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MEASURING TOOTH FLANK ROUGHNESS
The Contact Stylus Profilometer provides a pragmatic, accurate and reproducible tooth flank roughness measurement.
By MARK MICHAUD

GRADING THE STRENGTH OF STEEL
Newly developed high-strength steel for car powertrain and transmission components includes three grades — knowing the difference will help you meet your quality goals.
By GREGORY VARTANOV

THE DETECTION OF GRIND TEMPER ON GEARS
Magnetic Barkhausen Noise is quantitative, repeatable, non-destructive, and it is easily automated, thus removing operator influence as a variable.
By JAMES THOMAS and STEPHEN KENDRISH

COMMON SENSE INSPECTION SOLUTIONS
COMPANY PROFILE After 70 years, Precision Gage Company brings quality gear inspection to the industry, whether it be dimension-over-wires gages or fully-automated dual-flank composite test systems.
By KENNETH CARTER
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In this section, the premier supporter of gear manufacturing in the United States and beyond shares news of the organization’s activities, upcoming educational and training opportunities, technical meetings and seminars, standards development, and the actions of AGMA councils and committees.
2019 has new things in store

There are some big things coming to the gear manufacturing industry in 2019, and now that the new year has arrived, we can take a moment to reflect on what’s on the gear horizon.

One of the biggest developments is the name change in the biannual gear manufacturing trade show. What was once Gear Expo is now the Motion + Power Technology Expo (and kudos on the awesome plus sign). Even though the name has changed, it still will offer the same attention to gears, but with a whole lot more. The three-day event in September is for all manufacturers, suppliers, buyers, and experts in the motion and power transmission industries. I hope to see you there.

We at Gear Solutions are also constantly changing and evolving to best meet our readers’ needs and interests, and this month’s content is no exception.

With focus topics featuring raw materials and coating/finishing, we’re offering several articles that dive into these less-than-glamorous, but essential, aspects of gear manufacturing.

Mark Michaud with REM Surface Engineering offers up his expertise on measuring tooth flank roughness.

And Gregory Vartanov, a chief engineer with Advanced Materials Development Corp., shares his insights about three grades of newly developed high-strength steel used for car powertrain and transmission components.

I’d also like to take this time to introduce a new columnist to the Gear Solutions family. Guy Brada, a metallurgical engineer who is a technical sales service manager for Ellwood City Forge, is taking over our Materials Matter column. His inaugural contributions revolve around understanding what is meant by “aircraft quality” steel cleanliness. Gear Solutions is proud to be able to share his expertise.

I hope 2019 brings you much prosperity and happiness, and I also hope Gear Solutions can bring you the best the gear manufacturing industry has to offer this year and many years to come.

Happy New Year, and, as always, thanks for reading!

KENNETH CARTER, editor
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editor@gearsolutions.com
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**INDUSTRY NEWS**

**Precision Gear Inc. acquires Arrow Gear to form new company**

Michael Cowell, CEO, and M. Briggs Forelli, Chairman, announce Precision Gear Inc. (“PGI”) of College Point, New York, has acquired Arrow Gear Company (“AGC”) of Downers Gove, Illinois. The purchase was concluded on November 16, 2018.

The combined strength of PGI and AGC will provide the gear and shaft market with 160 years of manufacturing expertise in providing Flight Safety Critical hardware. The confluence of the advanced gear and shaft manufacturing capabilities and an experienced and proven management team will significantly improve our stature across the industry.

Precision Gear and Arrow Gear will continue to operate from the current facility locations, while leveraging their corporate affiliation. A management holding company has been established to ensure organizational guidance and strategic oversight to pursue a competitive vision for the group. The new entity has been established as Precision Arrow Gear Group (PAGG). The merger of these companies will enhance the diversity and depth of the product offering to the market while expanding the companies’ presence in the industry.

**MORE INFO**  www.precisiongearinc.com

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**Klingelnberg to present top-class technology know-how at IMTEX 2019**

On January 24-30, 2019, the Klingelnberg Group will be taking part in India’s Metal Cutting Machine Tool Exhibition (IMTEX) – now in its 19th year – in Bangalore, India. One of the largest exhibitions for the metal-cutting industry in South and Southeast Asia, the week-long trade show presents the complete spectrum of products and technologies in the machining industry.

Klingelnberg (represented by its Indian subsidiary, Klingelnberg India PVT LTD.) will also be on hand, showcasing its extensive line of products and services at Booth A-104 in Hall 4. Visitors can look forward to two machine highlights.

- **The Höfler Speed Viper² 180 cylindrical gear grinding machine with dual-spindle concept and Koenig automation**
  
  A winner of the iF-Design Award, the Speed Viper cylindrical gear generating grinding machine was developed by Klingelnberg with a special focus on high-production generating grinding.
  
  The innovative machine concept was unveiled for the first time at the EMO 2017 exhibition in Hanover, Germany, and was presented to a large international audience the following year. Klingelnberg is taking India’s IMTEX trade show as an opportunity to introduce additional new developments in the Speed Viper series.
  
  Thanks to an innovative drive in the dual-spindle model and its superb automation capability, the Speed Viper² achieves significantly lower auxiliary times, while offering a design that is optimized for the Industry 4.0 production environment. The dual-spindle concept of the Speed Viper² is therefore especially designed to meet the productivity requirements of the automotive industry and its suppliers. Whereas the single-spindle machines offer high versatility and short set-up times, the dual-spindle machines also feature a design that is suited to large-scale production and minimal cycle times.
  
  The Speed Viper² combines the outstanding grinding technology of Höfler machine tools with the tried-and-tested Klingelnberg Closed Loop method, which customers are already familiar with from bevel gear technology. By transferring the Closed Loop concept established by Klingelnberg to the world of cylindrical gears, the mechanical engineering company has made another systematic step toward digitalization in gear manufacturing. Thanks to a broad array of applications and software, Klingelnberg’s cyber-physical production system centralizes production control, leading to a standardization of results achieved on different machines and even in different plants.
Klingelnberg will also be showcasing a measuring machine made for just this type of Closed Loop process: The P 40 precision measuring center stands for future-proof quality management of gears and features a compact footprint suited to a workpiece diameter range of up to 400 mm. The machine and software concept are optimized for the measurement of complex drive components using a technology that replaces up to six conventional measuring methods: gear measurement, general coordinate measurement, form and position measurement, roughness measurement, contour measurement, and optical measuring technology. This guarantees maximum measuring accuracy and reproducibility. Klingelnberg’s P series is one of the most widely used standards in the industry and serves as a reference for metrology institutes.

Klingelnberg’s solutions bring it close to the market and the user – with regard to services and software solutions as well. IMTEX visitors will have an opportunity to see this for themselves at Klingelnberg Booth A-104 in Hall 4.

MORE INFO www.klingelnberg.com

SKF and KISSsoft release new interface for machine design

SKF and KISSsoft have worked together to create a new interface that makes it much easier to develop gear units. When designing machines, engineers can select suitable bearings based on the very latest bearing technologies in the interface. This enables KISSsoft’s customer to use these two calculations approaches: the usual ISO calculation and, now, the SKF rating life based on the updated bearing data.

KISSsoft users are provided with SKF bearing performance results based on up-to-date bearing data via the SKF cloud service. The user is supplied the appropriate results in an engineering report generated by the KISSsoft calculation software. By creating this new interface, SKF and KISSsoft are responding to the request, from many engineers, for a single tool that includes many different types of design data, and design guidelines and restrictions, automatically updates them, and is documented in a user-friendly format from end to end.

Victoria van Camp, Member of SKF AB’s management board and head of Technology Development, said, “This partnership

AKGears adds one-day onsite Asymmetric Gear Design seminar

In 2019, AKGears added a new one-day onsite seminar called Asymmetric Gear Design. It is a part of a two-day onsite seminar, Direct Gear Design, provided since 2015. These onsite seminars, led by Dr. Alex Kapelevich, are motivated by the successful implementations of the Direct Gear Design method in different industries for a variety of gear drive applications.

The goal of the seminars is to familiarize attendants with an advanced alternative gear geometry definition and optimization method that can achieve gear drive performance that is not obtainable by traditional gear design methods. Along with the analytical aspects of this gear design approach, attendants will learn about its experimental confirmation and practical implementation, and also use AKGears’ custom-built software.

The new Asymmetric Gearing book addresses all aspects of asymmetric gear development, including the origins, theoretical fundamentals, tooth geometry optimization, stress analysis and rating, design and production specifics, analytical and experimental comparison to the best symmetric gears, and application examples.

AKGears, LLC, is a gear design consulting firm that specializes in performance maximization of custom gear transmissions. “Asymmetric Gearing” is available at CRC Press and Amazon.

MORE INFO www.akgears.com
The Coordinate Metrology Society (CMS) has formally issued a call for technical papers for the 35th annual Coordinate Metrology Society Conference (CMSC) to be held July 22–26, in Orlando, Florida. The CMSC provides an inclusive knowledge platform for subject matter experts from the portable and traditional Coordinate Measurement Machine (CMM) communities. Author practitioners are encouraged to submit abstracts covering technological advancements, research findings, successful implementations, and best practices. Authors must submit their abstracts to the CMS by March 8, 2019. Since 1984, more than 525 original technical papers have been presented to the eminent membership association for measurement professionals worldwide. The organization maintains a digital library of more than 100 technical papers delivered at the CMSC over the past 12 years. Ideal for research, this is the most comprehensive repository of metrology knowledge and information in the world.

The Coordinate Metrology Society Conference is a premier venue for metrology practitioners and scientific researchers. The CMS seeks original, expert contributions or major developments in previously reported work on topics that include, but are not limited to: case studies, technology benchmarks, metrology solutions for automation, process control, assembly, and more, as well as other Smart Factory trends that unlock the potential of 3D metrology technologies. Each new harvest of technical papers serves to introduce next-generation ideas and forge a collaborative bridge between professionals with different skill levels, as metrology becomes more impactful across the manufacturing domain than any time before.

Submissions are accepted from master practitioners working in the portable and traditional CMM fields. Commercial content is not accepted by the CMS. All technical papers that are presented at CMSC 2019 will be reviewed, scored, and selected by the CMS executive committee for publication in the prestigious Journal of the CMSC. Authors and researchers are also encouraged to cite CMSC technical papers if referenced in their own technical papers. The comprehensive CMSC Technical Paper Guidelines document can be downloaded at www.cmsc.org.

Each abstract is peer-reviewed by the CMS executive committee, and if selected, the author will receive a Notification of Acceptance on April 5, 2019. Conference reg-
istration and membership fees are waived for accepted individual speakers. In the case of multiple authors, the CMS will waive one conference registration and membership fee.

The Coordinate Metrology Society supports the ongoing development and career advancement needs of expert and novice metrologists. A record-breaking 28 authoritative technical papers and presentations were delivered in the 2018 CMSC conference programming. Attendees experienced a wide range of topics including automated part inspection using CNC machine probing, laser tracking measuring systems with an integrated traceable frequency comb, and automated Coordinate Measuring Machine uncertainty analysis. Speakers represented many leaders in the field: Boeing South Carolina, Tusas Engine Industries Inc., Lockheed Martin Aeronautics Company, Newport News Shipbuilding, Boeing Canada, MetroSage llc, Electroimpact, Argonne National Laboratory, Los Alamos National Laboratory, MIT Lincoln Labs, Fermi National Accelerator Laboratory, National Institute of Standards and Technology (NIST), National Physical Laboratory (NPL-UK), Missouri University of Science and Technology, Tianjin University, Chinese Academy of Science, and University of Bath Mechanical Engineering.

