

We have state-of-the-art gear manufacturing facilities under one roof. These are CNC VTL and Lathes, CNC and Convention Hobbing and Shaping Machines, 5 Axis and 3 Axis VMCs and HMC, Heat Treatment plant, CNC ID/OD Grinder, Surface Grinding Machines, and CNC Gear Grinding Machines also.

Our product range covers spur and helical gears, straight and spiral bevel, worm wheel, worm shaft, precision rack, pinion and spline shafts.

Besides this, we also have the latest inspection facilities that comprise CNC Gear Tester, CMM, Video Measuring Machine, Spectrometer, CNC Universal

Tester and more. These coupled with trained and experienced quality assurance team ensure precision measurements of the components.

How did Techno Gear Works Pvt. Ltd. come to be involved in this project?

Around 2012, engineers from Vikram Sarabhai Institute and ISRO visited our factory for their requirements of precision gear manufacturing service. They were satisfied with our setup and recommended our name to Brahmos Aerospace, and later on to Godrej Aerospace, for critical gears of liquid engine assemblies.

We supply components to them for precision gear manufacturing for many projects, with Chandrayaan-3 being one of them, for the last ten years.

These components are very precise and very complicated to manufacture. Godrej Aerospace then took the gear components for further assembly, and supplied it to ISRO for the Chandrayaan project.

What is your approach to handling design specifications and tolerances, especially when it involves intricate and highly precise gear components?

Every new component is deeply studied by our experienced process engineering team who prepare a process sheet considering the tolerance requirements.

This process sheet includes the details of machines, tooling, and special fixture requirements which ensure that the specified tolerance be achieved.

How would you describe Techno Gear Works Pvt. Ltd.'s approach to lead times and delivery schedules when working on time-sensitive projects?

Lead time and delivery schedule depends on the priority of jobs, the complexity of the components, new tooling, and fixture requirements.

Our team always aims to meet the specified delivery schedule and urgency of the customer.

What were some of the biggest technical challenges your team faced, and how did they overcome it?

As we manufacture a large variety of gears, we do run into some technical challenges or the other. However, our biggest challenge involves the

development of very small precise gears for the defence sector; it not only involves the manufacturing difficulties, but also precise measurements.

Initially, we struggled to manufacture the parts for the project since the quantity was less, but for our country, we gave it our all to develop these parts.

Measuring these parts was equally challenging with measuring instruments; however, this was achieved by the high magnification video measuring system.

We have designed many new fixtures, and used the latest manufacturing machines like the 5 Axis VMC. Thorough knowledge of manufacturing and design is key to overcome technical challenges.

Please tell us what it means for you and Techno Gear Works Pvt. Ltd. to be involved in a huge project like Chandrayaan.

We believe that achieving anything meaningful starts with doing what is fundamentally correct.

Every component manufactured by us, be it aeronautic applications or machine tools, we steadfastly follow all the processes and procedures without accepting any deviation. So, while we feel proud to work for the nation, our best reward lies in our customer satisfaction.

How does your company stay updated on emerging technologies in gear cutting and precision machining?

It is very important to keep yourself and the company updated with new technology. We do so by regularly taking part in different exhibitions like Motion + Power Technology Expo USA, SUBCON in UK, IPTEX-GRINDEX India etc.

By also visiting EMO Hannover, IMTEX, and other exhibitions, we learn about the emerging technologies by gear machine manufacturers. We also read and watch the latest articles on modern manufacturing technologies in magazines like *Gear Technology*, and on YouTube as well.

What lies ahead for the future of gear technology and space exploration?

The future of the gear technology depends on the new engineering talent entering the gear manufacturing field.

That being said, we do feel there is a dearth of skilled engineers, and a shortage of new skill talent. Multi-tasking CNC machines, Automation, Robots, Smart Manufacturing are the future.

As India moves quickly in space exploration, there are plenty of opportunities in the market for gear manufacturers to capitalize on this.

