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www.gleason.com/grsl
TO SEEK OUT FASTER SHAPING
Forest City Gear is boldly going where no gear jobber has gone before, with the first Gleason GP300ES Gear Shaping Machine featuring a 40-percent faster cutter spindle speed.

DIAGNOSTIC SIGNS OF DEVIATIONS OF THE TOOTH PROFILE OF GEARS
The proposed method of identifying the content of corrective and warning actions allows for systematic identification of corrective actions to effectively improve the quality of cylindrical gears.

INFLUENCE OF MANUFACTURING VARIATIONS OF SPLINE COUPLINGS ON GEAR ROOT AND CONTACT STRESS
A simplified power-transfer system of gears and shafts connected through involute splines is used to study the influence of spline lead variations on gear-mesh behavior and load distribution on the gear teeth.

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WILLIAM MARK MCVEA
IMPORTANCE OF GEAR INSPECTION AND THE MEANING OF THE DATA
Result interpretation from testing can be used to determine what went wrong during the manufacture of a gear or as a means to explain the results obtained from tests.

BRIAN DENGEL
WHEN THE CORONAVIRUS PANDEMIC IS OVER
The pandemic has changed many facets of life. How has it affected the gear industry?

D. SCOTT MACKENZIE
CALIBRATION OF REFRACTOMETERS FOR CONTROL OF POLYMER QUENCHANTS
There are three basic methods to calibrate an analog or digital refractometer; refractive index fluids are the most accurate, as well as being directly traceable to NIST.
Time to move toward normal again

Last year was a wild ride not just for the gear-manufacturing industry, but for the world at large.

*Gear Solutions* was not immune to the challenges the pandemic forced on us, but now that millions are vaccinated, it really appears that much of the world is returning to some semblance of normalcy.

Case in point, tradeshows are starting up again, and we couldn’t be more excited to be there to meet up with old colleagues and share your latest and greatest innovations with the gear-manufacturing world.

We plan on sending a full complement of staff to September’s Motion+Power Technology Expo in St. Louis, Missouri. Watch this space for more developments, because it’ll be here before you know it.

The industry definitely endured some challenges since the pandemic began, but companies across the U.S. really rose to the challenge to make those challenges as painless as possible. The gear industry boasts some amazing leadership, which, I have no doubt, helped make for a strong economic recovery.

In that vein, *Gear Solutions* is here to give you some amazing articles and information to help get you through the first official month of summer and, hopefully, a slow return to normalcy. Our June issue is a prime example with a focus on gear shaping and hobbing, along with expert advice from our monthly columnists.

In what will be of particular interest to the aerospace portion of gear manufacturing, enjoy a case study on Forest City Gear’s gear shaping capabilities that are literally out of this world, having shaped gears that are roaming the surface of Mars at this very moment.

Last month, I introduced you to our new Media Portal found on our website at www.gearsolutions.com. We’re very proud of this new tool that we offer to our readers. If you’re in search of a gear company’s social media offerings, as well as blogs, webinars, and podcasts, please take advantage of our Media Portal. It’s a social media smorgasbord.

That’s just one of many reasons why *Gear Solutions* exists: to be a visible and viable tool you can use to continue to get your word out to the industry.

Let us be your eyes, ears, and, most importantly, your voice. We are here, first and foremost, to shine a spotlight on your valuable products, services, and know-how.

Whether it’s a powerful ad or an expert article, let us share your insights with the people who are searching for it.

Stay safe and healthy out there, and, as always, thanks for reading!
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www.NewEnglandGear.com
Nordex achieves AS9100D quality management certification

Nordex, Inc., a leading manufacturer of precision electromechanical parts and assemblies, has been certified to the AS9100D quality standard by the American Systems Registrar, LLC. AS9100D is the gold standard of quality certifications, building upon ISO9001:2015 to account for the high stakes involved in manufacturing for the aerospace industry.

“AS9100D certification is an important milestone for Nordex,” said Dan Agius Jr., Nordex’s CFO and part-owner. “We are ready to take our reputation for quality gears, machined parts, and assemblies to new heights by welcoming a wider range of clients from the aerospace sector.”

Nordex has been manufacturing in the United States for more than 60 years.

“We have relationships with clients who are Fortune 500 companies that go back decades. It is our constant goal to improve — to be the best manufacturer we can possibly be — that helps us to keep serving these customers. AS9100D certification is another achievement that demonstrates our commitment to continuously improve.”

AS9100D certification has helped Nordex to improve all facets of its manufacturing operations, including its gear manufacturing. “Nordex’s bread and butter is gear manufacturing. The gear industry constantly changes and advances. Becoming AS9100D certified has helped Nordex to build the tools we need to keep evolving with the industry,” said Randy Ketchum, Nordex’s vice president of quality and regulatory affairs.

“Our entire existing client base gains from these improvements.” Agius said. “AS9100D helps us to better run and manage our business, while improving our quality processes and better controlling our costs — this is a benefit to all of our customers.”

MORE INFO www.nordex.com

ExOne accelerates expansion into 3D-printed tooling business

The ExOne Company, a global leader in industrial sand and metal 3D printers using binder jetting technology, has acquired the assets of Freshmade 3D, an Ohio-based startup with a patented method of creating durable AMClad® tooling out of sand forms 3D printed on ExOne machines.

The strategic move will strengthen ExOne’s position as a provider of large-format 3D printed tooling for industrial applications.

AMClad tooling, which is 3D printed in low-cost sand on ExOne systems and then infiltrated and coated using Freshmade 3D’s patented method, often eliminates weeks or months of time spent waiting for conventional tooling, and typically offers a 30-50 percent cost saving.

This fast, durable, and affordable solution can be used for a wide range of tooling applications, including composite layup, vacuum forming, compression molds, trim fixtures, hydroforming, sheet metal stamping, and more. AMClad tooling is being used today by customers in the aerospace, art, architecture, automotive, construction, and energy industries.

ExOne has been developing tooling products for its large, industrial 3D printers since 2014, and offers sacrificial tooling for composite layup that washes out with water. However, ExOne believes Freshmade 3D’s patented approach offers additional unique benefits and can help accelerate adoption of 3D printed sand tooling solutions.

“We are delighted to add Freshmade 3D’s patented process for creating durable 3D printed tooling to our portfolio,” said John Hartner, ExOne CEO. “We plan to scale up this process for a global aerospace customer, who intends to use this tooling for composite layup of parts. This is an ideal solution for companies looking to shorten supply chains and produce tooling and final products locally.”

MORE INFO www.exone.com

Send Us Your News
Companies wishing to submit materials for inclusion in Industry News should contact the editor, Kenneth Carter, at editor@gearsolutions.com. Releases accompanied by color images will be given first consideration.
“We launched AMClad with the idea of using sand 3D printing technology to deliver hard tooling faster and with more design freedom, to enable U.S. manufacturers to produce more locally and faster,” said Rich Wetzel, Freshmade 3D co-founder, who will now join ExOne’s applications team. “ExOne is the best company to accelerate this technology as we scale up for customers who’ve decided to leverage our solution to meet production goals faster. Companies are just beginning to discover how robust and affordable this technology is over conventional tooling.”

In addition to tooling, the AMClad process is being used to produce artwork or restoration pieces, including replication statues for museum exhibits, exterior reproductions for architectural refurbishment, or custom chrome details on classic cars. The versatile surface finishes available with the AMClad process include metal, stone, or painted finishes that allow for a range of artistic applications to be realized in a cost-effective manner.

Freshmade 3D was founded by Wetzel, Christopher Tomko, and Dr. Brett Conner in 2016 and is a portfolio company of the Youngstown Business Incubator, which supports the development of innovative high-tech companies in the Northeast Ohio region. Freshmade 3D has also received development support from America Makes, part of the National Network for Manufacturing Innovation established by the Revitalize American Manufacturing and Innovation Act of 2014.

“We’re so proud to be a part of Freshmade 3D’s success,” said Barb Ewing, CEO of the Youngstown Business Incubator. “Two of the three founders started their entrepreneurial career as part of our team. They are proof that northeast Ohio is fast becoming the epicenter for additive manufacturing in North America.”

Gleason strengthens North American sales team

Gleason added to its North American sales team in order to support increased customer activity in several market sectors growing in importance.

Nick Deaville joined Gleason as regional sales manager. Deaville is located in the Houston, Texas, area and will support Gleason’s customers in the Western United States and Canada. He brings 10-plus years of machine tool, cutting tool/abrasive, and automation experience to the market. He is a...
hands-on technical service and support provider with a strong mechanical background which fits well with the technical expertise of all the Gleason sales team.

Mike Gessler has transitioned to Detroit, Michigan, as regional sales manager for the North-Central sales region. He will continue to bring his depth of industry experience to provide Gleason’s customers with world class support. In addition, he will expand his role to take responsibility as Gleason’s key market manager — eDrive Technologies, a fast-growing and vitally important market for Gleason.

Gleason also recognized the long and distinguished sales career of Jamie Washburn, who is retiring from his role of regional sales manager after a 49-year career with Gleason. Gleason honors the accomplishments he has amassed through his dedicated service to the company and the gear industry.

MORE INFO  www.gleason.com

ANCA announces key European leadership appointments

Edmund Boland is general manager Europe; Martin Winterstein — an external appointment — is sales manager Europe, and Jan Langfelder moved to global key accounts manager. ANCA Europe has been operating for more than thirty years and the new appointments mark an expanding local footprint.

The company has a purpose-built technology center in Weinheim, Germany, and a UK facility and local sales and technical support in most European countries. The almost 70-strong European team provides a premium customer experience with expertise covering sales, customer training, application support, service, operations, engineering, finance and administration. Customers from across Europe can visit the state-of-the-art machine demonstration area to experience ANCA’s latest products and see first-hand the technology in action.

Boland moves into the role general manager Europe, having led global operations from ANCA’s headquarters in Melbourne. He has worked at ANCA for 15 years across several roles. He brings a broad range of expertise having worked in ANCA’s finance, operational and application teams. He has most recently led the global supply chain including successfully bringing ANCA through the COVID pandemic.

“I am very excited to join the team in such an important market. ANCA is in my blood and years of experience in our Australian headquarters has built a deep understanding of the business to help me further develop the European team’s capabilities to better listen to and service our customers,” Boland said.

Winterstein has led global, multinational teams in a number of successful machining businesses. Most recently, he worked as the chief sales officer, managing director at Gehring Technologies GmbH in Ostfildern. Prior to that he was the director global market sales and market service at Liebherr Verzahntechnik GmbH in Kempten. He has also worked for MAG Europe GmbH in a number of roles and at ThyssenKrupp MetalCutting, Hüller Hille GmbH in Ludwigsburg.

“It is a pleasure to join ANCA, a leader in the cutting tool industry with a strong reputation for accuracy and performance. Having worked in the European manufacturing market for many years at Gehring Technologies and more recently at Liebherr Verzahntechnik, I see many opportunities for ANCA to grow. Europe is a unique region with unique needs and ANCA offers the solutions and the expertise to provide a premium local experience,” Winterstein said.

MORE INFO  www.machines.anca.com

Klingelnberg among 2021 German Innovation Awards winners

Machine manufacturing firm Klingelnberg was among 2021 German Innovation Awards winners with its “Done-in-One – Complete Measurement in a Single Stage” solution. The German Innovation Awards honor products and solutions that distinguish themselves from earlier solutions primarily by their user centricity and added value. The German Innovation Awards are granted by the German Design Council, which was enacted into law by the German Parliament in 1953 and is funded by the Federation of German Industries (BDI).

With its innovative “Done-in-One – Complete Measurement in a Single Stage” solution, Klingelnberg entered the “Machine
and Engineering” category in the “Excellence in Business to Business” competition class. Klingelnberg’s approach is to perform various measurement processes in a single stage as one complete measurement (“Done-in-One”), all in the immediate production environment. A Klingelnberg precision measuring center (G variant) has rapid measurement capability for dimensions, shape, contour, and surface roughness in one automated cycle. By combining measurement tasks traditionally performed on up to four different devices, it is possible not only to lower investment costs, but also to decrease setup times and reduce quality costs.

The integration of measuring technology into the immediate production environment, in particular, helps to increase the productivity and output of the production plants. A fully automatic measuring run can save approximately 40 percent of the measurement and setup time.

“The German Innovation Awards honor projects that are pioneering in their field. So, we are thrilled that our Done-in-One solution is among the winners of the 2021 German Innovation Awards,” said Jan Klingelnberg, CEO of the Klingelnberg Group. “True to the expert jury’s ‘Making innovations Visible’ motto, the award represents our hard work in recent years.”

“This success is ultimately the result of many small- and large-scale developments from recent years, some of which are patented, including the further development of the tactile measurement system 3D NANOSCAN,” said Dr. Christof Gorgels, division head of the precision measuring centers product line. “The Klingelnberg Done-in-One solution can only be implemented when a wide range of innovations and detailed technical solutions come together. We are therefore extremely pleased to have received the award and gained widespread recognition in the market.”