MORE INFO www.csmc.org

Fives moving Machine Tool Services & Solutions business to new facility

Fives Machining Systems, Inc., a global machine tool and complete manufacturing solutions provider, has announced the relocation of its Machine Tool Services & Solutions business to a new production facility at 2200 Litton Lane, Hebron, Kentucky. The Machine Tool Services & Solutions business provides productivity enhancements and service support to aerospace and industrial manufacturers for the full range of machine tools in their facilities.

"With the tremendous growth we have experienced since the acquisition of the Konecranes MTS in January of this year and the addition of service centers in the key strategic markets of Wichita, Kansas, and Charlotte, North Carolina, our business has outgrown the space available in the former Konecranes MTS facility in Erlanger, Kentucky. This move provides the expanded floor space in a modern climate-controlled facility that is needed to accommodate the retrofit and rebuilding of our customers' key assets," said Steve Thiry, president & CEO of Fives Machining Systems Inc. "Our mission to be a world-class service and solutions provider requires the resources and infrastructure of a state-of-the-art production facility. It is an exciting expansion of our retrofit and rebuild capacity."

Within Fives, the Metal Cutting | Composites business line includes Fives Cincinnati in Hebron, Kentucky, specializing in aerospace and metal cutting and composite machines and systems; Fives Giddings & Lewis in Fond du Lac, Wisconsin, concentrating on large, high-precision boring mills, machining centers and vertical turning centers; Fives Lund Engineering in Seattle, that provides unique design-to-build solutions; Fives Liné Machines in Granby, Quebec, Canada; and Fives Machining in France, producing large portal mills, automation systems, robotic

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Circle Gear
Heller Machine Tools names Ellison Machinery sales partner for Arizona

Heller Machine Tools has announced its new strategic partnership with Ellison Machinery. Headquartered in Tempe, Arizona, Ellison Machinery is an industry-leading provider of machine tool sales, service, and support to the Arizona region.

Ellison Machinery will introduce and support the full range of Heller products to many sectors including defense, aerospace, military, and energy markets. Heller is proud to have Ellison Machinery promote Heller products in the Arizona region.

Ellison Machinery Company’s award-winning service team is committed to providing the highest quality technical support in the industry. Their service team is available 24 hours a day in the Phoenix and Tucson metropolitan areas. Factory-certified technicians are ready to respond quickly.

Ellison Machinery handles CNC machine sales, services, and training. Ellison Machinery Company is the leading CNC machine tool distributor in Arizona and Southern Nevada.

Heller designs, develops, manufactures, and engineers machine tool production solutions globally. It has manufacturing plants in Germany, the United States, Brazil, China, and England. Heller Machine Tools experts handle special manufacturing solutions in the automotive, oil and gas, aerospace, defense and heavy machinery industry sectors.

MORE INFO
www.heller-us.com
www.ellisonaz.com

Marposs acquires automation assembly and test company

Marposs, a world leader in measurement and process monitoring technologies, has announced the acquisition of Elettrosystem s.r.l. based in Scorzolengo (AT) Italy, specializing in automation, assembly, and industrial testing. This acquisition is part of Marposs’ strategy to expand its solution offerings by integrating products and capabilities that complement its traditional portfolio.

Founded in 1980, Elettrosystem offers custom-engineered solutions for a variety of needs such as plastic vial assembly and test machines for the medical industry or cylinder head assembly lines for automotive applications. These automated solutions can perform a variety of operations inclusive of material handling, vision inspection, measurement, functional testing, and assembly, to name a few.

The company is composed of 60 engineers and technicians and has installations across four continents.

MORE INFO
www.marposs.com

machining and tooling solutions.

The Machine Tool Services & Solutions will now be headquartered in Hebron, Kentucky, and support the activity of more than twenty service centers worldwide, including the seven in North America: Hebron, Kentucky; Seattle, Washington; Valencia, California; Wichita, Kansas; Charlotte, North Carolina; Fond du Lac, Wisconsin; and Cambridge, Ontario.

MORE INFO www.fivesgroup.com
January 2019

American Gear Manufacturers Association

Jenny Blackford
Vice President of Communications
AGMA

2018 was a year of evolved innovation

Looking back through the last 12 months, it is easy to see the changes within our industry, your businesses, and even some of our own programs. What hasn’t changed, and won’t ever change, is AGMA’s promise to drive power transmission innovation with members.

Our No. 1 issue is finding talent. It’s a tight labor market; you can’t achieve innovation without employees. To proactively address this challenge, the AGMA Foundation launched the “Get Into Gears” program in December. This program provides industry with marketing tools you can leverage to promote both the industry and the positions you have available. The AGMA Foundation has created the templates so you don’t have to! Your opportunity is to take those tools and share the exciting industry we work in to anyone and everyone you can in order to attract employees to your company.

What a simple innovation: a useable, tangible toolkit that provides tactical support to members looking to hire. I’m proud to share that 17 percent of the membership have already downloaded materials, and it’s only been a few weeks.

Another innovation driver is education. You can’t change something if you don’t have some idea of how everything works. At AGMA, we support your engineering team’s innovation efforts via strong, focused education. In 2018, we had 950-plus of your team members taking AGMA courses! We also saw four new people earn their Advanced Gear Engineering Certificate. We hosted our first Gear Failure Analysis course at Ranken Technical College and continue to build a strategic relationship with them to enhance the training process of gear professionals. We also continued to team up with Daley College on new training center initiatives that will put AGMA and its members into the forefront of industry education innovation. More to come on that soon!

To innovate, sometimes it’s critical that you hear from other experts or download data to help set a course. AGMA’s Business Connections Meetings: The AGMA Annual Meeting, the Fall Technical Meeting, the Strategic Resources Network, and Marketing & Forecasting, all delivered value to the more than 500-plus combined attendees. In a time of uncertain market conditions, tariffs, company changes, and global business relationship development requirements, we are reminded that coming together face-to-face can make all the difference in our growth as an industry. Haven’t tried one of these meetings to see how they can help your company? The 2019 lineup is already set — come out and see what you can achieve by learning with industry leaders.

AGMA also evolved a major value driver for Business Leads: Gear Expo is now Motion + Power Technology Expo. Strategically, we are positioning the event as a technically oriented, one-stop shop for everything power transmission related: machine tools, gears, fluid power, electric drive, heat treat, forged products — everything our customers need to have in order to achieve their own innovation.

AGMA is excited to have a formal partnership with the National Fluid Power Association at the show and will continue our strong relationship with ASM International to add value to this flagship event for the power-transmission sector. We are also connecting with other leaders from other associations in our space to ensure that the Power Transmission world comes to Motion + Power Technology Expo to learn and find innovation.

2018 was a year of innovation and new ideas with our members.

Change is challenging — hard even — yet change has always been a constant in the business world, and the same is true for the association space. The AGMA Board of Directors understands this, as do the renewed and energetic technical division and business division committees that drive the many programs we offer.

Working together, AGMA and its members are driving power-transmission innovation by staying focused on what’s really happening in the market, addressing proactively the primary challenges facing our sector, and changing when it’s required for the long term, greater good.

AGMA has more than 250 individuals that serve on committees across both technical and business committees. Are you one of them?

I encourage you to actively participate in AGMA programs in 2019 — not just because of loyalty — but because we can be a critical part of your own innovation efforts. You can start by visiting www.agma.org and see what’s happening.
Exhibit at the Motion + Power Technology Expo and make a true investment into your company!

VALUABLE CONNECTIONS AND QUALITY LEADS
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- Strengthen relationships with customers and colleagues.
- Benefit from a high-value machinery show with low costs and highly qualified leads.

MARKETING SUPPORT DEDICATED TO DELIVERING VISIBILITY
- Promotion through a multichannel, integrated marketing campaign including direct mail, digital advertising, print advertising, emails, social media, public relations, industry publications, grassroots partnerships, and one-on-one conversations throughout the industry.
- Motion + Power Technology Expo will be promoted all over the world through a network of partners and allied associations to bring the largest possible audience to your booth.

TRAFFIC ENHANCEMENTS BUILDING EXCITEMENT INSIDE THE EXHIBIT HALL
- Co-locations with ASM and NFPA deliver new attendees to the Expo.
- On-floor education attracts informed buyers looking for technical solutions.
AGMA's Fall Technical Meeting will be held concurrently with the show and includes access to the exhibits.

Networking events, such as lunch breaks and receptions, keep attendees active and engaged inside the exhibit hall.

MORE INFO  MotionPowerExpo.com

THE AGMA/ABMA ANNUAL MEETING REGISTRATION IS OPEN

Join the 300 gear and bearing executives from around the world in Scottsdale, Arizona, April 11-13. Engage with expert industry speakers, learn from panel presentations on the future of gears and manufacturing, and join your peers for a meeting that will connect you with the opportunity to drive your business into the future. Join us for an unforgettable 2019 Annual Meeting!

GET INTO GEARS IS HERE! DOWNLOAD THE AGMA FOUNDATION EMPLOYEE RECRUITMENT TOOLKIT TODAY!

Having trouble finding employees, especially at the operator level? Our free Employee Recruitment Toolkit is designed to help you recruit people into a great career in the gear industry. Download the kit at: agmafoundation.org/getintogears/.

Upcoming Classes

The 2019 courses are all up for registration. Make sure to register today to reserve your spot! Make 2019 the year that you join one of the many students who have completed their Advanced Gear Engineering Certificate.

GEAR MANUFACTURING & INSPECTION

JANUARY 29-31 | FORT WORTH, TEXAS

Discover key factors in the inspection process that lead to better design of gears. Develop a broad understanding of the methods used to manufacture and inspect gears. Interpret how the resultant information can be applied and interpreted in the design process. This course also includes a tour of Integrated Machinery Solutions.

GEARBOX CSI

FEBRUARY 20-22 | ALEXANDRIA, VIRGINIA

Gain a better understanding of various types of gears and bearings. Learn about the limitation and capabilities of rolling element bearings and the gears they support. Grasp an understanding of how to properly apply the best gear-bearing combination to any gearbox from simple to complex.

GEAR MATERIALS, SELECTION, METALLURGY

MARCH 19-21 | LAS VEGAS, NEVADA

Learn what is required for the design of an optimum gear set and the importance of the coordinated effort of the gear-design engineer, the gear metallurgist, and the bearing system engineer. Investigate gear-related problems, failures, and improved processing procedures.
CALENDAR OF EVENTS

Whether you’re looking for technical education, networking opportunities, or a way for your voice to be heard in the standards process, AGMA has something to offer you. If you would like more information on any of the following events, visit www.agma.org or send an email to events@agma.org.