Bhupendra Kansara is the Director of Techno Gear Works Pvt. Ltd. He has five decades of experience in the field of gear manufacturing, and holds a diploma in Mechanical Engineering

Helpline Operator

Keeping components up and running in heavy industrial applications

By: Matthew Jaster

How do gearbox and gear drive providers navigate the interesting challenges found in steel, cement, paper, and construction applications? Apparently, one application at a time.

Thanks to condition monitoring technology, IoT solutions and the flexibility of engineering teams today, plant downtime is not as problematic as it has been in the past. The secret to success in heavy industrial markets comes down to staying ahead of component failures.

Bonfiglioli Pushes Efficiency Gains in Heavy-Duty Drives and Gearboxes

"The focus today is on complete pack ages; gearmotors and high-power inverters. Customers in heavy indus trial applications are looking for partners that can be a solution provider.

They are also sensitive to new IoT solutions," said Leonardo Sgarzi, heavy-duty sectors, sales, and development.

This kind of product modularity and flexibility is found in Bonfiglioli's Planetary Series (300). The 300 series is compact and powerful, excelling in areas

Bonfiglioli's Planetary Series (300)

where shock loads and impacts are more the rule than the exception. The product configuration is highly versatile, due to several options for mounting, gear layout, output shaft and motor interface. Sgarzi believes customer's needs in the heavy-duty sector are related to personalized services and solutions for every application.

"They require the highest flexibility and reactivity mainly due to market volatility and uncertainty, as well as to match even tighter time- frame in project developments," Sgarzi said.

"Bonfiglioli is continuously improving and developing tailor-made processes for product lines and solutions, also investing on new and focused production plants and hubs in the aim of a higher verticalization."

This verticalization concept brings all the Bonfiglioli teams together to focus on the organization's technological advantage and strong specialization that greatly benefits end users.

The most fascinating challenge in providing solutions for the heavy-duty industry is the commitment to supply customers with perfectly balanced drives packages that are maximized — in terms of efficiency—to increase the profitability of the entire process.

So, why are customization and reverse engineering so vital in applica tions like construction, steel, cement, cranes, shredders and screw conveyors?
"We're highly focused on providing solutions suited to customers' needs to have full control and knowledge of their machine usage and lifecycle.

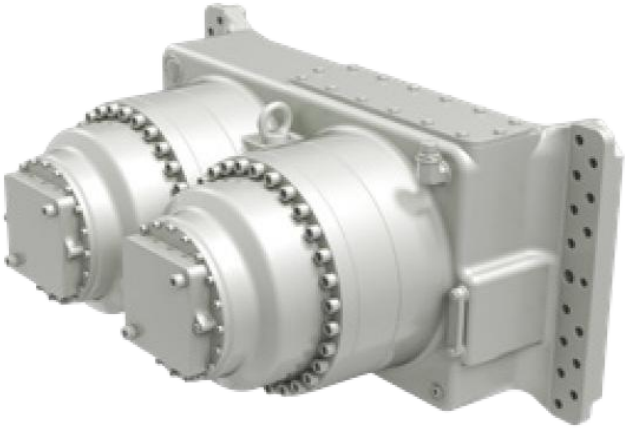
IoT and predictive maintenance are the keys to technological improvements and uti lized to minimize the maintenance/ failure cost impacts," Sgarzi said.

Condition monitoring strategies have led the company to develop dedicated solutions that are in-line with every customer/end-user expectation.

"Customers will also benefit from higher efficiency gains, scheduled maintenance, and a reduction of cost of ownership," he added.

From a design point of view, the strategy Bonfiglioli pursues is to increase the power density of gearboxes through the optimization of structural components.

"In this sense, we use the most modern software tools, trying to reduce the weight without compromising performance. From a technological



Bonfiglioli's R3-EVOX gearbox

point of view, the introduction of new gear finishing processes and high-level components and materials, allows us to increase the efficiency of our products.