The jury is made up of independent interdisciplinary experts from industry, science, institutions, and finance. The assessment was based on the criteria of innovation, benefit to users, and economic efficiency. The innovation strategy had to take aspects such as social, ecological, and economic sustainability and the use of energy and resources into account. Factors such as the potential of the location and employability, durability, market maturity, technical quality and function, materiality, and synergy effects also played a decisive role in the judging process.

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Wayland makes first sale of Calibur3 metal AM system

In advance of its physical launch event in May 2021, Wayland Additive announced the first sale of its Calibur3 metal AM system to Exergy Solutions Inc., Calgary, Canada.

Since its virtual launch event in March, Wayland garnered interest in the Calibur3 machine from across a wide cross-section of industry. Peter Hansford, director of business development at Wayland Additive, said, “We are extremely pleased with the response to the launch of our Calibur3 machine, and to be able to announce our first sale to Exergy is very exciting. We are in advanced discussions with a number of companies interested in our groundbreaking metal AM process, all of which recognize that NeuBeam™ affords them access to numerous production alternatives. Most importantly, the charging issues that

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MORE INFO  www.klingelnberg.com

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Wayland Additive made its first Calibur3 metal AM system sell to Exergy Solutions. (Courtesy: Wayland Additive)

make electron beam (EBM) processes so unstable have been fully neutralized with NeuBeam™.

Traditional workarounds for the eBeam process have been developed by the AM industry, but these lead to downstream complexities. The use of very high processing temperatures across the entire build plate creates a part within a semi-sintered cake, and this makes part removal and post processing difficult, time consuming, and expensive. These compromises also limit the materials that can be used, the geometrical forms that can be produced, and ultimately the applications that can benefit from the eBeam process.

Neubeam™ is material agnostic, can produce complex geometries that are impossible on other eBeam systems, and is typically 30-40 percent faster by removing the need to maintain and sinter the cake.

Exergy Solutions is an engineering consultancy offering end-to-end, fit-for-purpose lab-scale and pilot-scale equipment for research and innovation. The company has been operating in Calgary since 2013 and opened its X-Lab in 2019, offering state-of-the-art industrial additive manufacturing and post-processing solutions, as well as a wireless augmented and virtual reality studio. Exergy works with clients in a variety of sectors including demanding, highly regulated industries such as oil and gas, mining, manufacturing, and R&D.

Dr. Dave Waldbillig, director of advanced manufacturing at Exergy said, "The investment in Wayland’s technology means that we can present a compelling solution to our customer’s wear challenges. The partnership combines the high wear resistance and toughness of the Vibenite® series of materials from VBN Components, with the larger build volume and speed of the NeuBeam™ process, and Exergy Solution’s application engineering support.”

The Vibenite® series of materials used by Exergy are developed by VBN Components, which has a reputation for creating unique hard and wear-resistant materials for additive manufacturing, thereby allowing customers to create large geometrically-complex parts and components that are impossible to produce using traditional production processes. The Vibenite® series of materials are characterized by the production of components with extreme fatigue resistance thanks to the high cleanliness in Vibenite® materials, supreme wear resistance and hardness, thanks to the high carbide content, and no porosities and full hardness all the way through the component.

Mazak to showcase latest tech advances at PMTS 2021

At this year’s Precision Machining Technology Show (PMTS) August 10-12 in Cleveland, Mazak will highlight some of its latest high-output, cost-effective, and space-saving machine tool technology in Booth #3083. In particular, the company will spotlight its Kentucky-built Ez Series of machines and CNC – all touted as game changers for medium- to high-volume small-part applications.

At the show, Mazak technology in action will include the QT-Ez 12MSY horizontal turning machine, the VC-Ez 20 vertical machining center, the HQR-200MSY multi-tasking machine, and the company’s new MAZATROL SmoothEz CNC. Ez Series machines are designed to give job shops and other manufacturers affordable access to Mazak technology and engineering expertise.

For maximum efficiency, reliability and value in precision part production, the QT-Ez 12MSY is a turning center with milling and Y-axis off-centerline capabilities paired with a second turning spindle for complete DONE IN ONE® part processing. Productivity and unmanned operations are further enhanced when shops seamlessly integrate the machine with a range of automation solutions, from a bar feeder and parts catcher to full cooperative robot systems.

The QT-Ez 12MSY features a 20-inch bed length. With a larger A2-8 spindle nose, the machine delivers 3,300 RPM, 30 HP, and 285 ft-lbs of torque and features a 3-inch bar capacity. Its milling spindle puts out 6,000 RPM with 10 HP and 32.5 ft-lbs of torque. Likewise, the second turning spindle also delivers 6,000 RPM, with a 6-inch chuck offered with an optional through-hole package for shaft transfer applications.

Mazak’s 3-axis VC-Ez 20 packs a standard 12,000-RPM, 25-HP spindle, and offers an optional 15,000-RPM, 29.5-HP spindle. To keep spindles in the cut, the machine’s auto tool changer accommodates 30 tools, with 50 as an option.

The machine sports a C-frame design with X and Y axis motion via moving table and saddle. For repeatable part precision, guideway systems incorporate Mazak’s high-rigidity MX linear roller guides, while pre-tensioned ball screws ensure precise axis movement. Auger-type chip removal systems provide economical operation, with the option of an affordable hinge-type chip conveyor that
ships affixed to the machine to eliminate the cost of a second shipping pallet.

In addition to featuring Ez Series machines at PMTS, Mazak will feature its HQR-200MSY multi-tasking machine equipped with highly productive twin spindles and twin turrets for unequaled part processing and high throughput. The machine makes easy work of complex workpieces, processing them complete from raw material to finished part in single-setup DONE IN ONE® operations.

Sporting equal Y-axis off-center capability in both its upper and lower turrets, the HQR-200MSY significantly shortens part cycle times through balanced cutting and simultaneous first and second-op processing. The machine also integrates easily with a bar feeder or robot loader/unloader for lights-out production.

Blending simplicity and advanced functionality into one platform, Mazak’s new MAZATROL SmoothEz control provides an efficient, user-friendly interface that is easy to learn, especially for new operators. The most prominent feature of the control is its 15-inch capacitive touch-screen display, which accommodates a full-width on-screen keyboard or up to 60 lines of code. The NC system operates on two 800 MHz CPUs with an expanded 512 MB of DDR3-SDRAM memory. In addition to its redesigned Launcher screen, the new control also offers an expanded range of software features, including SMOOTH machining configuration, QUICK MAZATROL and MAZATROL TWINS, all of which first debuted on Mazak’s highly advanced MAZATROL SmoothAi CNC.

Like all Mazak controls, the MAZATROL SmoothEz CNC offers operators access to both EIA/ISO and MAZATROL conversational programming modes. In addition to standard G-codes, the control can use conversationally presented questions to gather information and generate a part program automatically. Enhanced MAZATROL features, including new end mill pecking cycles for point machining and support for more precise chamfering, further improve the programming mode’s industry-leading usability.

MORE INFO  www.mazakcorp.com

AGW rebuilds 50-year-old gearboxes to help protect Arkansas farmland

In 2019, a high-water event at one of the world’s largest water pumping stations, the W. G. Huxtable Pumping Station, built to prevent flooding in southeastern Arkansas, damaged two 50-year-old gearboxes that led to an operation failure that threatened 1.2 million acres of farmland in a mostly rural county in the Mississippi Delta.

The plant operator, the Memphis District of the U.S. Army Corps of Engineers (USACE), awarded the contract to repair and rebuild the two gearboxes to Atlanta Gear Works (AGW) in March 2020, just as the country was beginning to shut down because of COVID-19.

The Huxtable Pumping Station is located in Lee County, where according to the last U.S. census, 42.6 percent of the population lives below the poverty line. Bordering on the east by the Mississippi River, Lee County has two other navigable rivers, one of which is the St. Francis. The Huxtable Pumping Station was completed in 1977 to prevent flooding in the St. Francis River bottomlands.

The potential impact of the failed pumps was so significant that despite the entire country shutting down, AGW began planning the repair immediately on March 20, with an estimated year to complete.

Management at the plant had analyzed the two failed pumps and estimated the time needed to get them up and running again to be a year, but like many large projects, the problems turned out to be more complicated than initially thought.

Though the original job specs required the contractor to rebuild the two failed gearboxes on site, to make use of their extensive infrastructure and resources, they brought the gearboxes back to their shop in Dawsonville, Georgia.

In Dawsonville, the AGW team discovered that though the gearboxes were identical, the repairs would be not just complicated but also different for each one, including manufacturing new gears. To prevent future wear and tear, additional work at Huxtable

Mazak’s 3-axis VC-Ez 20 packs a standard 12,000-rpm, 25-hp spindle, and offers an optional 15,000-rpm, 29.5-hp spindle.

Two failed gearboxes threatened farmland in a county where 42.6 percent of the population lives below the poverty line. Atlanta Gear Works completed repairs in January, 2021. (Courtesy: Atlanta Gear Works)
 included vibration tests and adjustments on a total of 10 gearboxes.

Despite the unexpected complexity of the repairs, AGW completed the job two months ahead of schedule, on January 15, 2021. “We’re proud to have been selected for a project of this scope and significance,” said AGW President Jack Conway. “It’s why we hire the best people and stay ready to serve 24/7.”

MORE INFO  www.atlantagear.com

Kapp Niles undergoes change in executive management

After many years of success at machine tool manufacturer Kapp Niles, Martin Kapp is retiring from the joint management of the company with Helmut Nüssle. His sons Michael Kapp and Matthias Kapp began their new roles in January with Michael Bär.

The motivation for strengthening the management, combined with a reorganization of the areas of responsibility, was not only the retirement of Martin Kapp but also the increasing importance of global markets.

“We have decided to broaden and strengthen the management team. This will allow us to focus more on operational topics and intensify our global orientation, especially towards China,” said Martin Kapp.

In the future, Helmut Nüssle will be responsible for China, the most important single market in the group, the coordination and development of the international offices, and strategic issues. Michael Kapp will cover the value-creating areas, Matthias Kapp the development and sales, and Michael Bär the commercial part.

Martin Kapp will join the advisory board at this time and take over as chairman.

After studying mechanical engineering, brothers Michael and Matthias Kapp first worked for other companies and have now been with Kapp Niles for several years. Michael Kapp was previously responsible for production, Matthias Kapp was previously in charge of marketing. The grandsons of company founder Bernhard Kapp would like to maintain and expand the current business areas and increasingly focus on new business areas such as digitalization and e-mobility.

Bär brings his years of experience in the commercial sector to the management team. The graduate in business administration has been with the group since January 2012, most recently as division manager for controlling, finance, and human resources.

Even with the new management, Kapp Niles remains a family-run company with open communication with its employees, attaching highest importance to stability, independence, and security for the future.

MORE INFO  www.kapp-niles.com

RadTech promotes Fortune to education and outreach role

RadTech, The Association for Ultraviolet and Electron Beam (UV+EB) Technologies, promoted Mickey Fortune to associate executive director, education and outreach. Fortune has been with RadTech for nearly 20 years, spearheading a number of important new opportunities and initiatives while overseeing RadTech conferences and educational programming.

“His recent accomplishment of almost single-handedly developing, shooting video, and editing our important new environmental health and safety video series is a prime example of his wide-ranging skills and contributions.”

In addition to his role within RadTech, Fortune will continue to provide key services to the International Ultraviolet Association (IUVA) to support its mission to advance ultraviolet technologies for public health and the environment. With unprecedented interest in UV disinfection technology as a result of the global COVID-19 pandemic, he has worked tirelessly with IUVA members to produce vital educational opportunities, advancing technical collaboration and public knowledge of UV technology.

MORE INFO  www.radtech.org

Ipsen training brings education directly to customers

In addition to classroom-style trainings at its manufacturing facility, Ipsen offers on-site Ipsen U courses to accommodate large groups at customer facilities. Ipsen U is a course designed to teach heat-treatment fundaments, best practices, and new methods. Attendees receive an extensive overview of vacuum furnace equipment, processes, and maintenance.
Cadenas, Aveva technical search engine accelerates efficiency

Aveva and Cadenas have joined forces to integrate the Cadenas technical search engine, 3DfindIT.com, into the Aveva™ E3D Design system in the process plant and marine industries. This new, free plugin will provide users of Aveva’s 3D design solution with the ability to select accurate equipment models from thousands of manufacturer catalogs and integrate them directly within their computer aided design (CAD) software environment, saving hours in design time and costly rework.

“This partnership transforms engineering processes by accelerating the detailed design phase of industrial capital projects and the development of engineering digital twins,” said Amish Sabharwal, executive vice president of the engineering business at Aveva.

The 3DfindIT.com plugin deploys intuitive search methods including 3D geometric similarity search, sketch search, color search, and function search, specially tailored to the needs of CAD users. With the integration of 3DfindIT.com into Aveva’s 3D design suite, users will no longer be required to spend hours surfing the web to find and verify the parts they need for their plant or ship design. Instead, engineers can quickly configure the desired components individually and capture the CAD and Building Information Modeling (BIM) equipment models directly into their existing designs with just a few clicks, all within a fully integrated design environment.