JANUARY
- January 17 — Metallurgy and Materials Committee Meeting — WebEx
- January 23 — Helical Gear Rating Committee Meeting — WebEx
- January 29 — Wind Turbine Gear Committee — WebEx

FEBRUARY
- February 5 — Gear Accuracy Committee Meeting — WebEx
- February 12 — Helical Gear Rating Committee Meeting — WebEx
- February 13 — Nomenclature Committee Meeting — WebEx
- February 26 — Metallurgy and Materials Committee Meeting — WebEx

MARCH
- March 5 — Gear Accuracy Committee Meeting — WebEx
- March 7–8 — Working Group 2 — AGMA Headquarters
- March 12 — Metallurgy and Materials Committee Meeting — WebEx
- March 13 — Spline Committee Meeting — WebEx
- March 14 — Wind Turbine Gear Committee — WebEx
- March 26 — Helical Gear Rating Committee Meeting — WebEx
- March 27 — Nomenclature Committee Meeting — WebEx
"The most decisive aspect when buying our 2\textsuperscript{nd} ZP15 KAPP NILES machine is the advantage of a kinematic capability that allows us to work much bigger diameters than having to purchase a larger and higher priced machine. Since we're already running on a ZP15, we knew that we can count on the KAPP Technologies team for support whenever needed. The KAPP applications engineers are particularly responsive to our needs and their knowledgeable service team keeps our machines in top shape with their annual maintenance."

- Jerry Capone
  Shop Operations Manager with Umbra Group

Umbra Group provides motion solutions and components or systems for Aerospace, Power, and Industrial high-tech markets. They just purchased their 2\textsuperscript{nd} ZP15 machine from KAPP NILES.
When someone gives you the shaft

Many methods exist for securing gears to a shaft, but there are pros and cons for each.

Did you ever have someone “give you the shaft”? This insult is defined as ignoring or putting someone down. In gearing, giving you the shaft is just the beginning part of constructing your gear train. Each gear in a system is going to be resting on a shaft as the purchase of each gear is to transmit motion through the shafts of the mechanism. Just as there are many types of gears, there are also many types of methods to attach a gear to a shaft.

In last month’s column, I mentioned keys and keyways. Typically, when keys are used with gears, they are accompanied by set screws (also known as grub screws). The tapped holes to accommodate these screws are commonly positioned above the key slot as shown in Figure 1 and the second at 90 degrees to the key slot.

This allows one set screw to hold the key in place and the other screw to press into the shaft. However, a better solution is to have two tapped holes set at 120 degrees from the centerline of the key slot as shown in Figure 2, as this balances the gear and reduces noise at higher speeds.

Although set screws and keys are the most common form of attaching a gear to a shaft, there are many other methods, and each of these methods makes sense depending on your application.

- **Press-fit:** Just as it sounds, it is possible to press a gear onto a shaft. If the tolerances between the bore of the gear and the diameter of the shaft are properly sized, (the bore is undersized, and the shaft is oversized) then you can use a press to force the gear onto the shaft and the resulting pressure will hold the gear in place. This method works best if you never need to remove the gear from the shaft and if you do not need to have a specific alignment between the gear teeth and the shaft.

- **Drill & Pin:** This is one of many permanent methods of fixing the gear to the shaft. This method involves drilling a hole through the side of the hub and through the shaft and out through the opposite side of the hub and then fixing a taper pin or a cotter pin into the hole. This method is infrequently used because it does not permit alignment, creates noise and vibration at high speeds, and will fail if the pin falls out.

- **Welding:** It is possible to weld a gear to a shaft. This method is not very common because heating the gear and the shaft can result in distortions that will cause the gear to either be noisy or fail prematurely. It does however guarantee a strong bond between the gear and the shaft.

- **Shrink fit:** This method is preferable to both press-fitting and to welding. In this method, you use an induction heater to warm the gear nearest to the bore and then you slide it onto the shaft. As the gear cools, the bore shrinks, and the bond between the gear and shaft is formed. This method works well when the gear needs to be repeatedly removed for maintenance or for replacement as it does not distort the gear teeth, nor does it warp or score the shaft.

- **Use of a keyless shaft-hub locking mechanism:** There are several styles of locking hubs that exist. Their primary purpose is to allow for the repeated repositioning of the gear and also to prevent any damage to the shaft during installation or removal. Thus, they perform the same action of a shrink fit, but they use mechanical means instead of heat.

- One such style uses two hubs in which the inside hub presses...
against the shaft when the screws are tightened, and the outside hub presses against the bore. Together these two hubs force equal pressure on the bore and shaft and hold the gear in place. What is great about this style of mechanism is that they allow for infinite positioning of the gear teeth in relation to the shaft. The downside is that they add mass to the mechanism and require additional space for installation. (Figure 3)

- Another style integrates a locking mechanism directly into bore of a gear. This style is marketed as the Concentric Maxi Torque© keyless shaft hub mechanism. It combines a proprietary hub with a tapered insert. As a set screw is tightened between the insert and the hub, the mechanism presses on both the bore and the shaft, generating the necessary holding force. This item is also excellent for repositioning, and neither mars the shaft, nor does it take additional space.

- A third style integrates a locking mechanism into the hub of a gear. This style uses two intersecting slots in the gear hub to generate a wedge section. The wedge is closed by a cap screw, which forces the free section of the hub to clamp onto the shaft. This mechanism is excellent for repositioning but is limited by the holding strength of the wedge. (Figure 4)

These are some of the many ways that you can fix a gear to a shaft. Each has its pros and cons, both mechanically as well as cost. Hopefully the next time someone hands you a shaft, it is for assembling a gear mechanism and they are not “giving you the shaft.”

ABOUT THE AUTHOR
Brian Dengel is general manager of KHK-USA, which is based in Mineola, New York. Go online to www.khkgears.us

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Understanding different types of heat treatment: Annealing

Annealing provides a uniform microstructure to a soft part to enable forming or machining. Let’s take a look at the different processes and application methods.

In the last few installments we discussed the use of Time-Temperature-Transformation and Continuous Cooling Transformation diagrams to understand the phase changes that occur during heat treatment. In this column, and in forthcoming installments, we are going to discuss the application of CCT diagrams to actual typical heat treatments. This month we will focus on annealing. We will use a couple of typical alloys to illustrate the microstructures resulting from different heat treatments. The resultant microstructures will be predicted using JMatPro (Sente Software, 2018), a software program that allows the prediction of microstructure for many different alloys and ifv Integra (Swerea IVF AB, 2012), which calculates the microstructure based on actual cooling curves of quenchants.

ANNEALING

The purpose of annealing, is to make a part have a uniform microstructure, that is soft, to enable forming or machining. Annealing can be performed at the mill, and the material received at the plant ready to be machined, or it can be done in-house to facilitate machining. There are many different types of annealing that can be performed. But in all cases, the primary reason for annealing is to soften the part and increase the ductility for forming or machining.

Homogenization Annealing is an annealing method that is used at the steel mill. This annealing process is somewhat specialized, in that the purpose is to level out segregation in steel ingots or continuously cast strip. Very high temperatures and very long times are used to allow variations in chemistry due to segregation to level out. This segregation is why there is a different hardenability at the ends of a coil. Once ready to be cooled, the ingots or coils are removed from the furnace, and allowed to air-cool. Because air cooling is relatively uncontrolled, variations in grain size and microstructure can occur. This often explains the different performance of one mill over the other during forming, even while meeting the procurement specifications.

A full anneal is accomplished by heating the steel above the upper critical temperature, transforming the microstructure to completely austenite. The furnace is turned off, and the temperature allowed to drop. Alternatively, the furnace is ramped down in temperature at a specific rate (typically no more than 40°C/hour). Typically, this can take 30 hours or more depending on the alloy. In an AISI 4140 steel, cooled at a rate of 18°C/hr resulting microstructure is a coarse pearlite that is readily machined (Figure 2).

Isothermal annealing or process annealing, is slightly different from a full anneal, but produces a similar microstructure. In this process, the part is heated to above the upper critical temperature, and then is cooled quickly to approximately 650°C (1,200°F), and is held isothermally for a period of time. The austenite transforms to ferrite and pearlite. The part is then withdrawn from the furnace, and allowed to air cool in some convenient manner. The advantage of an isothermal anneal over a process anneal is predominately shorter time. A full anneal will require about 30 hours, but an isothermal anneal will require approximately four hours, depending on the alloy. This is shown in Figure 3.

NORMALIZING

Normalizing is a similar process to full annealing, but with some important differences. When normalizing, the temperatures are approximately 25°C above the normal hardening or austenitizing temperature. After complete transformation to austenite (generally soaked at temperature for one hour per inch or 25 mm of thickness), the part is withdrawn from the furnace and allowed to air cool. These processes are typically performed on weldments, forgings or castings.

The forging process (as well as welding and casting) occurs at elevated temperatures, where grain coarsening can occur. This means that forgings can have a large variability in the grain size. Depending on how the forging (or weldment) is cooled from the forging or welding temperature, the microstructure will be mixed, and exhibit large variability in hardness. There are also large residual stresses (thermal and transformational) that can result in distortion. The purpose of normalizing is produce a fine-grained and uniform microstructure — typically fine grains of fine pearlite.

The largest difference between full annealing and normalizing, is the lamellar spacing of the resulting pearlite. Very coarse pearlite is very soft. Fine grained pearlite is harder, and somewhat easier to machine. There is also less work hardening during machining, because the steel is less “gummy.” For low hardenability steels, air
cooling can produce a fine pearlitic microstructure, with fine grain. The resulting hardness is in the upper HRB range. However, for steels with high hardenability, a fast air cool can result in a mixed microstructure containing significant quantities of bainite, and possibly martensite (for very high hardenability steels). The resulting hardness is also greater. For instance, AISI 4140 normalized at 875°C, and air cooled at 1°C/s, would have a hardness of approximately 28 HRC, and a microstructure consisting of 62 percent bainite, 32 percent proeutectoid ferrite and approximately 6 percent pearlite (Figure 4).

SPHEROIDIZING ANNEAL

Spheroidizing or a spheroidizing anneal is a process where the lamella of pearlite consisting of iron carbide or Fe₃C is transformed to spheres of iron carbide. The resulting matrix is now ferrite with spheres of cementite, instead of pearlite, which is a matrix of ferrite with lamella of cementite. Below the lower critical temperature, the diffusion of carbon is slow, so long times are required to spheroidize the cementite lamella.

The primary reason for spheroidizing is to produce a very ductile steel suitable for deep forming, or forming in complex shapes. The spherical carbides allow the steel to plastically deform without cracking. It also reduces die wear by reducing the necessary pressure for forming. Since long furnace times are necessary to produce the spheroidal carbides, this annealing practice is usually reserved for difficult to form parts, or where the extended die life can justify the increased costs of spheroidizing.

There are two basic methods to spheroidizing annealing. These are subcritical annealing and inter-critical annealing. In subcritical annealing, the steels are heated to just below the A1 temperature and held for an extended period of time (usually many hours). The steels are then cooled to room temperature in some convenient manner (usually air cooling). The parts do not transform to austenite, and so it is possible that some elements of the prior microstructure can remain. A fine pearlitic structure could be maintained to decrease the diffusion distance and improve kinetics. The structures of subcritical spheroidized parts usually contain fine spherical cementite inside ferrite grains. The final carbide size is adjusted with the selected heat treatment time and temperature.
In the inter-critical spheroidizing process, the steel is heated to above the A1 temperature and allowed to transform to austenite. This allows all the carbon to go into solution in the austenite. The part is then slowly cooled to approximate 650°C, where it is held for several hours. The precipitated cementite as pearlite will coarsen into spheroidized cementite. Large cementite particles may precipitate at grain boundaries. In general, inter-critical heat treatment produces larger cementite particles, with resultant lower hardness. The two processes are illustrated in Figure 5.