Our customers obtain a reduction in energy consumption to be more compliant with market demands," Sgarzi said.

The future of heavy-duty drive and gearboxes will be linked to efficiency."The real machine/plant lifecycles settled by specific sector/application rules will drive this change," Sgarzi said.

"Proper longevity and minimized energy downtime and cost of ownership will be the pillars for the future of our business.
Advanced solutions such as sensors, predictive maintenance, augmented reality and IoT will be the keys to this important switch."

Xtek Focuses on Engineering Expertise

Xtek products can be found anywhere durability is needed for the most demanding applications in industries ranging from steel and aluminum production to mining and energy, and more. The

company, headquartered in Sharonville, Ohio, provides high-quality custom machined and heat-treated parts and component assemblies for heavy-duty industrial processes.

Founded in 1909, Xtek was known as the Tool Steel Gear & Pinion Company.
A young inventor, Russell Bloomfield, was seeking a way to make cup and cone bearings for bicycles that could take the harsh pounding of the period's cobblestone streets.

Bloomfield's work led to the development of a steel hardening process that eventually became known as the Tool Steel Process (TSP) because the metallurgical properties that it imparted to gears and bearings made them "as hard and as durable as tool steel."

The original focus of the organization was on gears for traction cars. Later, the company applied its metallurgical techniques to heavy-duty equipment applications in railroads, mines, and steel mills.

Through the decades, Xtek has evolved into a manufacturer of custom engineered components for a wide range of industrial applications.
A recent blog on the company's web site detailed the variety of engineering expertise that makes the

Xtek applies its metallurgical techniques in areas like steel mills in order to reverse engineer components.

organization better with materials, customized heat treatment options, and finish machining techniques. Xtek boasts a diverse lineup of engineering expertise with backgrounds in mechanical, manufacturing, materials science, electrical, aerospace, biomedical and industrial engineering.

Application engineering: providing analysis (FEA, etc.) on parts and assemblies, analyzing application requirements, and offering design recommendations.

Design engineering: applying industry standards to product development, and creation of manufacturing and detail drawings.

Manufacturing engineering: developing manufacturing processes and programming for all CNC equipment.

Service engineering: reverse engineering application components, offering upgrade recommendations and determining repair specifications.

Metallurgical engineering: conducting material failure analysis and specifying material composition and heat treat process selection.

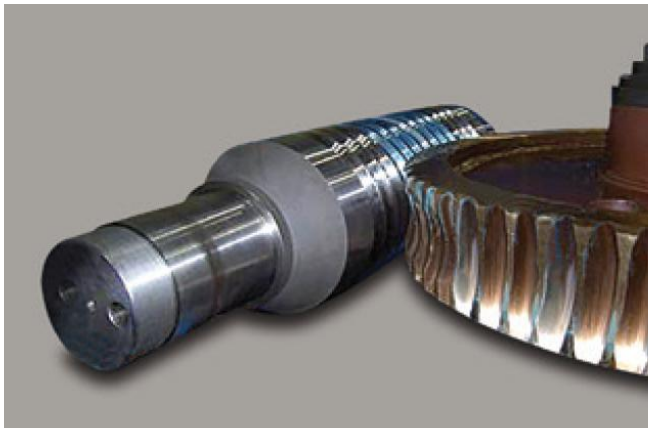
With such diverse expertise, it's not surprising to hear that the company recently retired a mill pinion after 58 years of service.

This set of carburized mill pinions for a major European hot strip steel mill was manufactured in 1964. Although it had some minor sur face wear, it was still in great condition considering the timeframe.

Altra Highlights Heavy-Duty Upgrades

Engineers at Nuttall Gear and Delroyd Worm Gear spend many shifts reverse- engineering equipment in harsh, heavy-duty environments.