In alignment with Aveva’s and Cadenas’ shared ambition to accelerate industrial digital transformation, this new offer will provide a step-change in engineering work processes by improving overall engineering efficiency and accuracy and ultimately helping the customers deliver industrial capital projects around the world on-time and on-budget.

Motion names NSK 2020 supplier of the year

Motion Industries, Inc., a leading distributor of maintenance, repair, and operation replacement parts, and a premier provider of industrial technology solutions, named NSK “2020 Supplier of the Year.” The award recognizes companies that have shown exceptional commitment to Motion through quality products and services, as well as earning the highest score in the multi-faceted supplier stratification rating system.

“2020 was a tough year in general, so for NSK to move to the top of the ranks is impressive,” said Joe Limbaugh, Motion executive vice president of supply chain, operations support, marketing and enterprise excellence.

“Our standards as measured through our supply chain process are rigorous, and improvement takes understanding, dedication, and overall hard work. NSK rose to the occasion and we are proud of their accomplishments. Suppliers who finished in our Top 50 are the ‘best of the best’ in our industry.”

“NSK is committed to delivering value to our customers above and beyond being experts in our own business by demonstrating expertise in our partners’ and customers’ business,” said Reid Jajko, vice president of Motion’s aftermarket business unit, NSK Americas.

“Our success is not defined by the sale of a bearing; it is defined by our ability to positively impact our partners’ operations. I cannot imagine a greater affirmation of our commitment than to receive this acknowledgment from Motion.”

Award recipients are determined based on Motion's supplier stratification formula — a rating system that evaluates each supplier's performance in a number of supply chain, marketing, and field support categories.

NSK began its journey manufacturing the first bearings in Japan in 1916, and has since developed into a global organization researching, designing, and manufacturing Motion & Control™ solutions essential for mobility and industrial applications. NSK is the top supplier of bearings in Japan and is the third largest supplier in the world by market share.
INDUSTRY NEWS

in shrink fit tooling and machine technology have been at the forefront of the industry. Their machine tool spindle technology is of the finest quality in the machine tool industry.

Accutek, with its quality CNC toolholder technology and CNC workholding technology will be expanding its product offering to include the high-quality toolholder technology of Diebold as well as its high-quality shrink machine technology to further support their distribution partners and metal-working customers through Mexico, Canada, and the United States. Accutek will not only sell the Diebold products but also service and support all application requirements to maintain a strong quality and service position in the markets it serves.

With the partnership with Diebold, Accutek will be adding the following products to its product offering:

GOLDRING TOOLHOLDERS
- CentroGrip® micro-precision ER collet system.
- UltraGrip® power milling chucks.
- JetSleeve® 2.0 shrink fit coolant holders.
- Ultrajet® 3.0 innovative coolant-thru power chucks.
- Diebold ER Shrink – ER collets with shrink fit technology.
- DMS – Diebold modular ER Tooling system.

THERMOGRIP® SHRINK FIT MACHINE TECHNOLOGY
- MS502-P mini-shrink fit machine.
- US 1100V – vertical shrink fit machine.
- US 1100H – horizontal shrink fit machines.
- US 1100VT – vertical shrink fit machines with integral solution cooling.
- Patented pyrometer coil technology for all US 1100 machines.

MEASURING TECHNOLOGY
- Clamping force tester.
- HSK taper and D-BT taper measuring gauges.
- VEG presetting and measuring systems.
- 3D edge finder technology.

Accutek, a high-quality manufacturer of toolholder and workholding products, has a strong Industrial distributor partner support system throughout North America servicing all of Mexico, Canada, and United States manufacturing businesses.

MORE INFO www.accutekusa.com

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Gears for the wild blue yonder aren’t for the faint at heart. Look to Southern Gear.

Going Up? LOOK SOUTH.

There’s a Better Way.
Strong outlook for gear market recovery in 2021, 2022

With recent administration changes, trade/tariff regulations, unpredictable tax laws, and the slow return from the COVID-19 pandemic, many of our members and companies in the power transmission industry are cautious about their budgets. It is difficult to predict what will happen the remainder of this year and next, but through the extensive research from our Gear Market Report and the numbers presented by our experts at IHS Markit (Scott Hazelton, director, U.S. Industry Consulting; John Mothersole, director, Pricing and Purchasing; and Tom Runiewicz, associate director, U.S. Industry Economics), the gear industry has a potentially bright recovery.

THE U.S. ECONOMY: THE GOOD
Pandemic relief measures of 2020 that included the recent $1.9 trillion American Recovery Plan (ARP), stimulus checks, unemployment programs, unrestricted aid to local governments, and numerous tax credits for pandemic-affected industries have influenced the ability for consumers to spend. Couple that with higher vaccination rates, increase in home values, the rise in GDP, and crude oil prices for the U.S., it is likely that we will see a good start to recovery in this second quarter.

THINGS TO WATCH
The forecast that Gear Market Report holders received did not yet incorporate the American Jobs Plan, which proposes to spend $2.2 trillion on infrastructure and social spending paid for more than 15 years by higher corporate taxes. In addition, higher personal taxes will be seen over time to compensate for the generous relief programs.

Commodity prices are also rising and, as you might already see in the news, inflation of goods will be unavoidable this summer. This is a true demonstration of the supply-chain bottleneck many of our gear manufacturers and suppliers are experiencing firsthand. Although this does provide a predicament for pricing, most industries are expected to meet demand efficiently.

HOW AGMA CAN HELP
Firstly, this article just shared a small glimpse into the vast information the Gear Market Report offers. It is the only report specifically researched for the gear industry and gives a great overview of what to expect each quarter for your business. Not only does it break down the different sectors, but it gives an incredible overview of how the current U.S. economy standings will affect your bottom line. It prepares our members to look ahead, and that is what AGMA is there for — to be the periscope for the power transmission industry. Visit: wwwAGMA.org for information on how to sign up to receive this quarterly report.

Secondly, we are one of the few B2B industry tradeshows happening this year, and we are doing it in person. The Motion + Power Technology Expo is September 14-16 in St. Louis, Missouri. The numbers show the demand is there — now all you have to do is meet your customers face-to-face and show them your products. Do not miss out on this unique timing for getting your sales team on the show floor to capitalize on the growing need for machines and supplies. Whether you are a buyer or an exhibitor, we have the space for you. Visit: motionpowerexpo.com to become and exhibitor or attendee.
Upcoming Education

Steels for Gear Applications
June 29-30, 2021*

Gain a basic understanding of steel and its properties. Learn to make use of steel properties in an application and understand the potential that different steel and heat treatment options can offer. Explore how performance of the material depends on how the steel is produced.

This course is IACET accredited and worth 0.6 CEUs.

*Deadline to sign up is June 22, 2021.

Fundamentals of Gear Design & Analysis (In Person)
July 20-22, 2021*

Gain a solid and fundamental understanding of gear geometry, types and arrangements, and design principles. Starting with the basic definitions of gears, conjugate motion, and the Laws of Gearing, learn the tools needed to understand the inter-relation and coordinated motion operating within gear pairs and multi-gear trains. Basic gear system design process and gear measurement and inspection techniques also will be explained.

This course is IACET accredited and worth 1.7 CEUs.

*This course is taught at Ranken Technical College. A shuttle bus is available each day to transport students to and from the hotel. Class will be 8 a.m.-5 p.m. each day.

Upcoming Webinars

Harness the Power of Machine Data
July 7, 2021 | 1-2 p.m.
AGMA Members: Free / Non-member: $29

It is estimated that 60 percent of global manufacturing companies will use connected device data for analysis this year. Data is transfor-
mative. Understanding all the various factors that can be measured on your machine tools can help you drive profitability. Just think, if you knew your real down-time, what actions would you take? How can you drive optimization? Graham understands this space and will provide you with case studies and tools that will help you better understand and use your data more effectively.

**When Discussing Electric Vehicles You Must Talk About the Consumers**

*August 4, 2021 | 1-2 p.m.*

AGMA Members: Free / Non-member: $29

We continue to discuss the paradigm shift in automotive manufacturing. The future is uncertain. In order to have a comprehensive picture, one must include the consumers. Escalent’s EVForward™ is the largest EV study of the next generation of EV buyers. Mike Dvorany and his team talked with 10,000 new vehicle buyers. Come and listen to what they discovered from this research as we work to move forward in this space.

**AGMA’s Emerging Technology Efforts – What’s Next?**

*September 1, 2021 | 1-2 p.m.*

AGMA Members: Free / Non-member: $29

The goal of the AGMA Emerging Technology committees is to identify, investigate, and inform AGMA members of Emerging Technologies that may disrupt or significantly affect the power transmission industry. As we enter our fourth year of work in this space, join us for an overview of what we have accomplished and a roadmap of where we hope to go next.
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.

**JUNE**
- June 18 — 3D Printing Committee Meeting — WebEx
- June 24 — Wormgear Committee Meeting — WebEx
- June 29 — Lubrication Committee Meeting — WebEx
- June 29 — Robotics & Automation Committee Meeting — WebEx
- June 29–30 — Steels Course — WebEx

**JULY**
- July 1 — Market Intelligence Committee Meeting — WebEx
- July 7 — Emerging Technology Webinar — Zoom
- July 13 — Metallurgy & Materials Committee — WebEx
- July 14 — Powder Metal Committee Meeting — WebEx
- July 15 — Nomenclature Committee Meeting — WebEx
- July 20 — Fundamentals of Gear Design & Analysis Course — St. Louis, Missouri
- July 29 — Gear Accuracy Committee — WebEx

**AUGUST**
- August 4 — Lubrication Committee Meeting — WebEx
- August 10-11 — Basic Gear Inspection for Operators Course — Chicago, Illinois
- August 12 — Plastics Committee Meeting — WebEx
- August 17 — AGMA Board of Directors Meeting — Alexandria, Virginia
The importance of gear inspection and the meaning of the data

Result interpretation from testing can be used to determine what went wrong during the manufacture of a gear or as a means to explain the results obtained from tests.

A topic near and dear to my heart, I am often tasked with answering the question; “What went wrong?” As we all know, there is no one answer and as our buddy Ray Drago has oft been heard to say, “it depends.” Seriously, it is paramount to know what you are working with prior to placing a gear system into service. Especially if the gear design is new to the application, whether a completely new design, a redesign, or an upgrade to an existing design. When you place a new design into service for the first time, you are verifying the results of your development work and determining whatever adjustments it may need. To be able to effectively determine the correct changes, if any are needed, requires the results of the first run to be well documented.

Without knowing the precise geometry of the gear under test, there is no way to work backward from effect to cause. The interaction between any two gears is a function of the contact geometry and the lubricant layer managing the energy transfer between them. As we also know, all our analysis techniques are based on constant tooth face geometry, equivalent load distribution and a fully formed elastohydrodynamic shear layer. Deviations in any one of those parameters significantly alters things such as service life, efficiency, NVH response — the list goes on. Not to say that small deviations in geometry, etc., are not part of the final production implemented physical product, however they must be quantified and understood. If you think about it, this is how we determine the appropriate quality designation. Certainly, it is common to start product development with higher than hoped for quality requirements as these add cost to every component. As the robustness of the full product becomes more completely understood, the cost of quality may be able to be reduced, gears included.

So, what do we do? My recommendation is that before any newly designed (or redesigned) gears are placed on test or into service, they are thoroughly vetted via a full GMM (Gear Measurement Machine) analysis. The gears will be measured, inspected, and the results analyzed. As we know, the pitch point (pitch circle, pitch diameter) are all defined as the instantaneous point of contact between two mating teeth where there is no sliding motion. This “diameter” can be different for every tooth combination. Which in turn makes this “pitch point” a function of the two teeth in mesh at any given moment. The concept of increasing quality (higher AGMA 2000 Q numbers, or ISO A numbers) is to reduce transmission error (TE) and improve gear tooth conjugacy. Measurement, on the other hand, is the quantity at which any object can be compared to a known value. Finally, inspection is the process by which one checks the measurement against the requirement to determine whether it is fit for function, or whatever the criteria that has been established and is expected from the part.

The first level result of our inspection will be to verify suitability of application for whatever our first piece test or use will be. The second level use of the inspection results (GMM or other) will be to be a baseline to compare test results with requirements: generally, service life, NVH, etc. The basic composite checks, like profile evaluation and/or lead evaluation, etc., are a good start and can be used to tell us a lot about the gear tooth. Remember, there are four attributes...
that we evaluate in terms of a gear and the pair. Relative to the gear as an individual piece we evaluate the shape; usually the involute profile, the size (height, width, etc.), and the spacing (pitch, tooth-to-tooth runout, etc.). The fourth attribute is of the pair, generally mesh interaction at a defined center distance, that sort of thing. The trend in the industry is to move away from quantifications that involve the pair in mesh (backlash, runout, etc.) and define the gear data chart specific to only the gear it references. We see this in the move away from parameters such as SAP and EAP and toward SOI and TIF, for example. To that end, we now recommend that attributes such as the aforementioned backlash and runout, etc., are better placed on the assembly drawing of the gearbox.