STRESS RELIEF
The purpose of stress relieving is to reduce the residual stresses present from forming or machining. It is not done to change the metallurgical properties or the microstructure. Cold working, grinding, machining or thermal cutting can produce significant residual stresses in the steel. During heat treatment, and specifically during the heating cycle, these stresses relive themselves. This manifests as a change in geometry. Further, stress relief is also accomplished between manufacturing steps to provide a residual stress free part, that will not bind or change shape as additional manufacturing steps are performed. It can also be done after heat treatment to improve fatigue strength. It will also improve dimensional stability of the part.

For many low alloy steels that have been severely cold-worked, heating slowly to 200-425°C (400-800°F) for a relatively short time (two to four hours) will reduce the residual stresses. For alloy steels, most stress relieving is performed 480-540°C (900-1,000°F) for two to four hours. This will reduce most of the residual stresses present. If the part is stress relieved after heat treatment and tempering, a temperature is used that is approximately 30-50°C below the tempering temperature. In all cases, the parts are slow cooled after stress relief to prevent the reintroduction of thermal residual stresses.

EXAMPLE
As an example of the benefits of annealing, landing gear for the Boeing F/A-18 A-C aircraft is manufactured from 300M. This is an extremely high hardenability alloy, that is similar to AISI 4340, but with additional carbon and silicon. This enables very high hardness while maintaining good ductility at strengths of 2000+ mPa (290,000 psi) UTS. The landing gear started as large forgings, which were air cooled in an uncontrolled fashion. This resulted in a large variation in surface hardness, with the hardness ranging from 25-55 HRC. This made machining difficult, and resulted in poor surface finish. To eliminate this problem, we used a specialized annealing heat treatment called spheroidizing or spheroidize annealing to eliminate the hard spots, and to produce a uniform microstructure for proper response during heat treatment.

After spheroidizing (24 hours at 718°C or 1325°F), the microstructure consisted of fine rounded iron carbides (spherodite) in a matrix of ferrite. The carbides acted as chip breakers, and the ferrite produced a very soft matrix for machining. Not only was machining time reduced by 50 percent, a much more consistent surface finish was achieved. In addition, distortion during heat treatment was reduced due to the elimination of forging residual stresses.

CONCLUSION
In this column the various types of annealing practices have been covered, with the benefits of each type provided. In later articles, different types of heat treatment will be discussed.

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AQ (aircraft quality) testing requirements

Understanding what is meant by aircraft quality steel cleanliness and how it’s determined.

Much has been written about the critical nature of steel cleanliness as it relates to the performance of highly stressed, cyclically loaded gear components. Modern steel making technology using ladle metallurgy practices and vacuum degassing enables production of very high-quality steels that approach cleanliness levels historically only achievable by vacuum arc re-melt (VAR) or electro-slag re-melting (ESR) practices.

Previous Materials Matters columnists have detailed current technologies used to quantify and evaluate steel cleanliness via metallographic techniques by direct examination of non-metallic inclusions using both light and electron microscope methods in addition to details on the developing ultrasonic cleanliness evaluation techniques. The ASTM E45 (First issued 1942) specification is perhaps the most well-known method of evaluating steel cleanliness. E45 involves metallographic samples that are polished and non-metallic inclusions are examined at 100X magnification using a light microscope and evaluated for size and quantity by comparing with reference charts.

Beyond standard E45 cleanliness requirements, many gear specifications have a call-out requiring the material be “aircraft quality” cleanliness. While the term aircraft quality, or AQ for short, implies that the material will be used in aerospace applications, the reality is that AQ steels are specified in nearly all types of industrial applications including many OEM and industry gear standards. AQ testing is, in fact, another method whereby the cleanliness of steel is evaluated using magnetic particle inspection techniques.

The primary test standards for AQ testing are controlled and distributed by SAE International (www.sae.org) and are labeled AMS (Aerospace, Material, Specifications). There are four AMS specifications that are commonly referenced and detail the testing and requirements for aircraft quality steel cleanliness.

AMS 2300 (FIRST ISSUED 6/1/1959)
- Steel Cleanliness, Premium Aircraft-Quality Magnetic Particle Inspection Procedure.
- VAR or ESR required, highest quality level “re-melted” steels.

AMS 2301 (FIRST ISSUED 1/1/1960)
- Steel Cleanliness, Aircraft Quality Magnetic Particle Inspection Procedure.
- Most commonly seen specification.

AMS 2303 (FIRST ISSUED 11/1/1967)
- Steel Cleanliness, Aircraft Quality Martensitic Corrosion-Resistant Steels Magnetic Particle Inspection Procedure.
- Similar to AMS 2301 but for martensitic stainless steels.

AMS 2304 (FIRST ISSUED 5/1/1995)
- Steel Cleanliness, Special Aircraft-Quality Magnetic Particle Inspection Procedure.
- “Special” quality to address modern, high quality, non-re-melted steels.

These AMS methods are intended to “qualify material used to produce highly stressed parts where very strict magnetic particle inspection standards are used in final inspection of such parts but may be used for qualification of a heat, melt, or lot of steel.” The testing methodology involves magnetic particle inspection and are therefore different than the ASTM microscopy methods perhaps more well known for evaluation of steel cleanliness.

Each of the four referenced specifications use very similar methodology for sampling, test piece preparation, and magnetic particle inspection. The primary differences between the four specifications are the size of the indications that are recorded and how they are rated based on size and ultimately the acceptance criteria that is applied. The original AMS 2300 specification is the most stringent, as might be expected when evaluating the highest quality VAR or ESR re-melted steels.

The most modern “special quality” specification detailed in AMS 2304 has essentially the same quality requirements as the original AMS 2300 but is intended to evaluate today’s higher quality steels produced without a re-melting process. The AMS 2301 and 2303 specifications are similar to each other in terms of the relevant inclusion sizes counted and the acceptance criteria applied; both have less stringent acceptance criteria as compared to the AMS 2300 and 2304 requirements.

While commonly requested when purchasing steels for a wide variety of applications, the details of how the AQ cleanliness testing is conducted may not be well understood by the industry at large. The goal of this Materials Matters series of columns will be to help readers better understand the process of the aircraft quality testing methodology as specified in the AMS standards — from material sampling and test piece preparation through the magnetic particle inspection to the evaluation and reporting of test results. This column is only intended as a general understanding overview and readers should refer to the official SAE International publications for the specification details.

ABOUT THE AUTHOR

Guy Brada is a metallurgical engineer with more than 25 years in the steel industry. He received his Bachelors and Masters degrees in Metallurgical and Materials Engineering from the Colorado School of Mines. During his career, he has worked in steelmaking, the heavy forging industry, at an independent metallurgical test laboratory, and at a commercial heat treater. He has authored seven steelmaking and steel product patents. Currently he is technical sales service manager for Ellwood City Forge the open-die forging division of the Ellwood Group.
MEASURING TOOTH FLANK ROUGHNESS
Gear performance has continuously increased over the past two decades. Improvements in metals, heat treatments, geometry, and lubrication are just a few of the sources of these improvements. For gears operating in high load, EHL-type conditions, tooth flank finishes have experienced a similar improvement trend. These tooth flank finish improvements minimize the risk of surface distress failures such as wear, fretting, scuffing, macro and micropitting, or to reduce vibrational excitation (tonality). As such, it is not uncommon today to have highly loaded gears specified and manufactured to tooth flank finishes of Ra < 4 µin (Ra < 0.1 micron).

These tooth flank finishes have been achieved from improved grinding, honing, or superfinsihing technology. However, with improved flank finishes, confusion, uncertainty, and errors have arisen regarding the specification, measurement, or documentation of flank roughness. Part of these problems stems from the fact that there will always be some variation of roughness across a given flank surface. Furthermore, the range of variation can increase depending on the finishing process. Fortunately, the current state of the art of gear manufacturing produces tooth flank finishes with reasonably small surface finish variation such that the gear performance can be generally predicted. The unavoidable roughness variation of a given tooth flank is generally small and can easily be accounted for in the tooth flank roughness specification and manufacture without a loss in gear performance. However, other sources for flank roughness measurement problems can result in poor gear performance and are [1, 2, and 3]:

- The wide capability range of available roughness measurement equipment.
- Poor roughness measurement equipment maintenance.
- Ambiguous roughness specification.
- Imprecise roughness measurement procedures.
- Poor documentation of the required flank finish.

Even with proper roughness measurement, there will be some variation in the results. Gear designers and manufacturers need to understand and accept this unavoidable variation in surface roughness. The first step in this understanding starts with the realization that no surface can be exactly equal to a single roughness number. Too often a flank roughness is specified or reported to be Ra = XX µin. However, a surface roughness can either be:

- 1: Greater than (>): greater than or equal to (≥).
- 2: Less than (<): less than or equal to (≤).
- 3: Or within a range of a specific roughness number.

Fortunately, there are a small number of ISO Specifications within the GPS (Geometrical Product Specifications) Matrix of Standards that can be used to reduce the problems that can lead to unacceptably large or erroneous roughness measurement. If these ISO Specifications are understood and applied correctly, the significant variations or errors can be reduced such that the roughness measurements are accurate, repeatable, and reproducible. This will be the first in a series of articles on the subject of Tooth Flank Roughness Measurement based on these ISO Standards.

THE CONTACT STYLUS PROFILOMETER

The goal of these articles will be to describe how to carry out and document pragmatic, accurate, repeatable, and reproducible roughness measurement of tooth flanks. This article will describe the characteristics of the measurement equipment needed to analyze surface texture and achieve some of the above goals. This article is about the Contact Stylus Profilometer based on ISO 3274: 1996. [4]

It should be noted that this and the following articles will assume that environmentally induced roughness measurement variations (i.e. from forge shop vibrations) will not be an issue in achieving these goals. The author is familiar with many gear manufacturing facilities where the profilometry is successfully carried out adjacent to the flank finishing equipment without the introduction of environmentally induced errors. Modern profilometer setups can easily cope with forklift traffic, hoists, gear grinding equipment, and the like without the introduction of roughness measurement errors. For the purpose of these articles:

- Pragmatic will mean a flank roughness measurement and documentation that can be carried out by gear production staff in a manufacturing environment using robust equipment at a reasonable cost.
- Accurate will mean the flank measurement results are reasonably close to the known roughness value and or to a calibrated roughness standard.
- Repeatable will mean reasonable variation of flank roughness measurement results when carried out by the same operator using the same robust measurement equipment.
- Reproducible will mean reasonable variation of the flank roughness measurement results when carried out by different operators using the same robust measurement equipment, or by different operators...
using different robust measurement equipment, in either the same or different locations.
> Documentation will mean the flank measurement specification and or measurement results are interpreted without ambiguity by different individuals.

**SURFACE TEXTURE**

Surface texture is made up of three elements: its roughness, its waviness, and its form. The surface roughness is made up of the process marks or grinding asperities produced by the cutting tools or machining process. The roughness is characterized by short wavelengths (i.e. short spaced surface imperfections or asperities). The waviness is typically produced by machining instabilities or cutting tool imbalances (i.e. poor grinding stone dressing) and the like. Waviness is characterized by longer wavelengths compared to the roughness, which is superimposed within the waviness. Form is the general shape of the surface (i.e. an involute tooth flank), ignoring the variations due to the roughness and waviness. Surface waviness and form are rarely found in isolation (i.e. there are rarely truly flat surfaces) and are treated the same by the profilometer.

The fundamental function of a contact stylus profilometer is to separate the three elements of a surface and to analyze the waviness and roughness separately. The issue is how to separate surface irregularities into roughness versus waviness. This separation is accomplished by the profilometer through the use of filtering and is a critical capability of the instrument.