Whether it's a gearbox or gear drive, maintenance managers meet with application engineers to



A Delroyd reverse-engineered worm and worm gear for a screwdown mill.

determine the best course of action to keep steel mills running optimally to avoid downtime.

Nuttall Gear Rebuilds Enclosed Reducer for Steel Processing Line

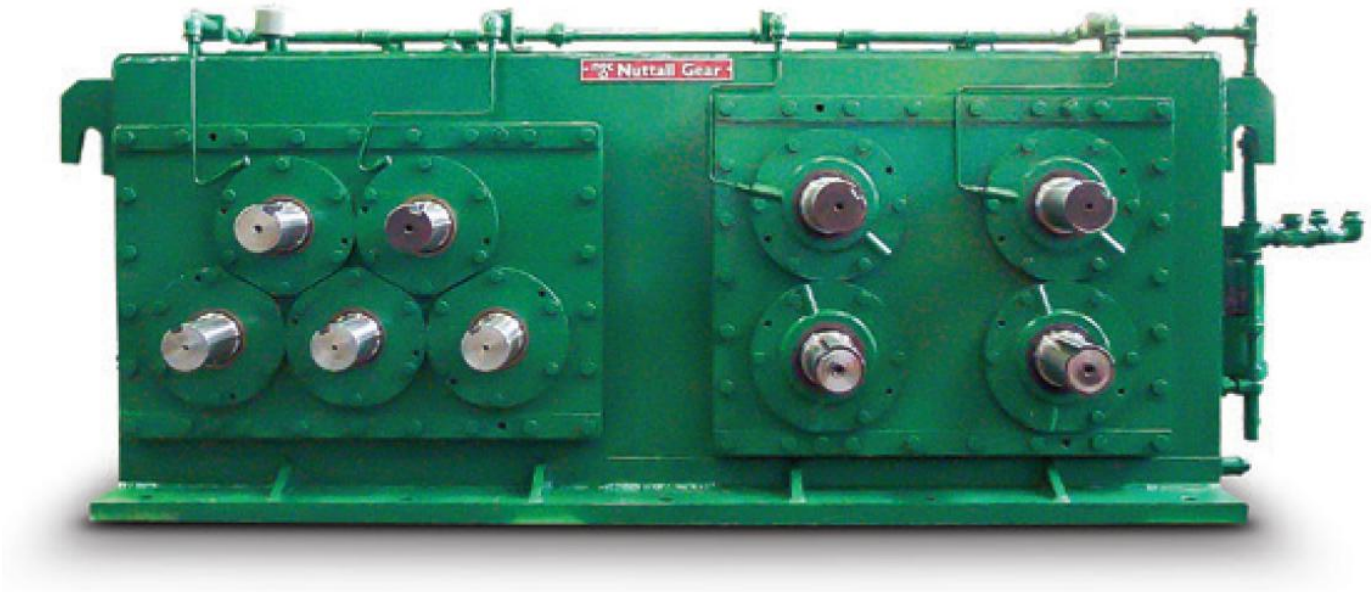
A major steel producer needed an upgrade to a straightener gear drive. The service requirement on the exist ing drive was increased which caused the heavily loaded gear in the train to fail due to overload.

Driven by a 500 hp motor, the straightener pulls strip steel through two sets of rollers that relieve stresses while straightening the coil.

Nuttall Gear provided the upgraded gear drive based on their long-stand ing working relationship with the cus tomer and their reputation for design ing and manufacturing robust steel mill gear drive solutions.

The rebuilt drive featured a reduction ratio of 1:1, a 1.25 service factor with a 160 rpm input and 160 rpm output.

The gearing upgrade to the affected components was changed from through hard ened gears to carburized



A rebuilt Nuttall gear drive from a steel processing line

Upgrades to a charging crane hoist gearbox resulted in extending the gearbox life by more than five years.

and ground gears for enhanced wear resistance and improved shock load capacity.