The measurement categories of elemental and composite address and evaluate all tooth surfaces, whether in tight mesh with a master gear or in comparison to the ideal gear (generally the mathematical representation). When we look at either the basic or complex attributes, we are looking at individual attributes of the gear tooth. The difference between basic and complex is the measurement tool used. Basic inspection elements use either measurement tools and/or gauges typically developed to assess one attribute of all tooth parameters at a time, whereas complex inspection elements use measurement systems that perform multiple measures in one setup and are usually conducted via computer-controlled gauge techniques. These usually are defined as GMM systems and are very precise, accurate, and repeatable.

Okay, so we have the basis of the measurement techniques and a very brief overview of the tools at are at our disposal. Now what? As this article started, we will use some or all of these various tools to quantify the various attributes of importance prior to placing the gear into service. We strive to know exactly what we are dealing with when we conduct a test or runoff of a new design or gear development. The plan entails measuring all aspects of the gear tooth form, spacing, and pair development. This information can be used to either determine what went wrong during the manufacture of the gear or as a means to explain the results obtained from testing.

We use GMM results to also record history such that we can build a history of all our designs, as well as develop family representations of gear designs to be used during new concept development. Certainly, with enough tooth surface representation data, one can build a model of each tooth and then analytically “mesh” it with its mate to better understand all sorts of tooth-to-tooth interactions. All of this and more can be done as more time is committed to the analysis. It can also be very overwhelming.

Now fortunately for all of us, AGMA offers two highly valued courses on gear measurement, inspection, and result interpretation. I encourage you to look them up, sign up, and I will see you there.

ABOUT THE AUTHOR

Dr. William Mark McVea, P.E., is President and Principal Engineer of KBE+, Inc. which develops complete powertrains for automotive and off-highway vehicles. He is the Principal Engineer with Kinatech, a joint venture with Gear Motions / Nixon Gear. He has published extensively and holds or is listed as co-inventor on numerous patents related to mechanical power transmissions. Mark, a licensed Professional Engineer, has a B.S. in Mechanical Engineering from the Rochester Institute of Technology, a Ph.D. in Design Engineering from Purdue University.
When the coronavirus pandemic is over

The pandemic has changed many facets of life. How has it affected the gear industry?

When we were making our business plans in 2019, the thought of a pandemic was never a consideration. Business leaders and CEOs were looking at their sales and marketing data and the forecasts revealed the economy should continue to grow, albeit at a slow rate. This combined with a presidential election occurring in the latter part of 2020 gave CFOs a signal to maintain current investments but to refrain from starting new projects. Little did any of them know what was about to occur.

In early 2020, business in the gearing industry was strong. Most suppliers would say that the fourth quarter of 2019 and the first quarter of 2020 were the best that they had seen in years. Although the limited availability of skilled labor was beginning to impact production, orders continued to flow in, and shipments remained strong. And then the virus began to spread.

In the first half of the 1900s, one of the greatest public health fears was poliovirus. Poliovirus was feared by society because of the potential effects of exposure. Although three-quarters of people exposed experienced flu-like symptoms and recovered completely, approximately one half of one percent of children who were exposed would end up with some form of paralysis. The paralysis could be mild, requiring the use of leg braces, or it could be so severe that children would need to spend the rest of their lives inside a pressurized breathing apparatus nicknamed the iron lung. Because of the possibility of paralysis, whenever an outbreak occurred, children were kept from public pools, beaches, and movie theaters, bans were placed on using drinking water fountains, and public meetings were canceled. The fear of infection continued until 1955 when a vaccine was introduced.

In late January 2020, business in the gearing industry was strong. News about a mystery flu-like virus emanating from China began to permeate the airwaves. By mid-February, the number of people infected by this novel coronavirus was increasing exponentially, causing businesses and government leaders to question how to contain the outbreak. Some pointed to the seasonal influenza and thought that the new virus would just work its way through society. Others feared that the high infection rate and serious nature of the illness would result in mass casualties. By mid-March, the spread of the virus appeared uncontrollable, and businesses began to shut down in order to keep employees safe from possible exposure. Many of the people who got sick ended up hospitalized, breathing with assistance from a respirator due to the aggressive nature of the virus.

The general business shutdown hit the gearing industry hard. Production stopped. Customers delayed deliveries. Projects were halted. New sanitation procedures were advised. “Social distancing” became a new buzzword.

During the period of late March through early June, the output of most gear suppliers decreased by more than 50 percent. Some producers remained open during this time in order to meet the continued demand for critical national defense components. Other gear suppliers shipped product from stock but halted all production. The suppliers who remained operational became the proverbial canaries in the coal mine as they were able to test the newly proposed hygiene procedures.

As the post-pandemic period continues, the gearing industry should continue to grow. The raw material and component shortages are transitory, and once resolved will allow for the return to steady growth.
standards both in their offices and on their shop floors. With new standards in place, most manufacturing was permitted to re-open in June 2020.

As the re-opening of manufacturing started, demand was immediate. Factories that had been shuttered returned to full operation as demand for personal protective equipment and other goods skyrocketed. As these factories restarted, the need for gearing and related components spiked as well. Other drivers of demand for gearing included newly developed machinery designed to produce plastic point-of-purchase shielding, newly developed machinery designed to produce virus testing equipment, and newly developed automation equipment designed to maintain production when equipment operators were home due to quarantine.

Sales and other office operations of gear suppliers were able to transition to remote work during the pandemic via VPNs and virtual video meetings. Gear production equipment, however, requires live operators to start, stop, load, and unload the gear production machinery. Thus, once they re-opened, gear suppliers had a new set of tasks to tackle including implementing hand sanitizing stations, ensuring safe distances between workstations, and checking the health of all employees prior to each shift. Once these procedures were in place, gear suppliers were back to full production.

In December 2020, the United States Food and Drug Administration issued an emergency use authorization for the first of several vaccines for the virus now known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

As more and more of the general populace got one of the vaccines, a general uptick in business activity occurred. However, manufacturing and the gear industry hit a plateau in the first quarter of 2021. The sharp demand for new equipment and mechanical components created an outsized demand for raw materials. This demand for raw materials, at a time when mines and foundries had just restarted from shutdown, caused shortages of some materials and significant inflation in the cost of those materials.

Gears are mechanical components and are themselves immune to viruses. However, the motion they transmit is generated by a motor located somewhere in the mechanism. This motor, in turn, is operated by a controller that contains microchips. The shutdown of the chip manufacturers resulted in a shortage of chips just as the demand for finished products spiked. This shortage, combined with the rise in cost of raw materials, slowed the growth of the mechanical components industry.

As the post-pandemic period continues, the gearing industry should continue to grow. The raw material and component shortages are transitory, and, once resolved, will allow for the return to steady growth. Gears will continue to drive industrial automation systems, which, in turn, will be used to produce and deliver the goods that industry and consumers desire.

**ABOUT THE AUTHOR**

Brian Dengel is general manager of KHK-USA, which is based in Mineola, New York. Go online to www.khkgears.us
Calibration of refractometers for control of polymer quenchants

There are three basic methods to calibrate an analog or digital refractometer; refractive index fluids are the most accurate, as well as being directly traceable to NIST.

In the last column, we described the use of refractometers for controlling the concentration of many different types of fluids, including polymer quenchants and coolants. They can also be used to monitor sugar content during wine and beer making. In this article, we will talk about the proper method of calibrating a refractometer.

In general, refractometers can be either simple handheld analog or digital refractometers. These are shown in Figure 1. The general procedure is to obtain a sample of the fluid to be measured, and a small sample of the water that is used to make the diluted fluid. Using the same source of water that is used with the fluid being measured, apply a small drop to the prism (for analog refractometers), or the measurement location of the digital refractometer. The water is measured, and in the case of analog refractometers, an adjustment screw is adjusted until the line observed in the sight glass and the line on the reticle correspond. For digital refractometers, the use of the “ZERO” function will perform the same task as the adjustment screw.

For many manufacturers of refractometers, this provides the sole method of calibrating the refractometer. However, many agencies, such as NADCAP, require a “ZERO,” “SPAN,” and “MIDPOINT” to demonstrate a fully calibrated refractometer.

METHODS OF CALIBRATION

There are three basic methods for calibrating a refractometer, and each is acceptable to most auditing agencies.

METHOD I – EXISTING SOLUTION CALIBRATION

In this method, samples from a tote or drum of the material being measured is used. This could be a coolant or polymer quenchant. For the sake of argument, we will confine ourselves to aqueous polymer quenchants. The procedure is the same for a coolant.

Taking a new, neat sample from the tote or drum of unused quenchant, two different solutions are created. First will be the “SPAN” solution, which is the maximum amount of quenchant expected to be used, or the maximum that can be measured by the refractometer. For instance, if the maximum permitted concentration is 40 percent, and we are using a quenchant with a multiplying factor of 2.0, then the “Brix reading would be 20° Brix. Using this example of maximum 40 percent quenchant, then a solution is created of 40 percent quenchant. It is important to understand if the concentration is reported at weight percent or volume percent. If your supplier or laboratory reports the concentration by weight percent, then a solution of 40 percent by weight should be created. If measured by volume percent, then the solution should be made by 40 percent by volume. If you are measuring weight percent, you will need a calibrated gram or milligram scale. If you are measuring by volume percent, you will need a calibrated graduated cylinder. The necessary amounts needed to create a 40 percent by weight or 40 percent by volume are shown in Table 1. It is important to understand how your laboratory or supplier reports their concentrations. If it is measured by volume in your shop, and by weight by your supplier, then a discrepancy will result of potentially several percent of solution. This discrepancy will produce unnecessary audit bait. Make sure that you measure in the same fashion as your supplier or laboratory, and a lot of auditing headaches are avoided. The method, volume percent or weight percent, should be recorded.

The second sample that needs to be taken in the “MIDPOINT” sample. This is created in the same fashion as the “SPAN” sample.

Once the two samples have been created, and a sample of the water used to make the samples is obtained, then the measurements are taken and recorded for each refractometer. The data is plotted, and a trendline is graphed. The resultant graph should accompany each refractometer.

<table>
<thead>
<tr>
<th>Type</th>
<th>Quenchant</th>
<th>Water</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>40% by weight</td>
<td>40</td>
<td>60</td>
<td>milligrams</td>
</tr>
<tr>
<td>40% by Volume</td>
<td>40</td>
<td>60</td>
<td>milliliters</td>
</tr>
</tbody>
</table>

Table 1: Amounts needed to create 40 percent by weight or volume.
The disadvantage of this method is that a single lot or batch of material is used to create the calibration curve. In the case of AMS 3025 Type I quenchants, the allowable water content is 45-48 percent by weight. Therefore, there will be lot to lot variations in the measured calibration curve if only one lot is used to create the curve. The best method is to take samples from different lots and create solutions from each lot and add it to the data. This way a bulk average can be taken, and a more representative calibration can be obtained.

METHOD II – BRIX FLUIDS

A Brix refractometer measures the amount of sucrose in water. Therefore, a suitable calibration fluid can either be obtained (with non-tracible certificate of analysis) or created internally. 1° Brix is 1 gram of sucrose in 100 grams of solution (99 grams of water = 1 gram of sucrose) at 20°C. There is a direct relationship between the refractive index and °Brix (Figure 2). The refractometer uses the refractive index to convert the refractive index to °Brix. Therefore, a simple Brix fluid is simply a mixture of water and sucrose.

In a similar fashion to creating a “SPAN” and “MIDPOINT” standard in Method I above, sucrose is measured out by weight, into a known weight of water (Example: 40g sucrose in 60 grams of water). The weight measurement should be carried out to the nearest milligram. A similar “MIDPOINT” sample is created near the typical in-use concentration. Distilled water should be used.

Once the calibration standards have been created, the standards are measured by the refractometer, along with the water sample. The data is plotted. Each refractometer measurement is recorded, and a calibration curve developed for each unit. The curve should accompany each instrument.

Brix fluids created in this way are completely non-toxic as they are only sucrose and water. If made internally, these calibration fluids should be stored in a refrigerator between uses. Once the calibration standards are mixed, the shelf life is very short – usually measured in days. Disposal of the sucrose Brix fluids is very simple and can usually be poured down the drain. Cleaning the refractometer is also simple, just requiring water.

Depending on the auditor, the in-house creation of Brix fluids may create additional areas for the auditor to investigate. For instance, if these fluids were created in-house, the auditor may ask to see the calibration record of the scale used, as well as the certificate of analysis of the sucrose. Purchasing these calibration sources usually can be obtained with a certificate of analysis. This usually satisfies an auditor.

METHOD III – REFRACTIVE INDEX FLUIDS

For most polymer quenchants, the refractive index of the solutions will vary between 1.300 – 1.395 nD, with most no greater than RI = 1.3636° (20 °Brix). Refractive index fluids have a very precise refractive index and are traceable to a national standards body. In the U.S., this is the National Institute of Standards and Technology (NIST). This usually allays any questions from auditors regarding calibration.

These refractive index fluids are usually mixtures of methylene iodide, silicon oil, and alpha bromonaphthalene. These fluids are generally chosen to be non-toxic, but may have an unpleasant odor like mothballs (personally I like the smell of mothballs). These refractive index fluids can be purchased to have a very precise refractive index usually to a precision of ±0.005. Often, these refractive fluids can be purchased as a set, so that discrete points can be calibrated.