For a tooth flank, its surface texture is described by its waviness, its roughness and its lay. The surface lay is created during manufacturing of the flank by the primary direction of travel of the machining process used. The lay is the primary direction of the roughness irregularities. Lay can have a significant impact on gear performance based on how it effects the movement of lubricant between mated teeth. Lay is addressed in these articles only in regards to how a profilometer is setup and operated to produce the roughness measurement.

**THE CONTACT PROFILOMETER: ROUGHNESS VS. WAVINESS**

To understand profilometer filtering, understand that a surface is nothing more than a series of peaks and valleys (asperities) of varying heights and with various distances between them. From this perspective, a surface is made up irregularities of varying wavelengths and varying heights. The profilometer filter separates out different wavelengths (the filter wavelength is called a cut-off) of the surface being measured so that they can be analyzed separately. The analysis results in determining the roughness and waviness of the surface.

Early surface measuring instruments used electronic analog filters known as 2CR filters. The 2CR stands for two capacitors and two resistors. These electronic filters suffer from phase distortion due to their electronic components. As such, separation of the waviness from the roughness of a surface can be unsatisfactory using this type of filter.

Today, ISO 3274 compliant profilometer instruments use phase corrected filters, preferably Gaussian filter in the case of tooth flank roughness measurement. These types of filters drastically reduce the distortion when separating waviness from roughness. These filters are very robust, but can only be implemented by mathematical algorithms using digital computer processing. A phase corrected Gaussian filter commonly used in today's profilometers complies with ISO 3274, and can be said to be the basis for modern day profilometry.

It must be noted that the distortion by 2CR filters can be minimized if the recommended sampling lengths (cut-off wavelength) are followed as per ISO 4288:1996. (ISO 4288; the procedures for roughness measurement (to be discussed in a later article). However, a minimal distortion can be achieved only in regards to the Ra and Rz roughness parameters. As such, 2CR filters can comply with ISO
3274 in regards to Ra and Rz, but for other types of roughness parameters the distortion can be significant. Since many more roughness parameters are important in today’s profilometry, 2CR filters are generally no longer available or used in profilometry.

THE PROFILE FILTER

How does the profilometer’s phase correct filter work? In basic terms, a cut-off (specific wavelength) is a filter and is used as a means of separating the irregularities found on a surface. Cut-offs have a numerical value that, when selected, will reduce or remove the unwanted wavelengths (irregularities) from the surface analysis. For example, a roughness filter cut-off of 0.8 mm will allow wavelengths below 0.8 mm to be assessed, or included in the roughness measurement, while wavelengths above 0.8 mm are reduced in amplitude, or removed. Inversely, for a waviness filter cut-off of 0.8 mm, wavelengths above 0.8 will be assessed while wavelengths below 0.8 will be reduced in amplitude, or removed. By this filtering method, the surface measurement can be separated into the short wavelength roughness profile or the long wavelength waviness profile. See Figure 1 for a graphical presentation of an ISO 3274 compliant profile filtration of a surface.

A detailed description of the filter characteristics needed to comply with ISO 3274 is beyond this article’s scope, but can be found in ISO 11562 [5]. Fortunately, the four nominal values for the roughness cut-off wavelengths of the profile filter cited in ISO 3274 are: 0.08 mm; 0.25 mm; 0.8 mm; 2.5 mm; 8.0 mm. The roughness cut-off wavelength is symbolized by \( \lambda_c \).

ISO 3274 completes the filtration specification by citing the relationship between the cut-off wavelength \( \lambda_c \), the stylus tip radius and the roughness cut-off ratio (the ratio of the cut-off wavelength to the trace sample length \( \lambda c / \lambda s \)) in a simple table. This table is the basis for all roughness measurement setup and procedures.

OTHER CHARACTERISTICS

Given the proper filtration capability, what other characteristics are needed in a profilometer to comply with ISO 3274? The Specification cites:

- The definitions of the surface profile.
- The stylus instrument schematic (see Figure 2).
- Lists the instrument’s sub-components.
- Cites the measurement loop.

SUMMARY

Modern day contact stylus profilometers that comply with ISO 3274 have ISO compliant filtration capabilities that minimize distortion using a phase correct Gaussian filter recommended for gear flank roughness measurement. Today’s instruments come equipped with tip orthogonality (positioning) boundaries (see Figure 4 for orthogonal tip positioning) and form (shape) correcting limits. These features result in surface measurements that can be completed easily, and with reasonable accuracy.

These instruments are robust, simple to operate with minimal training for set up and operational procedures, and can reproducibly measure flank roughness. A typical shop floor, ISO 3274 compliant profilometer set up will cost approximately $25,000 to approximately $35,000. This profilometer forms the basis for a pragmatic, accurate, repeatable and reproducible tooth flank roughness measurement and documentation capability in a gear manufacturing environment.

Future articles will discuss the profilometer stylus, set up and measurement procedures, and the proper specification-documentation of roughness.

REFERENCES

GRADING THE STRENGTH OF STEEL
Newly developed high-strength steel for car powertrain and transmission components includes three grades – knowing the difference will help you meet your quality goals.

By GREGORY VARTANOV

Vehicle manufacturers are faced with a difficult task of significantly improving fuel economy and safety while maintaining competitive position in the market. This can be accomplished, among other things, by using higher strength steel for car and truck. Newly developed high strength steel for car powertrain and transmission components (GEAR-Steel) can help accomplish just that. Replacing traditionally used carburized SAE 8620, 4320, and 9310 steel in by GEAR-Steel allows reducing weight of components without sacrificing their durability and lifetime.

DESCRIPTION
GEAR-Steel is being offered as bar products in three grades [1-2]. Grade 1 is carburizing steel for powertrain and transmission components, such as shafts, gears, axels, etc. Carburized Grade 1 has surface hardness of Rockwell C (HRC) 61-63 and core hardness of HRC 45-46 at 0.06/1.5 in/mm minimum case depth, which is higher than the SAE 4320, 8620, and 9310 [3] at the same level of ductility and toughness. Production cost of Grade 1 is similar to SAE 4120 grade.

Grade 2 is a deep nitriding steel perfect for high precision components, such as bearings, gears, shafts, pinions, crankshafts, camshafts, bolts, etc. After normalizing, quenching, tempering, and nitriding by conventional methods, Grade 2 has the case depth of 0.01-0.25 - 0.50 in/mm with the surface hardness Vickers (HV) of 760-800 and core hardness of HRC 46-48; an ultimate tensile strength (UTS) of 225-235/1550-1625 ksi/MPa, a yield strength (YS) of 205-215/1415-1480 ksi/MPa, elongation (El) of 9-10 percent, reduction of area (RA) of 40-45 percent, and Charpy v-notch impact toughness energy of 14-18.5/19-25 ft-lb/J. Production cost of Grade 2 is similar to SAE 4140 grade.

Grade 3 is a super-high strength steel for powertrain and transmission components such as gears, crankshafts, camshafts, axle shafts, connecting rods, etc. After quenching and tempering, Grade 3 has surface and core hardness of HRC 58-60, UTS of 255-265/1760-1830 ksi/MPa, El of 7-9 percent, RA of 30-32 percent and CVN of 12-16/16-22 ft-lb/J. Production cost of the Grade 3 is similar to that of SAE 4150 grade.

The following method of manufacturing of the automotive transmissions and powertrains components such as gears, camshafts, axle shafts and others from Grade 3 is proposed:
- Hot rolled or hot forged bars are normalized and stress relieved.
- The components are machined from the bars.
- The components are hardened by normalizing.

<table>
<thead>
<tr>
<th>Steels</th>
<th>YS, ksi/MPa</th>
<th>UTS, ksi/MPa</th>
<th>El, %</th>
<th>RA, %</th>
<th>CVN, ft-lb/J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>175-185/1210-1275</td>
<td>220-230/1520-1590</td>
<td>11-13</td>
<td>45-50</td>
<td>18.5-25/25-34</td>
</tr>
<tr>
<td>Grade 3</td>
<td>255-265/1760-1830</td>
<td>325-335/2240-2310</td>
<td>7-9</td>
<td>30-32</td>
<td>12-16.5/16-22</td>
</tr>
</tbody>
</table>

Using Grade 3 allows reducing weight of the transmission and power train components by reducing their thickness. For example, projected weight reduction of gears of an automatic transmission of...
230/104 lb/kg with gears of 130/59 lb/kg from carburized SAE 8620, 4320, and 9310 steels will be around 20 percent or 26/12 lb/kg in case of substitution of the carburized steels by Grade 3.

Granted, using Grade 3 requires additional investment in the redesigning of the automotive transmissions and powertrain components and the changing some tools. However, benefits of utilizing Grade 3 significantly exceed the expenses of its implementation.

The table shows a comparison of mechanical properties of three grades of GEAR-Steel after hardening to maximum strength.

**SUMMARY**

Newly developed high-strength steel for car powertrain and transmission components includes three grades. After carburizing and hardening, Grade 1 has strength and core hardness higher than 9310 grade at the same surface hardness. Vacuum melted deep nitriding Grade 2 is high-strength substitution of the vacuum melted Nitralloy 135 grade and it is applicable for the nitride aircraft components. Super-high strength Grade 3 allows reducing weight of the car components compared to the traditional carburizing grades.

**REFERENCES**


**ABOUT THE AUTHOR**

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FORMERLY GEAR EXPO
MAGNETIC BARKHAUSEN NOISE AS AN ALTERNATIVE TO NITAL ETCH FOR THE DETECTION OF GRIND TEMPER ON GEARS
MBN is quantitative, repeatable, non-destructive, and it is easily automated, thus removing operator influence as a variable.

By JAMES THOMAS and STEPHEN KENDRISH

The detection and prevention of grinding burn is critical to the production of ground gears of all types and sizes. Overheating during grinding, or grind temper, results in undesirable microstructure, hardness, and stress characteristics both on and below the surface. These characteristics result in failure modes on precision surfaces, which typically require high performance under load over a long lifetime. The traditional method for detection of grind temper, Nital Etch, is subjective, often destructive, and requires handling and disposal of hazardous chemicals. Additionally, the Nital Etch process requires a properly tailored process and a well-trained operator in order to prevent false-positives and/or false-negatives.

An alternative method, Magnetic Barkhausen Noise (MBN), is quantitative, repeatable, and non-destructive. Further, the MBN method is easily automated, thus removing operator influence as a variable. Using a sample set of carburized spur gears, ground to varying conditions of grind temper, the MBN method is demonstrated to match or exceed the detection effectiveness of traditional Nital Etch. Detection of various intensities of grind temper, including re-hardening burn, is demonstrated using fully automated MBN instrumentation. Residual Stress depth distributions measured with X-Ray Diffraction and electrochemical layer removal are utilized as a quantitative verification method.

INTRODUCTION
Grinding of hardened steel parts is a common and often necessary process in the manufacture of power train components. The grinding process results in components which can comply with tight geometrical constraints along with a fine surface finish. The risk, though, when performing grinding operations is a possibility of inducing grind temper.

Grind temper is thermal damage of a component due to a flaw in the grinding process, which results in excessive heat generation. Excess heat dissipation into a case-hardened surface effectively tempers the surface and, in more severe cases, can create reformed untempered martensite, also known as re-hardening. The consequence of grind temper is reduced fatigue life associated with the loss of surface hardness and resulting tensile residual stresses [1].