Delroyd Worm Gear Solves Drive Failure for Screwdown Mill Stands

The gear drives for screwdown mill stands at a major steel mill in Ohio were failing prematurely causing extensive downtime.

The worm gear teeth were wearing and breaking down at an accelerated rate due to improper meshing at the contact zone. The prob lem created excessive pressure at the gear's pitch line/contact zone.

Delroyd engineers met with the hot mill managers to conduct an on-site inspection and short-term mill stand monitoring period.

Through these efforts, it was determined that the cause of the drive failures was that three different gearing manufacturers had supplied gearing, all with differ ent thread designs, which were being mixed and matched over time.

A spare worm and gear sample was sent to the Delroyd facility so that a new gearing solution could be reverse engineered to ensure that all gear sets installed on the hot mill stands would have a matching thread/tooth design.

The new Delroyd gearing solu tion extended the gearing life from six months to more than six years.

Delroyd Worm Gear Develops New Gear Set for Steel Mill Charging Crane

Gearboxes for a charging crane hoist drive were failing prematurely at a large steel mill in Northeastern U.S.The failures were causing unfavor able outages and expensive periods of downtime.

Due to their desire and reputation to solve problems, Delroyd was called in to help analyze the situation and develop a solution. A meeting was held at the mill with various parties includ ing an outside service group, mill

engineers, maintenance managers and Delroyd engineers. All aspects of the ongoing issues were reviewed and an on-site inspection of a failed gearbox was performed.

Based on their findings, Delroyd engineering developed new worm gear sets utilizing aluminum bronze gears and redesigned the bearing mountings to enhance strength and durability.

lA carburize hardened, ground, and polished alloy steel worm develops a smooth, work-hardened surface on the aluminum bronze gear.

Extra- heavy side plates were used to connect the worm and gear shaft bearing supports, assuring proper meshing of the gear under all conditions of load.

A more rigid fabricated steel housing design was utilized to reduce bending moment stresses. A redesigned, more efficient lubrication system was also incorporated.

The Delroyd design changes resulted in extending the gearbox life by over five years. The charging crane gearbox success prompted the mill to utilize Delroyd's expertise by providing gearboxes for their gantry cranes as well.

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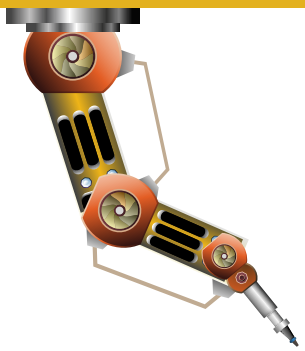

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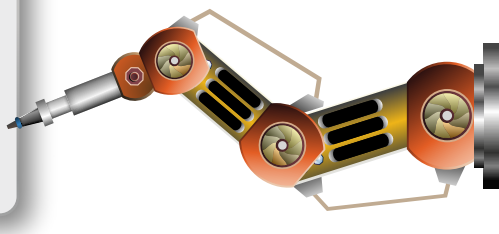

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Nimble Machines: Redefining Gear Cutting

By: Sai Sagar

In today's rapidly evolving gear manufacturing landscape, the demand is growing for high performance, precision and high-quality gears. The customers expect a techno-commercially competitive solution in precision gears for various fields such as automobile, automation, energy and other allied sectors. The requirement of high precision gears is on the rise with the emergence of the e-mobility market.

Nimble Machines provides high-speed CNC Gear hobbing machines - VAJRA 130, 250, and 400, capable of hobbing up to 8 modules and 400mm diameter. VAJRA 130 was recently launched to cater to the demands of smaller, high-quality gears. It is suitable for dry and wet hobbing up to module 3 and 130mm diameter. VAJRA Gear hobbing machines have found much interest in diverse industries including Tier-1 Automobile gear manufacturers, Gearbox Manufacturers and SMEs in General engineering.