Temperature compensation is different with refractive index fluids. Most Brix fluids can be measured on a temperature compensating refractometer. Refractive index fluids show a different temperature dependency than do Brix fluids. This means that additional care must be taken to control the temperature of the refractometer. For instance, this would require that the refractometer be allowed to equilibrate with the room temperature and refractive fluid temperature prior to performing calibration. Allowing the refractometer to equilibrate for at least one hour is usually sufficient.

The life of these fluids is measured in months, with many having a room temperature shelf life of two years or more.

Unlike sucrose Brix fluids, which only require water for clean-up, refractive index fluids must be cleaned with an organic solvent. This rinse solution must be disposed of, as well as the refractive index fluid. Verification with your in-house environmental person will provide the proper disposal method.

CONCLUSION

In this short article, the three basic methods to calibrate an analog or digital refractometer have been provided. Method III is the most accurate, as well as being directly traceable to NIST.

Should there be any question regarding this article, or suggestions of further columns, please contact the author or the editor.

About the Author

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CASE STUDY
TO SEEK OUT FASTER SHAPING

Forest City Gear has produced gears for every Mars Rover, including the Perseverance. (Courtesy: NASA)
Forest City Gear is boldly going where no gear jobber has gone before, with the first Gleason GP300ES Gear Shaping Machine featuring a 40-percent faster cutter spindle speed.

By UDO STOLZ

The search for intelligent life on Mars took a big leap forward on February 18, 2021, when Perseverance, NASA’s latest Mars Rover, touched down on the surface of the Red Planet. Its mission? To seek signs of ancient life and collect rock and soil samples for possible return to Earth, as well as pave the way for future human exploration. It’s the most ambitious of NASA’s Mars missions, with a larger, more sophisticated Rover that builds on the lessons learned by previous Rovers dating back to 1997.

Fortunately for NASA, “intelligent life” can be found a lot closer to home at Forest City Gear. Gears produced by this well-known precision gear jobber in Roscoe, Illinois, have been used on every Rover, helping ensure these vehicles operate dependably, whether traversing the rugged Mars terrain or surviving in temperatures down to minus-130°F.

NASA puts its trust in Forest City Gear, and Forest City Gear in turn trusts Gleason — this time for North America’s first GP300ES Gear Shaping Machine with a 1,500-strokes-per-minute cutter spindle speed that’s significantly faster than anything in its 300-mm diameter size range. The GP300ES is the company’s seventh CNC shaping machine, making Forest City Gear one of the largest and most productive shaping resource available for contract gear production. And now, with the GP300ES, it’s one of the fastest.

“We are fortunate to be the first company in North America to put this new, faster GP300ES into production,” said Forest City Gear Director of Operations Jared Lyford. “It’s a versatile, highly-productive machine that’s added throughput for our customers seeking faster turn-around and higher quality, particularly for gears that require a unique approach to standard cutting strategies via higher feeds and speeds.”

**IMPROVING ON THE LEGACY**

According to Lyford, several important aerospace “legacy” projects already have benefited from the new Gleason shaping machine. Most notable is a family of aerospace internal and external spur and helical gears, fine and medium pitch, and involute splines — all made from 440C stainless steel.

440C stainless is a grade known for its superior strength and hardness, making it ideal for many aerospace applications. Lyford pointed out the material also can be a challenge to shape.

“We could overcome the machinability issues we’d been encountering when shaping these 440 parts by increasing the feeds and speeds to the very upper limits of our shapers (all of which are the latest models with guideless helical capability) — but...
then lead integrity would suffer as a result,” he said. “That’s the shaping conundrum in a nutshell: a process ideal for generating critical features against shoulders with limited clearance — but with inherent limits on how fast you can machine.”

With demand growing fast for not only aerospace parts of this type but other high precision work, Forest City Gear went shopping for a new shaping machine — one that ideally could add capacity and shape at much higher speeds than traditionally possible with machines in the 300-mm size range.

Serendipitously, Gleason had just improved on one of its “legacy” shaping machines: the popular GP300ES. The new version is designed to address the long-standing shaping conundrum and deliver cutter spindle stroke speeds as high as 1,500/minute. This is 40 percent faster than the existing model and anything else in its size range. In short order, Forest City Gear purchased the first of these new-series GP300ES machines ever to be installed in North America. To accommodate Forest City Gear’s ambitious delivery requirements, Gleason even arranged to have the machine — typically built at its Ludwigsburg, Germany, facility — assembled at the Gleason headquarters in Rochester, New York, instead.

BUILT FOR SPEED
When the earlier GP300ES and the new, faster model are compared side by side, there aren’t any obvious differences. But, while the enhancements made might be subtle, they are significant. Gleason began by developing a new balancing weight that minimizes unbalance for all cutter-spindle-stroke axis lengths and speed ranges. New control parameters for the stroke-and-tool-back-off axes were applied as well to achieve the higher stroke rates. The back-off axis also features a new-design back-off cam specially designed to operate more reliably at the higher stroke rates.

To accommodate the potential for more noise and vibration, Gleason also stiffened the housing sheet metal and added insulation. New leveling wedges with two-chamber air spring elements also were added for greater vibration damping.

INCREASED SPEED, PROBLEM SOLVED
Now, with the new GP300ES, Lyford reports the problems experienced with the 440 stainless parts have been eliminated. “With the higher surface footages, we can slow the rotary feed enough to put less of a chip load on the cutter to get the required quality but without impacting cycle times,” he said. “In fact, we’ve about doubled surface feet per minute (SFM) for production of almost every part we produce on that machine, while at the same time reducing chip load. This results in improved quality and extending tool life. I believe this machine really marks the beginning of a new chapter in shaping, both for the industry and Forest City Gear.”
TECHNICAL DIAGNOSTICS OF A GEAR HOBBING TECHNOLOGICAL SYSTEM ON DIAGNOSTIC SIGNS OF DEVIATIONS OF THE TOOTH PROFILE OF GEARS
The proposed method of identifying the content of corrective and warning actions allows for systematic identification of corrective actions to effectively improve the quality of cylindrical gears.

By DT SAFAROV and AG KONDRASHOV

The article reveals the main provisions of technical diagnostics of a gear hobbing machine system with CNC on the diagnostic parameters of the profile of the sides of the teeth. The scheme of embedding diagnostic processes in the cycle of improving the quality of manufacture of gears. The developed scheme is universal and applicable to any gear processing operations. It consists of several successive steps — the evaluation of indicators relative to the limit values, the identification of the technological structure of the profile errors and the identification and analysis of diagnostic deviations of the profile of the lateral surface of the teeth, indicating. Each step of the improvement cycle is necessary to determine the negative factors of the process leading to a deterioration in the quality of manufacture of gears.

Application of technical diagnostics profile diagnostic indicators allows detection of deviations of the technical condition of machine components, adjustment, or tuning machinery. Diagnostic indicators are identified for the most significant technological components of non-conforming errors of the profile of the sides of the teeth of the gear wheel. The advantage of this quality improvement scheme is that it is more efficient than traditional methods of statistical quality management.

1 INTRODUCTION

As a rule, technical diagnostics of machine systems consist in instrumental collection and analysis of information on various indicators of the technical condition of the machine system to determine the degree of compliance of its components with passport data.

In production conditions, methods for estimating the geometric accuracy of machine modules are widely used. Measurements are performed by traditional mechanical indicators, modern electronic, or laser systems (Renishaw laser system C-ALS) [1,2]. According to their measurements, geometric deviations of machine modules, beating of mobile rotational modules are estimated. Another type of technical diagnostics is the evaluation of the performance of modules on vibration indicators. They are recorded by vibro-diagnostic complexes measuring the parameters of the vibration spectrum at selected measurement points or by strain gauges [3]. Special diagnostic methods are also used, allowing for a combined assessment of the technical condition of the geometric accuracy and positioning accuracy of the movable machine modules in idle conditions. This evaluation is performed by the coordinates of the trajectory change of the high-precision disk fixed in the spindle of the machine (system F. Ballbar QC20-W). Technical diagnostics are carried out according to the equipment inspection schedules. Depending on the obtained values of indicators planned equipment maintenance — replacement of quick-wear parts of equipment of small, average, or capital repair of equipment for the restoration of rails, replacement of lead screw, ball screws, and other moving parts of the machinery. Note that compliance with the passport data of machine modules does not guarantee the quality of products. For example, the machine system corresponding to the passport data can be a source of inappropriate products in the event of deviations of quick-change clamping equipment or adjustment parameters, individual for different batches of parts. Thus, the planned procedures of technical diagnostics are not integrated into the processes of improving the quality of production.

Production of complex engineering products is associated with the simultaneous provision of a complex of interrelated indicators of accuracy of machine parts elements. To reduce their variations, other methods of quality management are used, the application of which is possible by systematic measurements of the volume of output [4]. These methods include probabilistic and statistical analysis, various types of control maps, assessment of technological accuracy, etc. the result of their application are conclusions about the mood and stability of the process of formation of the measured indicator. If process index inconsistencies are detected, the actual cause of their nonconforming values remains undisclosed. To identify index inconsistencies, there is a need for unplanned additional studies, including the use of technical diagnostics. Thus, the methods of product quality management are not related to the processes of planned technical diagnostics [5,6]. Many modern studies are aimed at providing various individual indicators of the process of tooth processing and parameters of cutting tools by constructing models of varying degrees of compliance with the actual processes of shaping [7,8], without paying attention to the modeling of key indicators of the accuracy of the processed side surfaces of the crown depressions.

The errors of the involute profile are [9] error involute profile: the total error, $F_{C}$, directions profile, $F_{H}$, the shape of the profile, $F_{H}$, and the errors of the longi-

June 2021
The measurement of the geometric parameters listed above is performed by specialized coordinate measuring machines. The result of the process of measuring machines is a standard protocol for measuring geometric accuracy indicators, the requirements for which are contained in the normative document (Figure 1).

A mandatory requirement of the standard for the measurement protocol is the presence of profiles of the side surfaces of the tooth cavities in the end section and along the length of the tooth [9]. The protocol also contains quantitative data on the amount of errors. The measured values of indicators are used by enterprise control services to assess the suitability of manufactured gears but not for the more popular tasks of gradually reducing variations in the measured error values. The reduction of variations in the values of indicators is associated with their use for the purpose of organizing timely technical diagnostics of machine tools for gear milling.

2 THEORETICAL PART
Consider the content of levels that allow for timely development of corrective and preventative measures to improve the efficiency of the process of technical diagnostics of gear-milling machines. At the first level, standard measurements of manufactured products are performed. Product conformity assessment and accumulation of measurement protocols are performed. If the product is suitable and all indicators correspond to the maximum set, then level 2 is not used. If discrepancies are detected, the metrological structure of the measured errors of the profiles is constructed in accordance with the content of the second level (Figure 3). The metrological structure is determined by the nesting of metrological indicators. The nesting of indicators can be estimated by the contribution of error values from one level to another. For example, the contribution of longitudinal profile errors to the total side surface error can be found as a percentage based on the following relationship:

$$K_L = \frac{F_{\Sigma L}}{F_\alpha + F_{\beta L} + ff_\alpha} \cdot 100$$

where
- $F_{\Sigma L}$ is the total error level of the profile on the side surface, micrometers.
- $F_\alpha$  profile error, microns.
- $F_{\beta L}$ angular error, mkm.
- $ff_\alpha$ form error, mkm.

A signal for the implementation of the third level, which identifies diagnostic signs of deviations of the nodes of the gear-milling machine. The signal for implementing the third level of analysis is that the contribution coefficient exceeds the threshold value. The threshold value is 70 percent.

At the third level of analysis, the geometric parameters of the profilograms are analyzed, which reveal the most likely operating negative technological factors that lead to deviations of the profile from the nominal position.

The advantage of the scheme for embedding technical diagnostics and quality improvement processes is to perform corrective actions only in case of violation of the metrological indicators structure, indicating the urgent need for their implementation.

The scheme of embedding technical diagnostic procedures in the process of improving the quality of products is carried out, taking into account the technological structure of the accuracy indicators shown in Figure 2.

It consists of several successive steps — the evaluation of the
profile relative to the limit values, the identification of the technological structure of the profile errors by calculating the contribution factors of the components (Figure 3), and the analysis of the profile on the diagnostic indicators signs of deviations of the tooth profiles. Each step of the proposed scheme consistently leads to finding inconsistencies and negative factors of the technological process in accordance with the degree of their importance. The improvement cycle is universal and applicable to both roughing and finishing operations.

Let us consider in more detail the content of the individual steps of embedding technical diagnostics procedures in the processes of product improvement. The implementation of the first step is to find inconsistencies in profile indicators' specified values. If they are detected, the second step of the scheme is activated. It consists in the calculation and evaluation of the significant coefficients of the contribution of errors.