Detection of grind temper is a critical capability for manufacturers of precision steel components. Traditional methods include Nital Etch, X-ray Diffraction Depth Distributions, and metallography. These methods have their own flaws, though, as they can be subjective, time consuming, insensitive, and they are often destructive.

Magnetic Barkhausen Noise (MBN), on the other hand, is a non-destructive testing technology which allows for sensitive, objective detection of grind temper in a fully automated package.

Efficacy of MBN for the detection of grind temper on carburized gears is demonstrated by directly comparing MBN measurements to X-ray Diffraction Residual Stress Depth Profiles (XRD RSP). Furthermore, methodology is hypothesized and verified for the detection of extreme re-hardening, which is a traditionally difficult application for MBN users.

GEAR SAMPLE SET
The sample set consists of select teeth from a single spur gear. The AISI 3310 grade gear was carburized and hardened to nominal hardness of 60 HRC and then form-ground. In order to vary the condition and quality of the sample set, the form grinding process was performed using a single pass for each tooth space without dressing the wheel as it proceeded around the gear. The end result is a progression of heat introduced from the grinding operation when proceeding around the gear.

BARKHAUSEN NOISE TESTING EQUIPMENT
The MBN testing was performed using a Stresstech Rollscan 350 Barkhausen noise analyzer, a wedge-shaped sensor suitable for gear tooth surface testing and a GearScan 500 system for automated tooth scanning (Figure 1). Automation with the GearScan 500 system allows for rapid and consistent scanning along the face width of each tooth, a necessity in order to achieve repeatable results.

For this experiment, spatial sensitivity was achieved by making nine evenly spaced scans along the face width, progressing from the form diameter of dedendum (scan #1) to the tooth tip (scan #9). The cross-sectional contact of the sensor covers approximately 10mm x 2mm. 660 data points were collected as the sensor scanned along the face width. The end result is a mapping of the entire tooth surface.

X-RAY DIFFRACTION EQUIPMENT AND METHODOLOGY
XRD RSPs are a destructive measure of the residual stress through the depth of a sample. They are typically used for detection of grinding burn and have several advantages over other methods. XRD is quan-
As compared to etch, which is subjective. XRD is sensitive to stresses and, via peak width measurements, sensitive to microstructure changes, compared to cross-sectional microhardness, which is only sensitive to hardness.

In the case of grind temper, a residual stress gradient results from the induced microstructure gradient [2]. Consequently, XRD RSPs are critical for detection of what is known as “hidden burn,” or cases where grind temper occurs and then is partially cleaned up by subsequent grinding processes. The result is a much thinner (or virtually unmeasurable) layer of tempered material that can be difficult to detect via Nital Etch or cross-sectional microhardness measurements. The tensile residual stresses that result from grind temper penetrate much deeper than the microstructure gradient, though, and remain in cases of hidden burn. MBN, which is sensitive to stresses, can detect hidden burn, but the only quantitative verification method which works in these cases is XRD RSPs. (Figure 2)

XRD RSPs were measured using a Stresstech XStress 3000 G2R diffractometer along with electrochemical layer removal for through-depth measurements. Residual stress measurements were made in accordance with ISO EN15305:2008, utilizing a modified-χ geometry [3]. Material properties for XRD RSP calculations include Young’s Modulus of 211000 MPa and Poisson’s Ratio of 0.3. XRD measurements were made with a 3.0 mm spot size and were aligned to measure stresses in the lead direction of the tooth.

BN TESTING RESULTS

Using the aforementioned measurement automation, MBN signal root-mean-square (RMS) data was collected across the gear flank surfaces, allowing for generation of MBN surface maps. MBN RMS, known in the industry as the magnetoelastic parameter (mp), is a measure
that is tailored for sensitivity to grinding re-temper burn.

In the case of tempered microstructure, there are two mechanisms at play that increase the MBN RMS measured value. A softer microstructure, which includes transformation of martensite to ferrite, is easier to magnetize by way of a lower magnetic coercivity, thus resulting in a greater MBN RMS [4]. Additionally, the tensile stresses that result from grind temper affect magnetic properties in a similar way as tensile stresses create easy magnetizing axes in iron-based alloys [5]. The end result is a higher MBN RMS when grind temper is present.

Tooth 1 from the sample set is ground under ideal circumstances and, as seen in the surface map in Figure 3, exhibits a low and homogeneous MBN RMS across the entire coast flank surface. Tooth 9, however, was ground with a wheel in need of dressing (Figure 4). This coast flank exhibits elevated MBN RMS values along with non-homogeneity across the surface — typical indications of grind temper.

MBN RMS surface maps can be used to more effectively sample data sets for other time- and labor-intensive test methods, such as XRD or metallography. In this study, MBN RMS surface maps were used to more effectively choose measurement locations for XRD RSPs in order to characterize the spectrum of grinding defects.

XRD TESTING RESULTS

XRD RSPs were measured using electrochemical layer removal through the depth. Depth values between 0.0 mm and 0.20 mm were selected in accordance with traditional grind temper evaluations via XRD RSPs. Except in cases of very high intensity grind temper, the effective depth of grinding stress is typically less than 0.20 mm and is weighted more toward the surface. As a result, more data points are collected near surface, where gradients are steepest, while depth resolution is decreased as depth is increased.
Typically, in the case of a good grinding process with no thermal damage, the residual stress remains mostly neutral or somewhat compressive on the surface and also through the depth. Grind temper usually creates a subsurface stress peak, often slightly tensile, while converging toward zero stress through the depth. The depth at which the stress reaches neutral or slightly compressive depends on the depth of the thermal damage or, in other words, the intensity of the grind temper.

As can be seen in Figure 5, grind temper damage increases sequentially with tooth number. Subsurface stress peaks are observed in all samples except Tooth 1 (both drive and coast flanks), Tooth 12 has been subject to significant thermal damage and does not reach a neutral or somewhat compressive stress within the 0.20 mm measurement depth range.

**CORRELATING MBN TO XRD RESIDUAL STRESS**

MBN is an electromagnetic test method which, similar to many non-destructive methods, is relative in nature. In order to properly leverage MBN as a process tool, the user must use reference samples or verification methods to initially set up both measurement parameters and evaluation criteria. A typical method for accomplishing this task is to compare MBN RMS measurements to XRD RSP data. Specifically, comparing the MBN RMS value for a particular location to the maximum subsurface residual stress within the grinding-affected depth is considered to be the best practice.

For the sample set in this study, MBN RMS surface maps were used to select locations for XRD RSPs. At each location, the MBN RMS and the maximum subsurface residual stress within the first 0.050 mm were compared, yielding the chart in Figure 6.

As can be seen in Figure 6, there is agreement between MBN RMS and maximum subsurface residual stress with one exception. An MBN user would likely use an upper limit of approximately 130 mV as rejection criteria, based on MBN results and corresponding residual stress data. The only samples tested that do not have subsurface tensile stress peaks are Tooth 1 coast flank and Tooth 1 drive flank. An upper limit of 130 mV allows both acceptable grind samples to be accepted while also rejecting the remaining samples.

The anomaly in the correlation, Tooth 12, drive flank, shows a decrease in MBN RMS despite a very large increase in subsurface residual stress. While the grinding conditions that resulted in the damage to Tooth 12 are extreme and not often found in the industrial environment, there still exists a need to properly sort out these defects.

**CASE OF EXTREME RE-HARDENING BURN**

In some cases, grinding-induced thermal damage is so great that the material surface is heated past the austenitizing temperature, only to then be quench-cooled by grinding coolant. The end result is what is known as grind re-hardening. This typically includes, as one examines through the depth, a surface layer of untempered martensite followed by a tempered zone with softer ferrite phases, before finally reaching the hardened case.

Grinding re-hardening can be detected with traditional methods, including XRD RSPs. Seen in Figure 7 is an XRD RSP along with XRD Diffracted Peak width through the depth of the measurement on Tooth 27, drive flank. Tooth 27 represents the highest level of grinding damage in the sample set, thus having exaggerated depths of damage as compared to typical production-ground components.

In addition to residual stress data, the XRD RSP measurements produce data that relate to the microstructure of the volume measured. Diffracted peak width (FWHM) is an indicator of microstructural refinement, or lack thereof, and FWHM increases with crystal lattice imperfection, dislocation density, etc. The end result of this relationship is that very high FWHM is observed in cases of untempered martensite while very low FWHM is observed in cases of soft ferrite. Consequently, FWHM is a useful indicator of microstructure transformation.

In general, there is agreement between the XRD Residual Stress and FWHM data, with higher subsurface stresses correlating to a lower FWHM. This relationship it typical in the case of grind temper, as the microstructure transformation which lowers the FWHM also creates the subsurface residual stresses.

Detection of grind re-hardening via MBN is often as simple as detection of grind tempering with one caveat: higher intensity damage does not necessarily increase the MBN RMS measurement. In fact, often the MBN RMS measurement will decrease as re-hardening damage increases. This is due to the re-hardened microstructure
possessing a very high magnetic coercivity, which makes it much more difficult to magnetize.

In order to best detect cases of extreme re-hardening burn, the MBN peak position can be used. MBN peak position is the phase position of the MBN peak with respect to the applied magnetic field $H$. It is often correlated to magnetic coercivity. As a result, it is able to be sensitive to the changes in magnetic coercivity that accompany grinding re-temper burn and grind re-hardening. As seen in Figure 8, the Tooth 2, drive flank MBN peak increases in height (higher MBN RMS) though its position shifts lower, relative to Tooth 1, drive flank, in the case of re-tempering. In the case of re-hardening with Tooth 27, the peak decreases in height but also shifts to a higher position, which is expected with the untempered martensite, resulting in higher coercivity.

Proper detection of grind re-hardening, in addition to grinding temper, is achievable in cases where traditional MBN measurements are not sufficient. In these cases, the MBN peak position can be used in addition to MBN RMS to detect any case of grinding thermal damage.

CONCLUSION

It has been demonstrated that MBN is an effective technology for detection of grind temper, specifically on carburized gears. MBN measurements were successfully corroborated with XRD RSPs. Using automation to precisely control sensor positioning, contact angle, and scanning speed. These are issues that are always a challenge when measuring by hand. The use of automation results in repeatable measurements which allow subtleties such as peak position variations to be detectable. Additionally, using MBN peak position analysis cases of extreme re-hardening were analyzed and were successfully detected, even in cases where traditional MBN measurements are ineffective.

REFERENCES

Precision Gage’s signature product is the VARI-ROLL, a dual flank composite tester developed in 1952.
After 70 years, Precision Gage Company brings quality gear inspection to the industry, whether it be dimension-over-wires gages or fully-automated dual-flank composite test systems.

By KENNETH CARTER, Gear Solutions editor

It’s a testament to Precision Gage Company that, from its beginnings in a living room in Chicago, it is celebrating its 70th year in the industry this year.

Precision Gage has prospered by offering common-sense inspection solutions for manufacturing, especially with regard to gear inspection, according to RG Layland, director of business development for Precision Gage. Layland is also the grandson of the company founder. RG’s father, Roger, is the company’s president.

“Gear inspection solutions comprise about 50 percent of what we do today,” he said. “We’re able to bring the knowledge about the manufacturing of gears and the understanding of how the inspection process applies to it. Maybe more importantly, we understand the many ways the gears are put to use. When we bring that holistic approach to the inspection of gears, our clients benefit. It’s the reason we’ve been able to gain this wide breadth of experience as a company.”