In the world of CNC gear hobbing machines, precision is our top priority. Our design and FEA teams conduct thorough Static and Dynamic Analysis, Modal Analysis, and Frequency Response Analysis. This ensures our machines are structurally sound and perform optimally in various conditions, resulting in high-quality gear production.

Key Technological Offerings

Incorporating cutting-edge technology, our CNC gear hobbing machines offer a range of innovative features that optimize performance and productivity such as:

1. **Direct-drive for Hob spindle and Work table:** This enables our machine to achieve higher hob speeds of over 240 with the latest high speed carbide cutting tools to give high productivity, superior cycle time and quality.
2. **Linear Scale:** the hobbing machines are also offered with linear scale which offers enhanced feedback on the location of the cutting tool and workpiece.
3. **UCRIDE Technology:** The machines are designed with UCRIDE® technology consisting of epoxy granite filling to ensure reduced vibration and higher damping effect.
4. **Automation:** Indexing type ring loader for component loading/ unloading Component Magazine with conveyor belt system for continuous component feeding enhances the overall rate of productivity.

These features enable the machines to produce high-quality gears of up to DIN7 Class at a higher production rate.

Enhancing User Experience and Efficiency

With a focus on user-centric design, our machine simplifies maintenance, offering compelling reasons to consider it.

1. **Latest CNC Controller:** The machines are offered with the latest Siemens 828D or FANUC Oi-MF control system to meet customer preferences around the globe.
2. **User-friendly and customizable macros:** These make the machines easy to operate, program and meet the expectation of customers with regard to ease of use.
3. **Softwares:** Machines are developed suitable for Hobbing Spur, Helical, sprocket, spline, taper hobbing, Tangential hobbing using taper hob for worm wheel, hobbing of Orientation components are developed. In addition, availability of CNC programs for bad sector skip and V-Shift enables maximum utilization of hob life.
4. **Remote diagnostic feature:** Allows real-time monitoring and troubleshooting from afar, enhancing efficiency and minimizing downtime.

Nimble Machines' VAJRA series of CNC gear hobbing machines meet the growing demand for precision gears. With advanced features and user-centric design, we're committed to excellence in gear manufacturing.

For more information, visit:
https://nimblemachines.co.in/

Webinar Recap: Maintenance & Troubleshooting of Gearboxes

By: Sushmita Das

Gear Technology India had its first-ever webinar on the "Maintenance & Troubleshooting of Gearboxes." This was conducted by Gear Technology India's technical advisor, Mr. C. Selvaraj. Held on August 18, the webinar was attended by 40 eager attendees who sought to enhance their technical knowledge on the subject.

Key Highlights

Expertise of Mr. Selvaraj: Mr. Selvaraj, our esteemed speaker, brought a wealth of knowledge and four decades of experience in the field of gear and gearbox manufacturing and servicing, to the virtual stage. His engaging presentation and comprehensive insights into gearbox maintenance captivated the audience.

Knowledge Sharing: The webinar successfully achieved its objective of educating attendees about various technical aspects of gearbox maintenance. Mr. Selvaraj's multi-dimensional approach covered every technicality ranging from preventive maintenance strategies, tooth breakage, pitting, scoring, gear defects to troubleshooting common issues, leaving participants better equipped to handle gearbox-related challenges.

Interactive Session: The Q&A session allowed participants to interact directly with Mr. Selvaraj, fostering a dynamic exchange of ideas. This interaction contributed to a deeper understanding of troubleshooting and maintenance gearbox best practices.

Conclusion

Following the success of our first webinar, the next webinar is on the servicing of gears and gearboxes. This will take place on September 22 at 4 pm IST.

Aimed at procurement engineers and maintenance heads from various industries like cement, power, paper, wind, mining, sugar and steel, this webinar will cover key areas such as:

1. To increase the power density of the gearboxes
2. To improve gearbox life
3. Technology upgradation in old gearboxes

Register here: https://us02web.zoom.us/webinar/register/WN_fzKL0G0nSgCz6WjPFY85EA