The content of corrective actions is revealed by the presence of diagnostic signs of deviation from its nominal position in the profiles. The causes of the diagnostic features of the profile are known and well-defined technological factors [10]. For example, the presence of periodic waves involute profile indicates a beating tool mandrel. In this case, the diagnostic features are the step and frequency of the wave sections of the diagram. The positive slope of the middle line of the profile indicates the presence of an anterior angle that distorts the profile of the cutter tooth in the main plane and leads to the thinning of the tooth. Diagnostic signs in this case are the angle and sign of the angle of inclination of the middle line of the profile. To confirm the presence of the identified diagnostic features, graphical run-ins with changed tool profiles or trajectories are performed.

The identified and frequently occurring diagnostic signs are entered into the database of the corresponding working gear-hobbing workplace. Additional features are contained in the reference data of the manufacturers’ gear machining systems. The database is constantly updated with the identified diagnostic indicators, which allow more effective corrective and preventative actions to improve the quality of the manufacture of gears.

The authors have developed similar methods for other types of parts based on the identification of diagnostic quality indicators of automotive components, which have shown high efficiency of product improvement [11].

3 PRACTICAL IMPLEMENTATION
Let’s consider an example of a practical application of the technique on the example of processing an oblique gear on a CNC gear milling operation.

On the first level of evaluation of conformity of values of the limit values identified disrepair of production in terms of error variances forms the involute profile error and the direction of the profile. Then, at the second level, the metrological structure of indicators was determined, which revealed that the threshold level of 70 percent was exceeded for the profile shape error from 80 to 100 percent for all six measured side surfaces of the teeth (Figure 4a).

For deviations of the longitudinal profile, the threshold values are exceeded in terms of the direction error to values from 100 percent to 110 percent for four of the six measured side surfaces of the teeth (Figure 4b).

Exceeding the threshold values leads to the need to use a mechanism for identifying diagnostic indicators based on the profilograms available in the standard measurement Protocol.

In accordance with the diagnostic features given in [9], the following diagnostic feature was identified from the longitudinal profile profilograms — different angular inclination of the longitudinal profiles of the teeth of the toothed crown. The reason for this feature is a deviation from the perpendicular axis of the gear mandrel in different angular positions when rotating the table of the gear milling machine feed line of the worm cutter. The deviation can be eliminated by carrying out adjustment work to reconcile the position of the mandrel with hour-type indicators.

The reasons for the tooth thinning are the presence of front corners in the teeth of the milling cutter. The cause of undulation can be complex. This may be the presence of runouts of the cutter teeth on the mandrel, runout, or contamination of the mandrel during
A profilogram of the involute profile (Figure 5a) revealed several diagnostic features: reduction in head-gear tooth on the left side, the waviness profile as on both the sides of the valleys, and the inclined shape of the tooth profile on the left and right side.

The reason for the inclined shape of the tooth profile is the deviation of the cutter sharpening. It is possible the mill is made or reworked with an error in the pitch of the helical line.

Thus, the reduction of variations in profile deviations is possible only after the above-mentioned reasons for the occurrence of diagnostic signs are eliminated.

4 SUMMARY

The proposed method of identifying the content of corrective and warning actions allows for systematic identification of corrective actions to effectively improve the quality of cylindrical gears. The application of the method described in the article requires the company to introduce additional functions for the personnel of technical control services, the adjusters of CNC gear milling machines, the introduction of registration of data of standard measurement protocols in a single information system, as well as maintaining a database of diagnostic features of profiles. The introduction of the method encourages the company to constantly improve the level of product quality in key operations of gear milling.

REFERENCES


ABOUT THE AUTHORS

DT Safarov and AG Kondrashov are with the Naberezhnochelneinsky Institute (branch) of Kazan (Volga Region) Federal University, Naberezhnye Chelny, Russia. Citation: DT Safarov and AG Kondrashov 2020 J. Phys.: Conf. Ser. 1546 012028. This article (https://iopscience.iop.org/article/10.1088/1742-6596/1546/1/012028/meta) is an open access article distributed under the terms and conditions of the Creative Commons Attribution 3.0 license. It has been edited to conform to the style of Gear Solutions magazine.
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INFLUENCE OF MANUFACTURING VARIATIONS OF SPLINE COUPLINGS ON GEAR ROOT AND CONTACT STRESS
A simplified power-transfer system of gears and shafts connected through involute splines is used to study the influence of spline lead variations on gear-mesh behavior and load distribution on the gear teeth.

By HAREESH KURUP and CARLOS WINK

Involute splines are widely used in mechanical systems to connect power transmitting gears to their supporting shafts. These splines are as susceptible as gears to manufacturing variations, which change their loading pattern and may eventually lead to failures. The influence of manufacturing variations of spline teeth on performance and failure mechanisms of spline couplings is available in the literature. Similarly, the influence of manufacturing variations of gear teeth on gear tooth stresses and gear noise has been extensively studied. However, the effects of manufacturing variations of spline teeth on gear tooth contact, noise, and stresses remain unseen in publications. This study investigates how manufacturing variations of spline couplings affect gear performance. A parametric study was done on a spur gear set and a helical gear set to determine the amount of gear mesh misalignment caused by manufacturing variations of spline teeth. Spline parameters, such as tooth alignment and spline side fit were considered. The changes in gear contact and bending stress patterns were also investigated.

1 INTRODUCTION
Load distribution of meshing gear teeth plays a vital role on the performance of power transmitting gear pairs. Uneven load distribution along the tooth contact surfaces may result in localized contact pressure, high-root stresses, and noise issues. Gear tooth micro geometry, manufacturing tolerances, and key misalignment sources are meticulously designed by the gear engineer to optimize load distribution and tooth contact pattern under operating conditions. Misalignments coming from elastic deflections of elements such as gear teeth, gear bodies, shafts, shaft-gear connections, bearings, and housing [1] are load dependent, which may make the optimum load distribution solution valid only to a narrow range of operating loads [1].

Shaft-gear connections, used to transfer mechanical power between gears and shafts, are typically interference fits, where the gear is press fit onto the shaft, keyed or spline couplings [1-2]. In the design process, the couplings are usually overlooked as a potential source of gear-mesh misalignment. Involute side fit spline couplings are preferred over the other coupling methods due to various advantages, such as high load carrying capacity, and self-centering action under load [3]. They can also tolerate a certain amount of angular misalignment and relative sliding between their internal and external components. However, like gears, uneven load distribution of the contact surfaces affects the performance of the side fit splines [4-5]. Tolerances of spline-tooth thickness and space width are selected to suit design needs as well as manufacturing capabilities [6]. Manufacturing tolerances of spline teeth include profile variation, lead variation, and index variation [6]. These variations affect both the effective clearance or spline fit, and load distribution [6]. Studies show pitch errors have a major effect on reducing the number of active teeth sharing load [7], while profile and lead variations change the load distribution over contact interface [8]. Shaft torsional effects also result in a non-uniform load distribution in the axial direction along the engagement length of the tooth [9]. In certain cases, an intentional lead mismatch of the spline contact interface is introduced by a slight change of helix angle of the external spline to achieve an interference fit or zero backlash condition [10], which may also result in uneven load distribution on the spline teeth.

Involute splines of shaft-gear couplings are affected by gear loads apart from the torsional load component. Wink and Nakandakari [11] showed gear loads in the radial direction significantly change the load sharing among spline teeth of the supporting spline coupling. Hong et. al. [8] investigated the load distribution along the tooth interface of spline using combined finite element and surface integral contact analysis model under various gear-loading conditions and manufacturing errors. Under helical gear loads, a tilting movement of the gear about the supporting shaft is created causing misalignments and non-uniform load distribution on the splined interface [8]. The studies on load distribution and misalignments of spline teeth were primarily focused on spline strength and preventing common spline failure mechanisms such as tooth breakage, surface wear, and fretting. Although many studies have investigated load distribution changes of the spline contact interface, the influence of manufacturing variations of spline couplings on gear performance remains unseen in publications. The objective of this article is to investigate the effects of manufacturing variations of spline couplings on the...
performance of gears. The study was limited to spline teeth variations in the longitudinal direction, assuming that effects of spline tooth profile variations on gear tooth contact are negligible. An advanced commercial CAE tool for transmission analysis, named MASTA [12] was used for the analytical predictions under various input conditions and manufacturing variations through an extensive parametric study. MASTA's Advanced Loaded Tooth Contact Analysis model was used for the gear calculations. Splines were modeled as a series of spline segments of variable stiffness, which was defined as a function of the initial gap between the spline teeth at each segment. The initial gap between spline teeth, under no load condition, was calculated from the spline geometry accounting for different manufacturing variations. A stiffness matrix of spline teeth in full contact was obtained from the SplineLDP program [13], which uses a custom finite element approach [14]. The base model results were verified using commercial finite element-based software, Transmission 3D [15].

The results show uneven load distribution due to spline coupling misalignment affects gear-mesh misalignment, which ultimately changes gear-load distribution, contact stress, and bending stress. The conclusions of this study point to the importance of accounting for misalignments of the spline coupling while designing and optimizing the macro and micro geometry of power transmitting gears.

2 ANALYTICAL MODEL

A simplified system of a helical gear pair along with the supporting shafts was used for the study. The driving gear was mounted on the shaft through a spline joint, and axial movement of the spline coupling was controlled on both sides. The driven gear was rigidly coupled to the supporting shaft. A schematic of the system considered is shown in Figure 1.

Parameters of the gear and the spline used are listed in Table 1 and Table 2 respectively. The system was supported by bearings at each end of the shafts, maintaining a perfect alignment between gears at no load.

Loaded tooth contact analysis was performed in MASTA, which uses a hybrid FE and Hertzian-based tooth contact model [16]. MASTA performs a system deflection analysis to predict misalignments at the gear mesh and couple it with the tooth contact model. Shafts and gear blanks are considered as classic Timoshenko beams [17] for the deflection analysis. Spline coupling between the driver gear and the supporting shaft was divided into multiple segments along the longitudinal direction. A node was defined at the center of each of these segments along with a corresponding stiffness matrix.

Twenty discrete points with specified stiffness matrix were used in the model to represent the spline coupling (Figure 2). Any misalignment in the spline coupling along the longitudinal direction was entered in the model as corresponding rotational clearances at each of these points as well as radial and tilt clearances along radial x and y directions, as shown in Equation 1 and Equation 2, respectively.

Rotational clearance:

\[ c_{\theta i} = 2 \left( c + \Delta c_i \right) / d \]

Radial clearance:

\[ c_{xi} \text{ and } c_{yi} = \left( c + \Delta c_i \right) \cos \alpha \]

where

- \( c \) is the nominal circumferential clearance from the spline design. That is half the difference between circular tooth thickness and space width of mating teeth.
- \( \Delta c_i \) is the change in clearance due to lead error at \( i^{th} \) location.
- \( d \) is the pitch circle diameter of spline.

\[ \alpha \] is the spline pressure angle.

\[ i = 1, 2, 3, \ldots n, \text{ where } n \text{ is the number of segments in the spline longitudinal direction.} \]

Change in clearance \( \Delta c_i \) are calculated as the variation of the tooth surface from its ideal position in the transverse plain at the

![Figure 1: Gear system considered in the analytical model.](image)

<table>
<thead>
<tr>
<th></th>
<th>Driver Gear</th>
<th>Driven Gear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of teeth</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>Normal module</td>
<td>3.8779</td>
<td></td>
</tr>
<tr>
<td>Normal pressure angle</td>
<td>20.000°</td>
<td></td>
</tr>
<tr>
<td>Helix angle</td>
<td>21.000°</td>
<td></td>
</tr>
<tr>
<td>Helix hand</td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Base diameter [mm]</td>
<td>127.713</td>
<td>135.453</td>
</tr>
<tr>
<td>Tip diameter [mm]</td>
<td>151.46</td>
<td>158.88</td>
</tr>
<tr>
<td>Involute form diameter [mm]</td>
<td>131.39</td>
<td>139.10</td>
</tr>
<tr>
<td>Root diameter [mm]</td>
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<td>136.21</td>
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<tr>
<td>Circular tooth thickness [mm]</td>
<td>7.658</td>
<td>7.267</td>
</tr>
<tr>
<td>Face width [mm]</td>
<td>30.00</td>
<td>30.00</td>
</tr>
</tbody>
</table>

Table 1: Parameters of example helical gear design.

<table>
<thead>
<tr>
<th></th>
<th>External Spline</th>
<th>Internal Spline</th>
</tr>
</thead>
<tbody>
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<td>Number of teeth</td>
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<td></td>
</tr>
<tr>
<td>Spline module</td>
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</tr>
<tr>
<td>Pressure angle</td>
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<td>Base diameter [mm]</td>
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<td>Face width [mm]</td>
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<tr>
<td>Major diameter [mm]</td>
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<td>75.11</td>
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<tr>
<td>Form diameter [mm]</td>
<td>70.97</td>
<td>71.18</td>
</tr>
<tr>
<td>Minor diameter [mm]</td>
<td>70.10</td>
<td>71.18</td>
</tr>
<tr>
<td>Circular space width [mm]</td>
<td>—</td>
<td>2.054</td>
</tr>
<tr>
<td>Circular tooth thickness [mm]</td>
<td>1.960</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 2: Parameters of example spline design.
specific location along the longitudinal direction. The effect of this is to either increase or reduce the nominal circumferential clearance \( c \) on the spline interface. For an angular lead error of \( \phi \), the change in clearance at a distance \( x \) is \( x \tan \phi \). Figure 3 shows how misalignment due to linear lead variation, \( \lambda \), is defined in the model as multiple connections along the spline contact length \( l \) with specific clearance matrix and stiffness matrix associated with it.