THE VARI-ROLL

Among the complete line of inspection and quality control products the company produces, Precision Gage’s signature product is the VARI-ROLL, a dual flank composite tester developed in 1952.

“When the VARI-ROLL was first developed my grandfather brought it to a customer for a demo. A mutual customer just happened to be there at the same time and noticed the tester and asked about it. After a quick demo in the lobby, this mutual customer informed my grandfather that he wasn’t going to do the scheduled demo, and that it was going into his trunk because he was buying it on the spot,” Layland said. “The rest of the company has grown from the success of that product. It firmly established our company in the Dual Flank Composite space.”

The VARI-ROLL Gear Tester is used by gear manufacturers and end users in the aerospace, automotive, home appliance, government, computer, and power tool industries, both nationally and internationally.

“The VARI-ROLL was developed with a building block approach to gear inspection,” Layland said. “The interchangeability is what makes it unique. The inspector can have one base unit and then tool it up to inspect any other type of gear. This is unique among the various types of gear inspection approaches in the industry.”

This degree of flexibility allows systems to be tailored economically, with fixtures for specific types and sizes of gears readily available for use, according to Layland. The VARI-ROLL lets fine-pitch gears and many coarse pitch gears be composite tested both accurately and cost-effectively.

“We always try to locate parts in ways that mimic how they will get used in their application,” Layland said. “That’s the best way to predict their performance. We strive to ensure that our customers and the people who use our products are getting what they expect in a quality part.”

QUALITY SERVICE

The Precision Gage philosophy is that quality products should come with quality service, according to Layland. That comes through in how the company interacts with its customers, especially when they present the Precision Gage team with a challenge to solve.

“Manufacturing is problem-solving. The first thing we strive to do when our customers ask us for help is to fully understand the problem,” he said. “We start by asking a lot of questions, so we can fully understand everything about their specific process. If we don’t account for all the variables they face on the job, then the solution we propose could have undesirable outcomes.”

After Precision Gage understands the nature of the problem, then it tackles the environment.

“It’s about making sure that we understand what their expectations are for the end-result,” Layland said. “Generally, we only have one shot at solving the prob-
lem, so we have to get it right the first time. That’s just the nature of our business. We don’t have a lot of opportunities where we can revise over and over. Normally, manufacturers need our inspection solution right away, and we take that responsibility very seriously.”

CUSTOM SOLUTIONS

Even though Precision Gage offers many services and products that are “off-the-shelf,” custom solutions are what the company is really about, according to Layland.

“When it comes to custom inspection equipment, we’ll quote it, providing concepts up front if that’s what’s required,” he said.

Any special designs a customer may need are approved in advance before any production begins, according to Layland.

“There are checks and balances throughout the whole process. That’s how we make sure that there are no surprises and that the customer gets exactly what they want,” he said. “It’s that conversation — the questions up front that help us make sure that everybody is on the same page about the challenge itself and the expectations for the outcome.”

“We’re known for providing options,” he said. “We don’t necessarily push one way or the other unless we’re very confident in a particular solution. Usually, each option has a trade-off — its benefits and its drawbacks. One option may have greater measurement variability, but the equipment is less expensive. Another option may be more expensive but is more reliable and reduces the chance for operator error. Often, that’s the more desirable option because it pays for itself in the long term.”

COMPANY LONGEVITY

Layland points to Precision Gage’s longevity, not only as a point of pride but also a contributing factor to the company’s continuing success.

“This is our 70th year, and VARI-ROLL has been part of that history for 65 of those years,” he said. “We are well known and well respected in the industry, in large part due to VARI-ROLL’s success but also because our customers know we’re stable and reliable. A lot of our business comes from referrals by customers we’ve served for decades. Prospective customers visit gear shops, see our VARI-ROLLs, and their owners say, ‘Hey, you should work with Precision Gage. They know what they’re doing.’”

A STAPLE WITHIN THE INDUSTRY

As the gear industry continues to evolve, Layland said Precision Gage remains steadfast to the things its known best for: its practical, common-sense, problem-solving ingenuity.

New technologies are being developed that will accelerate the manufacturing of gears. It’s for that very reason, according to Layland, that Precision Gage’s services will still be an important part of making sure those gears measure up.

“The direction the industry is going is toward higher precision, better throughput, and more automation at every step,” he said. “But problems will always come up during production, no matter how automated the processes become. You may not have people manually rolling parts anymore, but that only makes professional inspection that much more important. Inspection will still be the key to ensuring quality parts are produced at each step in the manufacturing process, and they’ll need the right gages to do it.”

“That’s obviously where we have our place,” he said. “When manufacturers need someone who can solve real, everyday problems, Precision Gage will be the company they call.”

MORE INFO

www.precisiongageco.com
All Metals & Forge Group offers open die forgings, seamless rolled rings

All Metals & Forge Group produces forged gear shapes for single hub, double hub, and other near net shapes for finish machining into several different shapes. All parts are rough machined and 100 percent UT tested (ASTM388).

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All Metals & Forge Group, as an ISO 9001:2015 and AS9100D registered forging manufacturer has a vast inventory (300 alloys & grades) on the floor, which will aid in the quickest deliveries, high quality, and extremely competitive products.

MORE INFO www.steelforge.com

New SV-30 cylinder hone features automatic step-and-repeat capability

The new Sunnen SV-30 honing series is the next generation in the line of legendary Cylinder King® machines. True to its heritage, it achieves expert results on engine cylinder blocks, cylinder liners, and other engine parts that require honing. Six standard models include four step-and-repeat capability versions allowing automatic bore-to-bore processing for in-line and V-block configurations, reducing setup time and improving bore quality. In addition, two models are available with a manual X-axis. The SV-30’s cylinder diameter range is 0.75 to 8.0 in. (19 to 200 mm) depending on the tooling option, and the new Sunnen GH-LF tooling is required for automatic step-and-repeat operation.

With six new models in the series, the SV-30 can be tailored to meet the needs of manufacturers, job shops, and automotive performance and rebuild shops. It includes a new PC control with simplified menus and storage for 1,000-plus setups for quick and easy changeovers. When used with the wide range of Sunnen-made abrasives, tooling, and coolants, the U.S.-built SV-30 produces ideal bore roundness and surface finish in a variety of part types and materials at an affordable price.

The new SV-30 also includes spindle reversal, standard bore oversize setup (.010”/.020”/.030”) and automatic tool protection at the top and bottom of the bore, which verifies an unobstructed stroke before starting a cycle. Models include either a variable-speed 6 hp (4.5 kW) servo or 5.5 hp (4.1-kW) induction spindle motor, producing speeds from 50-600 rpm. A 3.4 hp (2.5 kW) servo ball screw system produces up to 100 true vertical strokes per minute with a stroke travel of up to 27.75” (705 mm). The linear stroking drive maintains concentricity with the bore throughout the full stroke to produce a consistent diameter from top to bottom. A large, 48” x 30” (1,219 mm x 760 mm) work envelope allows versatility in processing larger parts.

The new spindle reversal feature duplicates the capabilities of machines used by automotive OEMs. “Reversal can be used anytime in the process, but is especially helpful during the finishing strokes,” said Phil Hanna, Sunnen product manager. “Reversal helps create a slightly rounder bore and aids in achieving the desired surface finish. It causes the honing stones to take out any less-than-round shape left after initial passes, while shaping up and dressing the stones themselves. Reversing the spindle also aids in removing folded-over metal and cleaning debris out of the valleys of the surface finish.”

The proven Phoenix industrial PC control ensures automatic, consistent bore-to-bore geometry and finish, without constant adjustment by the operator. The 15-inch (381 mm) color touchscreen with intuitive controls provides a real-time display of the full-bore
Seco Tools LP09 positive inserts are available in a full range of chipbreakers, including MD15, M13 and ME08. (Courtesy: Seco Tools LLC)

Cross section during the process. The control can store 1,000-plus part setup programs, and a USB port allows offline setup file storage. The control’s programmable Auto-Dwell feature corrects taper anywhere in the bore for unattended operation, while two-stage honing tools with diamond or CBN abrasives can complete roughing and finishing operations in one pass for high productivity.

Left/right positioning of the honing column on its 32-inch X-axis (813 mm) is easily accomplished with a servomotor or a manual hand wheel located immediately below the operator station (model dependent). The machine is equipped with a 55-gallon (208-liter) internal coolant system with two standard steel canister cartridge filters, heavy-duty pump, and filter status gauge.

In addition to the GH-LF tooling (required for automatic step and repeat operation), the SV-30 is compatible with all of Sunnen’s current large diameter tooling. This includes diamond abrasive hone heads and brushes, GHSS single-stage hone heads with CBN or diamond abrasives and brushes, and GHTS hone heads for two-stage honing with CBN abrasives. The new inserts are designed for high-feed milling operations including face, helical interpolation, slotting, side milling, pocketing, and plunging in challenging workpieces often found in the mold and die, aerospace, and oil and gas industries.

Extending the existing HighFeed 2 milling family, the new LP09 inserts combine higher insert corner strength with dual cutting edges, while the face milling cutter bodies feature strong reinforced cores and more teeth per diameter for increased feed rates and faster material removal rates. During high-feed milling, the optimized flutes of the cutter bodies evacuate chips quickly and efficiently.

The rectangular shape of the LP09 inserts along with the close-pitched cutter bodies help extend tool life beyond that of square inserts. Cutter-body pockets ensure consistent and precise insert positioning/seating when indexing, and high-strength screw clamping holds inserts securely in place.

Seco Tools LP09 positive inserts are available in a full range of chipbreakers, including MD15, M13 and ME08. HighFeed 2 cutter bodies range in size from 1.250 inches to 4.00 inches and from 25 mm to 100 mm.

KISSsys offers option of modeling gears with assembly groups

In the March 2018 release of KISSsys, there is the option of “group-based modeling.” Using it, individual finished assemblies can now be extracted from existing gear designs and then combined with other groups. For example, a shaft can be cut into parts at any point and then merged with a different shaft in a different assembly (e.g. the shaft from a Ravigneaux set).

Recurring assemblies are also offered as basic structures in a “Group Box” library. Company-specific gear components are also created and saved in this Group Box through simple modifications. This approach to modeling gear constructions in KISSsys simplifies and accelerates the entire development process. This function is useable with the KISSsys basic package (SYS).

Learn more about group-based modeling with the Group Box in the flyer at www.kisssoft.ag/english/pdf/Flyer_Group_Modeling_EN.pdf.

The KISSsys Training Course from March 19 to 22, 2019, will teach how to use KISSsys precisely and efficiently in gear calculations on the basis of practical examples. This training course will be held in English.

For details on 2019 training courses, visit www.kisssoft.ag, click on training courses/events, and then on “go to training courses.”

OPEN MIND to feature innovative CAM software at SolidWorks World

OPEN MIND Technologies AG, a leading developer of CAD/CAM software solutions worldwide, will demonstrate its latest CAM innovations including the newly released hyperMILL® 2019.1 at SolidWorks World February 10-13, 2019, in Booth #410 at the Kay Bailey Hutchison Convention Center in Dallas, Texas.

SolidWorks World is the annual gathering of the SolidWorks community to learn and share experiences. OPEN MIND is a SolidWorks Gold Certified Partner, offering high performance hyperMILL CAM software that is directly integrated in SolidWorks 3D CAD software, for highly efficient design and manufacturing in a wide range of applications and industries.
The SolidWorks solution from Dassault Systèmes allows manufacturers to speed up their product development, reduce production costs and improve product quality. The integration with hyperMILL enables SolidWorks users to also use one of the most powerful CAM systems for machine- and controller-independent programming during manufacturing.

HyperMILL for SolidWorks offers many benefits, including access to the easy-to-use hyperMILL user interface, enabling switching between the CAD and CAM tabs at any stage. CAM data is associatively linked with the geometric data of SolidWorks. Also, users can work in both single part and assembly mode. Clamps and holders are taken into account during collision checking. For increased productivity, there is a single file for CAD and CAM data.

During SolidWorks World, OPEN MIND will highlight its recently released hyperMILL 2019.1 CAM software for increased productivity and milling results. Key new features in 2019.1 include 5X Prismatic Fillet Finishing, an innovative method for efficient finishing with barrel cutters. New high-performance turning capabilities ensure significant time savings and tool- and machine-friendly roughing operations, all complementing the hyperMILL MAXX Machining performance package. A new surface precision mode enables superb surfaces when 3D profile finishing. Attendees are invited to learn about all these features and more in hyperMILL 2019.1 CAM software.

OPEN MIND’s strong focus on CAM, and its continued commitment to the latest technologies, produces trend-setting innovations that make it significantly easier for customers to achieve substantial quality, time and cost improvements. OPEN MIND’s hyperMILL software is a state-of-the-art CAM solution with 2.5D, 3D, 5-axis milling and turning strategies, as well as specialty applications, and deep drilling machines.

EMTEC-C delivers coolant at a higher rate than centrifugal pumps, allowing machines to run at peak levels without compromising tool life. Innovative features include a new screw system with a patented reversed hanging idler and integrated thrust compensation system for durability, reliability, and precision; improvements to seal life expectancy and maintenance requirements; and a unique transparent backflow pipe that alerts the user to possible medium return into the system. The EMTEC-C also features an extra-long piston to minimize flow loss. Users have the option of connecting a pressure sensor to the frequency controller for easy control and measurement.

“We’ve improved EMTEC-C to achieve maximum three-screw pump efficiency with a lighter weight and fewer components," said Marko Mandac, CIRCOR product manager, Three-screw Pumps. “EMTEC-C is interchangeable with previous models and available in different sizes and spindle pitch angles to accommodate tank-top, submerged and horizontal installation configurations.”

Open-Mind's Solution for SolidWorks


Allweiler EMTEC-C® three-screw pump used for coolant service

Allweiler, a CIRCOR International brand, and a worldwide supplier of pumping solutions for chemical engineering applications, announces the EMTEC-C® next generation three-screw pump, which removes abrasive machine chips, particles, and heat away from cutting surfaces in high-pressure machine tool coolant service. Delivering improved durability and best-in-class efficiency, the EMTEC-C is ideal for metalworking applications, transfer lines, and grinding

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More information is available at www.circorpt.com.

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January 2019 43
Greber offers wide range of live and dead centers for machine builders

With the highest quality machining standards and many years of experience in assembling precision tools and work-holding components, Greber has established itself as a main supplier of dead and live centers to many European and U.S. machine builders. Greber AG is a Swiss company specialized in manufacturing high precision work-holding and work-driving tools. Rotec Tools Ltd. Represents Greber in the North American market.

When high precision is required, Greber’s expertise on these products results in unsurpassed reliability and performance. Greber offers an extensive range of live and dead centers to suit any application, from high-precision measuring machines to heavy-duty lathes. Greber is specialized in all centers used for Studer grinding machines.

Series C:
- Drop-forged shank made of hardened steel.
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These live centers are designed for CNC machine tools and copying lathes with hydraulic tail-stocks as well as for machining workpieces with small center holes and precision machining at ultrahigh speeds.

High-precision workpieces require high-precision machine tools, sophisticated production processes and precise tools; this applies in particular to cylindrical grinding. The standard program of high-precision carbide dead centers includes all the standard and most commonly used shapes. Customized products are required for special machining processes or for process optimizations. With customer input, Greber engineers can develop the best workholding solutions for their components.

MORE INFO
www.rotectools.com
www.greberag.ch

Jergens Quick Loc™ (QL) pallet system offers fast, accurate fixture changes

Jergens Inc. announces its Quick Loc™ (QL) pallet system for fixturing solutions on horizontal, vertical, and rotary operations. These low-profile adapters and pallets ensure repeatability of 0.0003” and provide clamping forces of nearly 14,000 pounds. A single drive screw is used for fast operation.

Manufactured from case-hardened steel for high rigidity, QL is available in multiple styles including square, rectangle, round receivers, and cubes in both 52mm and 96mm patterns. The comprehensive selection of base, pallet, riser, and accessories makes this system configurable for an almost unlimited range of applications.

The QL pallet system, in combination with Jergens’ top tooling choices such as the new compact 130mm self-centering vise, are an industry first choice for increased machining access and quick change-over.
Jergens, Inc. is an ISO 9001:2015 certified company committed to helping its customers achieve leaner, more profitable manufacturing, and continuing to add products and engineered solutions for an integrated approach to “Manufacturing Efficiency.”

MORE INFO  www.jergensinc.com

Achieve small diameter boring with Big Kaiser’s Mini Indexable Boring Bar

Big Kaiser, a global leader in premium high-precision tooling systems and solutions for the metalworking industries, introduces the 4mm Mini Indexable Boring Bar – ideal for small component machining. To date, Big Kaiser has one of the smallest indexable inserts in the market.

The Mini Indexable Boring Bar helps meet the increasing demand for successfully boring small parts in industries like medical and aerospace, such as machined medical implant devices and micro-sized components.

The main advantage of this product is the cost savings of replacing just the indexable insert in production versus replacing the entire bar where the cutting edge is integral to the bar. The inserts can be easily exchanged without disturbing the overall geometry of the tool, providing optimized cutting results.

Indexable inserts feature sharp cutting edges that help lower cutting forces and vibration and inserts with special developed cutting geometry for carbon steel, alloy steel, and aluminum are available.

MORE INFO  www.bigkaiser.com

Jergens self-centering vises prevent lift for multi-axis machining

Jergens Inc. introduces a new range of vises for multi-axis machining productivity. Available in 75mm and 130mm with a number of mounting options, the self-centering vises feature a low-profile design to allow for a greater part (machining) access.

Part of the Fixture Pro® line of modular five-axis workholding, the vises feature a pull-down jaw design to actively reduce jaw lift caused by flex and raising up during the clamping process. These vises have an easy centering/re-centering adjustment and quick-change jaws that require no tools. Jaws are reversible and available in step jaws with serrated inserts, aluminum soft jaws, steel soft jaws, and hardened step jaws.

Versatile mounting options are compatible with several Jergens platforms including Fixture Pro®, Drop & Lock™, QuickLoc™, Lang Quick Point®, and 5th Axis RockLock™. Maximum clamping force is 3,600 lbs @ 50 ft*lbs. In combination with the full-line of Quick Loc pallet systems, the new vise offers versatility and quick-change on vertical, horizontal and multi-axis machining centers.

Jergens Inc. is an ISO 9001:2015 certified company committed to helping its customers achieve leaner, more profitable manufacturing, and continues to add products and engineered solutions for an integrated approach to “Manufacturing Efficiency.”

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“We identify, investigate, and inform AGMA members of emerging technologies that may impact the power-transmission industry.”

Your position is fairly new. What happened in the industry to move the creation of that position forward?

It was a board directive as part of AGMA’s 2016 strategic plan. The Board of Directors made a strategic plan. And from this strategic plan they saw the need for members to understand what’s happening with all of these new emerging technologies that are coming into manufacturing. So, the board decided that they wanted to be aggressive and put in a full-time position to develop information for the members, and the board actually chose the topics that I’m pursuing currently.

Those topics are 3D printing or additives with an emphasis on metal; electric drive technology, which is the newest one we added this year; the Industrial Internet of Things (IIoT), new materials; and robotics and automation.

What areas of emerging technologies is AGMA focusing on? Why those specific areas?

As a trade association, it’s our job to connect dots for our members. Hopefully, those dots will eventually lead to building bridges. With emerging technology, we started by having one emerging technology committee that met once a month for 12 months. The emerging technology committee was self-selected and individually invited members of AGMA member companies. In October 2018, we had our second face-to-face meeting, and at that meeting we established five separate subcommittees with five separate chairmen for each of the topics. Now we are building subcommittees that will do deeper dives into those topics.

How are emerging technologies shaping the gear manufacturing industry?

That is what we are working to help with: Manufacturers in general are getting hit from all sides by technology. They’re getting hit with new ways to make things, i.e. 3D printing. They’re hit by algorithms that are creating new alloys at record speed. They’re getting hit by their vendors wanting to have closed loop supply chains. Manufacturing is just getting hit by all sides; it’s being bombarded. And we’re working on providing information to our members so they can make much more informed decisions.

One example: The emerging technology committee has goals, and one of the goals is to bring emerging technology to the speakers stage at AGMA events. But it’s not just “bring a speaker.” At the SRN in October, we didn’t just have an electric drive speaker. We specifically went to a member company, Meritor, and asked them if John Bennett, who is their VP and CTO, could come and talk to the group about how Meritor is approaching electrification of drive trains — and he did. He literally told us what Meritor is doing with electrification of drive trains, because that is the kind of information our members need practical information on how new technology is hitting the marketplace, not just fluff. They need to know what’s happening within their peer companies, within their supplier companies, within their end-user markets.

Another example is we took the SRN on a tour to Fanuc America. We didn’t just take them so they could see the consumer or customer experience. We specifically asked Fanuc if they could present to us information on their use of IIoT, and they gave us a presentation on predictive maintenance solutions. We asked them if they could bring in the guy who buys gears for the robots they make in the United States, because it’s important for our members to see the market and to figure out how to get into those new markets. And they did; they gave us both of those presentations.

The other point that’s really interesting is, within the committees themselves, we are looking for thought leaders. In the new materials group, we have metallurgists; we have people that make powder metals; we have people that are developing alloys for 3D printing who are helping with the 3D printing group. We are talking with all of our steel providers, so they’re all on the same page and talking about development of new materials.

We’re inviting people who want to learn more to take part in committees. Because the members that are not experts are the greatest sounding board for the work that we’re doing. It’s a combination of members that need to learn this information. Then we have the experts who are telling us if we’re off the mark, and they can kind of knock us back onto the straight path.

The emerging technology committee is distinctly different from our technical committee. The goal of the emerging technology committee is to provide information. We do not do any testing; we are not doing anything that has to do with standards development. We are leaving that to the technical committees. We are just making sure that the information we are gathering is valid and that we are taking it in the right direction for the gear industry.

What is AGMA doing to make the industry more aware of these emerging technologies?

The ultimate goal is to provide our members with the opportunity to be informed in their decision making, so they don’t miss an opportunity.

Every Wednesday, we have a Tech Deck on the AGMA website. The tech deck is one article from each of the five topics from the past week. These are the five critical articles that, if you don’t read anything else that week, you should at least be aware of these five things.

The emerging technology committee is committed to providing speakers, so we assist in finding speakers for the FTM, the SRN, the annual meeting, and now a new conference in conjunction with our trade show: Motion + Power Technology Expo. The emerging technology committee is responsible for the emerging technology pavilion. We hope to have several more companies who will provide 20 minutes talk every day.

MORE INFO
www.agma.org/emerging-technology
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