In the case of effective side clearance, that is \( q_{\min} > 0 \), an assumption is made in the model that one member rotates relative to the other member making contact at the node with lowest clearance for the initial condition of the analysis. Therefore, at effective clearance conditions, \( c_{\theta i} \), \( c_{xi} \), and \( c_{yi} \) are recalculated as:

\[
\begin{align*}
C_{\theta i} &= c_{\theta i} - c_{\theta \min} & \text{Equation 3} \\
C_{xi} &= c_{xi} - c_{x \min} & \text{Equation 4} \\
C_{yi} &= c_{yi} - c_{y \min} & \text{Equation 5}
\end{align*}
\]

where

- \( c_{\theta \min} \) is the minimum value of rotational clearance along the spline length.
- \( c_{x \min} \) is the minimum value of radial clearance in \( x \) direction along the spline length.
- \( c_{y \min} \) is the minimum value of radial clearance in \( y \) direction along the spline length.

The SplineLDP program developed by the Gear Lab of The Ohio State University was used to calculate the stiffness matrix of the spline coupling. The stiffness values along with the clearance values were used on the model as shown in Figure 2 and Figure 3. Tooth contact analysis was performed on the model to study the impact of spline misalignments on the gear performance.

**3 IMPACT OF SPLINE MISALIGNMENT ON GEAR FLANK LOADING**

An input torque of 2,500Nm was applied to the driver shaft, and contact stress distribution on the gear flank was calculated under different conditions of spline misalignment, \( \lambda = -50, -25, 0, 25, \) and 50 \( \mu \)m. Figure 4 shows the gear tooth contact patterns for the various spline misalignment values.

The contact stress distribution charts of Figure 4 represent gear tooth flank area with distance in the axial direction on the \( x \) axis and distance in profile direction on the \( y \) axis. The high contact area is located toward the center in both lead and profile direction due to the lead and profile crowning considered as part of gear micro-geometry. \( \lambda = 0 \) represents the condition with no misalignment on the spline teeth interface; a centralized load distribution pattern is observed on the gear flanks in this case. A positive \( \lambda \) value represents lead variation in the same direction of the helix hand of the gear, which is right hand in this model.

This right-handed misalignment results in contact of spline teeth at the left edge (Side I) and gradually increasing clearance toward the right side (Side II) that leaves a clearance equal to \( \lambda \) at the right edge. A negative misalignment is left handed in this model, which is opposite to the helix hand of the gear. With the addition of spline misalignment in the positive direction, the high contact area moved from the center to the left side. The change in the contact pattern was due to the gear mesh misalignment caused by the tilting of the gear under load because of the spline teeth deflection. Effective gear mesh misalignment from the system deflection analysis compared in Figure 5 confirms that, under load, the misalignment on the spline influences the mesh misalignment of the gear, which is mounted on it. It is observed from Figure 4 and Figure 5 that, while the positive spline misalignment increased, the gear mesh misalignment and the negative spline mesh misalignment hardly affected the gear-mesh misalignment and the contact pattern. In the case of right-hand spline misalignment, the tilting moment on the gear due to the helix angle was in the same direction as the tilting moment due to deflection, which resulted in a higher deflection. The opposite effect happened for left-handed misalignments of the spline teeth.

As the increase in gear-mesh misalignment causes the highest stressed area of the loaded flank to move away from the Center, a
corresponding change also happens in the root stress. When the contact stress pattern on the gear flank moves away from the center of face width, the highest bending stress location also moves toward the edges of the face width. This increases the probability of gear-bending fatigue failures, since the crack initiation points can develop toward tooth edges under high-stress conditions. The change in the distribution of tensile root stress along the axial direction from the analysis results are compared in Figure 6. In the example shown in Figure 6, the location along the gear face width of the maximum tensile root stress is shifted around 5mm to the left under a 50µm spline misalignment as compared to the original condition of no spline misalignment.

The changes in gear mesh misalignment and load distribution on the tooth flanks might also affect the transmission error (TE) of the gear mesh, which is a main source of noise excitation in a geared system. TE varies as a function of the gear tooth elastic deflections, and the geometrical variations of the meshing tooth form from a true involute [18]. Since the variations on spline coupling affect the load distribution of the gear teeth, changes in the noise behavior of the system also are expected to happen.

4 INFLUENCE OF GEAR HELIX ANGLE

To investigate the effect of spline variations on spur gears, the original gear geometry of Table 1 was modified to the helix angle, \( \beta = 0 \), by keeping the same transverse geometry parameters. Spur gear data is shown in Table 3. Analysis was repeated with the spur gear model. The results show the effect of spline-tooth misalignments on the gear surface loading pattern is similar in both directions — that is, positive and negative spline tooth misalignment values, unlike the helical gear model (Figure 7). As expected, maximum contact stress is high in the spur gear model compared to the helical gear under the same input torque due to the reduction of contact area with no axial contact ratio.

The results confirmed the impact of spline misalignments on gear performance is affected by the helix angle and helix hand. Higher gear mesh misalignments are observed when the gear helix hand is in the same direction of the spline misalignment, and the spline misalignment effect is less when gear helix hand and spline misalignment are in opposite directions. The gear-mesh misalignment results of the helical gear set and the spur gear set are compared in Figure 8.

5 INFLUENCE OF LOAD

Since the amount of deflection is load dependent, the impact of the spline misalignment on the gear-mesh misalignment also increases as the load transferred through the system increases. The graph in Figure 9 shows the influence of input torque on the spur gear-mesh misalignment under various spline misalignment conditions.

6 INFLUENCE OF EFFECTIVE SIDE CLEARANCE

When there is a lead slope variation of the spline, the design clearances are consumed by the variation. This may result in a condition of effective side clearance or effective side interference between the external spline and the internal spline, depending on the amount of variation and the design fit. The effect of various fit conditions of the spline on the misalignment of the gear mounted on it were studied on the spur-gear model with \( \lambda = 50 \mu m \), and the results are as shown in Figure 10. All conditions were analyzed, considering there was enough axial clearance on the model to allow gear blank to tilt under load. In Figure 10, the zero point on the horizontal axis represents the condition of no effective clearance or interference, when spline lead variation is equal to the design clearance. Moving toward the positive (left) side on the horizontal axis represents effective clearance condi-

Table 3: Parameters of example spur gear design used.
tions, and the negative (right) side represents effective interference conditions. As the amount of interference increases, the length in the longitudinal direction of the spline coupling under interference also increases depending on the amount of variation $\lambda$. The percentage of the spline coupling length in contact under interference is shown in the upper horizontal axis of the graph.

It was observed that an increase in the effective side clearance of the spline does not contribute to the gear misalignment caused by the spline misalignment. As shown in Figure 10, gear-mesh misalignment remains the same under effective clearance condition, irrespective of the clearance value. That might be because of the modeling assumption of initial contact condition of the spline teeth, where the drive flanks are brought into contact, and any resultant clearance is moved to coast side. In case of helical gear loading or in the presence of other system misalignments, the effective side clearance may have an impact on the gear-mesh misalignment, which is beyond the scope of the analytical model considered. On the other hand, effective side interference condition drastically reduced the gear misalignments as the interference condition allows both right and left flanks of the spline to be in contact simultaneously, and more teeth area available for load transfer.

7 REDUCING SPLINE VARIATION EFFECTS ON GEARS

As manufacturing lead variations of spline teeth affect the performance of the geared systems, controlling these spline variation effects at the design stage might help the gear engineer to develop more robust gears. This can be achieved either by reducing the manufacturing variations of the splines or by designing gear micro geometries to accommodate mesh misalignments, including the contributions that come from the spline coupling. Selecting a tighter spline tolerance class reduces allowable manufacturing variations and consequently their impact on gear-mesh misalignment; however, it might increase manufacturing costs.

A solution in helical gear systems may be to use unidirectional tolerances of splines instead of bidirectional, so the hand of spline lead variation can be maintained relative to the gear hand to reduce the effect. Higher lead crowning on the gear micro geometry helps to accommodate more misalignments at the gear mesh. The amount of crowning is generally limited in the design by the increase in contact pressure and the TE levels, which need to be considered. A fair estimation of gear-mesh misalignment caused by the elastic deflections of the system, including the spline couplings at the design stage will help the gear engineer come up with an optimum design of micro geometry for the gear. The axial clearances in the system, which results from the tolerance stack up of various assembly elements, might limit the amount of gear tilting over the spline coupling under load. Thus, lowering axial clearance value may help reduce the effects of spline variations on gear mesh.

8 SUMMARY AND CONCLUSIONS

A simplified power-transfer system of gears and shafts connected through involute splines was used to study the influence of spline lead variations on gear-mesh behavior and load distribution on the gear teeth. Spline misalignments caused by manufacturing variations were shown to increase misalignments in the gear mesh, which caused the gear flank contact pattern to change, which also changed the gear root bending stress distribution. The spline teeth with misaligned contact was observed to deflect under load and developed a tilting moment on the gear resulting in the misalignment of the gear mesh. Manufacturing variations of spline coupling act as a source of gear-mesh misalignment, causing changes in gear tooth...
load distribution, which might be detrimental to gear load capacity and gear noise.

The effect of spline manufacturing variations on helical gears was more pronounced when the spline lead variation and the gear helix hand were in the same direction. Conversely, the effect was reduced when spline lead variation and the gear helix hand were in the opposite direction. As the spline tooth deflections are load dependent, the effect also increased with the load transmitted through the system. The results of a parametric study performed on the effective clearances revealed that transitioning from interference to clearance condition drastically increases the gear-mesh misalignments.

A few suggestions were offered to reduce the impact of manufacturing variations of spline couplings on gear-mesh misalignment, which included selecting the right spline tolerance class, applying unidirectional tolerance instead of bidirectional in opposite direction to the gear helix hand, limiting the amount of gear axial clearance of the assembly, and designing gear tooth micro geometry to accommodate the mesh misalignment coming from the spline coupling.

Accounting for the effects of manufacturing variations of spline couplings on gear mesh might help gear engineers to develop more robust gears of high load capacity.

ACKNOWLEDGEMENTS

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Gear Solutions’ online portal is your gateway to social media news and information resources from manufacturers and service providers in the gear industry. You’ll find links to social media as well as webinars, blogs and videos.

This quick-and-easy resource is just a click away at gearsolutions.com.
COMPANY PROFILE

SOLAR ATMOSPHERES

PROVIDING CONSISTENT RESULTS, TIME AFTER TIME AGAIN
Solar Atmospheres takes advanced technical expertise and equipment and uses it to thermally treat parts in a vacuum environment — serving industries that include aerospace, automotive, defense, medical, and power generation.

By KENNETH CARTER, Gear Solutions editor

Gears and other parts made from metals and metal alloys have to be heat-treated to ensure proper performance, and Solar Atmospheres was born out of that need to offer quality vacuum heat-treating services.

“Generally speaking, we offer vacuum heat treating, which produces clean bright results with limited distortion on most alloys,” said Tim Steber, regional sales manager for Solar Atmospheres. “Specific to gears, we offer vacuum carburizing and vacuum gas nitriding.”

CASE-HARDENING OPTIONS
Solar Atmospheres offers two different types of case hardening: vacuum carburizing and vacuum gas nitriding.

“Vacuum carburizing is most prevalent for the gear industry, where we basically add carbon to the surface of the product,” he said. “It’s actually a diffusion process, not a coating.”

This process uses high-purity acetylene as the carbon source being diffused into the surface of a material within the vacuum furnace, according to Steber.

“A typical process cycle introduces a ‘boost’ of acetylene into the furnace,” he said. “A dwell time allows the carbon to diffuse into the surface, and the cycle is repeated based on the required carbon content and case depth from the specification.”

Solar Atmospheres uses a thermal-process modeling program to determine the desired case steps, the carbon content, and the amount of time it takes to run a specific process, according to Steber.

“It’s very popular in the aerospace and high-performance racing applications, as well as commercial applications,” he said. “The purpose of carburizing is to increase surface hardness, wear resistance, and fatigue strength.”

In addition to clean, bright results, they emerge from the process with no inter-granular oxidation (IGO), and with uniform case depths, according to Steber. In some cases, no additional finishing is required after carburizing.

ATTENDING TO CUSTOMERS’ NEEDS
Solar Atmospheres takes pride in not only meeting but exceeding its customers’ expectations, no matter the level of heat treating.

Steber said Solar Atmospheres deals with a couple of different types of customers.

“We collaborate with some customers to develop custom heat-treating processes for specific applications,” he said. “We have an in-house tech center with metallurgists and a Ph.D. chemist to assist with the process development. We also partner with customers that have very specific heat-treating process requirements for aerospace and medical applications.”

Using microprocessor controls, Steber said Solar Atmospheres has the capability and expertise to provide consistent, quality results time and time again.

FERRIUM C61
Solar Atmospheres’ involvement in the gear industry has evolved over the years to include the development of an alloy called Ferrium C61, according to Steber.

“The alloy was in development around 2007,” he said. “Alloy development took approximately five years for this brand-new alloy, which was designed with vacuum carburizing in mind. We were part of

Hitachi scanning electron microscope (SEM) with energy-dispersive X-ray spectroscopy (EDS). (Courtesy: Solar Atmospheres)
“We embrace technical challenges related to thermal processing. We start with development, perform a risk assessment, and move on from there. It’s basically a strong suit of our company – problem solving leading to customer satisfaction.”
the R&D effort and performed hundreds of thermal cycles, including metallography. It became commercially available in 2012. Transcending from our R&D efforts, we designed a furnace specific for vacuum carburizing.”

Ferrium C61 derived from the need in the marketplace for a high-fatigue strength, high-temperature resistant alloy, according to Steber. The Ferrium C61 is used in high-performance automotive and aerospace applications.

**TAKING ON CHALLENGES**

From that brief resume of accomplishments, it’s obvious that Solar Atmospheres embraces any challenges that customers may throw its way.

Solar Atmospheres purchased a scanning electron microscope (SEM) to meet customers’ expanding needs, according to Steber. The SEM analyzes low level contamination from carbon, oxygen, and/or nitrogen, post heat treating. Additionally, the SEM enables Solar to fulfill materials characterization and microstructural determination requests beyond the basic metallography and hardness testing.

“We embrace technical challenges related to thermal processing,” he said. “We start with development, perform a risk assessment, and move on from there. The challenge could be anything from one or two pieces that could lead into full production, or it could finish with the one or two pieces. It’s basically a strong suit of our company — problem solving leading to customer satisfaction.”

**35 YEARS OF EXPERTISE**

Solar Atmospheres has evolved by leaps and bounds since it began more than 35 years ago, and its impressive inventory and history only solidifies that. The company has the world’s largest commercial vacuum furnaces up to 48 feet long with workloads up to 150,000 pounds. The company’s founder, Bill Jones, has more than 12 patents both on the capital equipment and processing side.

“He really built a foundation for us to follow through on,” Steber said. “Solar Atmospheres started with about four or five furnaces to now having over 60 vacuum furnaces across four locations. We are the largest family-owned vacuum heat treater in the country.”

**LOOKING TOWARD THE FUTURE**

To keep up with the constant development, Steber said the company works five shifts around the clock, 365 days a year. Solar Atmospheres is involved in many high-end aerospace contracts and customers — a testament to the company’s expertise and position in the marketplace.

As Solar Atmospheres continues to move into the future, Steber expects the company to remain involved in alloy developments and solving difficult thermal-processing challenges. 🎉

**MORE INFO**

solaratm.com

Cut-section of a carburized gear showing uniform case depth. (Courtesy: Solar Atmospheres)

Nadcap-approved metallurgical laboratory. (Courtesy: Solar Atmospheres)
Oelheld coolant: High emulsion stability, low maintenance

Selecting the right cooling lubricant is key for the optimization of machining processes, increasing productivity, and can significantly impact the quality of produced parts.

Oelheld offers its water-miscible product, AquaTec 7655, which is suitable for general to heavy-duty machining of steels, plastics, and aluminum alloys, is TRGS 611 compliant, formaldehyde free, and guarantees a long tool life, good corrosion protection, and a particularly good workpiece surface finish.

AquaTec 7655 has been specifically developed to offer high emulsion stability while requiring little maintenance, even in high production environments. The excellent results achieved in oelheld GmbH’s dedicated machining technology center during the development phase have since been reported by many customers, confirming AquaTec 7655 as an ideal choice for metalworkers operating at a high capacity and looking to reduce maintenance costs.

Free seminars on water-miscible cooling lubricants are held regularly at oelheld GmbH, conducted by product specialists.

MORE INFO  www.oelheld.com

Walter ups productivity, reliability in titanium machining

Walter has introduced two solid carbide milling cutters that successfully tackle titanium machining tasks: the MC377 Advance and the MD377 Supreme. The first is a highly cost-effective tool for universal use in ISO materials S, M, and P and the second is a high-end specialist primarily for the aviation and aerospace industry. Both solid carbide milling cutters can handle roughing, finishing, and semi-finishing as well as ramping, shoulder milling, and plunging.

The MC377 Advance, with protective chamfer, corner radii, and center cutting edge, can be used for chrome-nickel and steel materials, as well as titanium. The versatile cutter’s complete range features products with diameters from 2 to 25 mm and makes them particularly attractive for small parts manufacturers in the medical technology sector and food industry. The long tool life of its Walter high-performance WK40EA grade and its tough AlCrN coating extend tool life while helping to lower inventory costs.

The MD377 Supreme is a solid carbide milling cutter with a corner radius and central internal coolant engineered for titanium machining. Its HPC Ti40 geometry has been optimized for titanium cutting, with a high metal removal rate thanks to its five cutting edges, and the latest Walter-exclusive AIrTIN+ZrN coating with HIPIMS technology for maximum tool life. Ideal for dynamic milling, it is suitable for roughing, shoulder milling, finishing, and semi-finishing, with ramping possible, and full slotting up to 1 x Dc. This high-end titanium milling cutter is ideal for machining ISO S materials such as engine components, small parts or structural components, as well as additively manufactured components.

The Walter lineup of products consists of three tool categories. Supreme indicates the highest level of technology and performance available. Perform tools are products that provide an economical solution with focused importance on price, and Advance indicates product efficiently balanced between price and performance.

Walter, a global leader in the metalworking industry for more than 100 years, offers a wide range of precision tools for milling, turning, drilling, and threading applications. The company helps customers in the aviation and aerospace industries, automotive, energy, and general industry improve
process reliability and increase productivity. With regional headquarters in Waukesha, Wisconsin, Walter markets its competence brands Walter, Walter Titex, Walter Prototyp, and Walter Multiply through a network of channel partners and field engineers across the USA, Canada, Mexico and Brazil.

More Info www.walter-tools.com/us

Omni offers new electric drive option for driven axles

Omni Powertrain Technologies introduced a new electrified drive developed for driven axle applications with commercial vehicles, terminal tractors, and railcar movers. The system features Omni’s F12L gearbox coupled with its tandem Magelec M27D motors.

Gear ratios currently available with the F12L are 1:1, 2:1, 2.97:1, and 3.94:1. The gearbox is rated for maximum input torque of 1200Nm and a maximum input speed of 7,500 RPM.

The M27D motor is a high voltage axial flux design capable of 192 Kw continuous power at 600V and peak intermittent torque at 1,160 Nm. It is cooled with a water-ethylene glycol mix and conforms to international standard IEC 60034.

More Info www.omnipowertrain.com

EXSYS ER collet adapter speeds turning center changeovers

As part of its widely popular Preci-Flex modular tooling system, EXSYS Automation Inc. offers the Type 01 ER collet chuck standard adapter. This precision-made tooling allows shops to change over tools in turning center turrets quickly, accurately and economically.

For machining close to the OD or ID of a workpiece, the Type 01 adapter extends drills or endmills away from the face of the toolholder for much needed additional reach. Plus, the adapters allow for offline tool presetting for the next job while the machine continues to work uninterrupted.

More Info www.us.bigkaiser.com

Big Kaiser introduces its first BIG Capto rough boring tool

Big Kaiser Precision Tooling, a global leader in high-performance metalworking equipment, has introduced the Series 319 SW rough boring head with the BIG Capto connection.

The SW BIG Capto achieves high repeatability, in part, thanks to the flush fit of the polygon taper with the spindle. (Courtesy: Big Kaiser)

The new SW BIG Capto rough boring head makes it possible to perform rough and finish boring processes seamlessly with the finishing heads it has offered for years. Big Kaiser currently offers the widest range of rotating BIG Capto tooling of any provider.

In accordance with ISO 26623-1, the polygon shape of the taper and one-piece body construction provides for highly repeatable accuracy and torque transmission, an ideal fit for rough boring work. The SW BIG Capto achieves high repeatability, in part, thanks to the flush fit of the polygon taper with the spindle. The combination of a self-centering 1:20 taper and the long taper edge ensures stable runout accuracy.

The SW BIG Capto is available in sizes C3, C4, C5, C6, and C8. The diameter range is 0.984”-8.000”.

Big Kaiser is a worldwide leader in high-precision tooling systems and solutions for the metal-cutting industry.

More Info www.us.bigkaiser.com

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More Info www.us.bigkaiser.com
The EXSYS Type 01 adapter features a “cap style” collet nut that delivers increased clamping pressure and allows it to draw the collet into the adapter pocket for stronger holding power. (Courtesy: EXSYS)

The Type 01 adapter features a “cap style” collet nut that delivers increased clamping pressure and allows it to draw the collet into the adapter pocket for stronger holding power. The adapter also offers the ability to shrink the collet pocket size without having to switch out holders.

EXSYS Automation’s Preci-Flex is the first tooling system on the market with a single base holder and multiple tooling adapters. The system’s compact design ensures maximum torque transmission and rigidity, resulting in increased machining accuracy and improved productivity. Additionally, the modular system’s conical and flat face planar interface allows the use of either an adapter or a standard ER collet, and enables collets, endmill holders, expanding collet chucks, and shrinks fit tooling to be mounted on a single base holder.

MORE INFO www.exsysautomation.com

Helios adds flexibility with new CNC gear deburring

Helios added new CNC advances to its line of Tecnomacchine chamfer-deburring machine tools, offering manufacturers a machine platform with maximum flexibility for a high mix of part sizes and types.

These include spur and helical gears, bevel gears, bore- and shaft-type parts, and others. These abilities are driven by a new CNC system that programmatically controls all factors for the chamfer-deburring process. This equips manufacturers with a process that is easy to set up and change over for reliable and consistent quality.

“Gear manufacturers need a new level of gear chamfer-deburring that offers quick and easy setups with repeatable high quality,” said Adam Gimpert, president of Helios Gear Products, of the changes to meet this demand.

Several factors impact successful chamfer-deburring with abrasive wheels and carbide end mills. These include the tool position (radial, axial, tangential, and inclination), tool pressure, tool rotation speed, tool rotation direction, workpiece rotation direction, and workpiece rotation speed. Traditional machine tool deburring often requires manually setting several if not all these items. Now, Helios offers its gear chamfer-deburring machines with friendly dialog programming of all these items. This allows a setup technician to store a complete application to later be recalled by the CNC with just a few software steps. Additionally, tool spindles can be configured with brushing units for CNC brushing within the same chamfer-deburring cycle.

As one example, manufacturers use the Helios TM 250-CNC machine for profitable gear chamfer-deburring. This machine features a rotating table with two stations — one for loading/unloading parts by hand or integrated robot, and the second for chamfer-deburring and brushing of the workpiece. This feature minimizes machine idle time and drastically improves productivity of the solution. Moreover, the machine implements a complete CNC system for the above-mentioned abilities — quick and easy changeovers from saved setups of all tool and work positions and parameters. Changeovers can be accomplished in just a few minutes rather than the traditional 30 to 45 minutes.

For productive gear chamfer-deburring, the new series of Tecnomacchine equipment from Helios Gear Products offers manufacturers an ideal machining solution. With complete CNC functionality, these machines minimize changeover time, maximize repeatable quality, are easily programmed, and minimize idle time. Consequently, gear manufacturers can achieve top levels of productivity from their chamfer-deburring operations.

MORE INFO www.heliosgearproducts.com

Dillon’s diamond-shaped serrations reduce slippage on hard jaws

Aggressive diamond-shaped serrations on hard jaws from Dillon Manufacturing increase the pull-down effect which reduces part slippage and push back from using a bar feeder.

Serrations on the gripping surfaces are ideal for cast parts, scaly parts, or parts with imperfections. They are manufactured of 8620 steel and case hardened with precision ground locating surfaces, then black oxide coated for corrosion resistance. The hard
jaws are available in one-step or two-step sets and are reversible for OD or ID chucking. One set covers a wide clamping range. Dillon hard jaws are available in standard sizes from stock and in different mounting configurations including serrated, T&G, Acme, and square serrated key types to fit all brands of chucks. Dillon chuck jaws are very versatile with multiple radii for both inside and outside clamping, making them ideal for any size run. Dillon also offers special or modified hard jaws with industry-best turnaround time, which saves time and money by reducing down time.

Dillon Manufacturing, Inc. manufactures a complete line of standard and custom workholding solutions including chuck jaws, chucks, vise jaws, soft jaws, hard jaws, collet pad jaw systems, chuck lubrication, and more. All products are made in the USA and Dillon is ISO 9001:2015 registered.

MORE INFO  www.dillonmfg.com

Serrations on the gripping surfaces of Dillon Manufacturing’s hard jaws are ideal for cast parts, scaly parts, or parts with imperfections. (Courtesy: Dillon Manufacturing)

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With a community storefront, your company also receives a premium listing in the annual Buyer’s Guide published each November. Premium listings feature graphic treatments to draw more attention to your company.

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## CONTENTS

<table>
<thead>
<tr>
<th>ADVERTISER INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENTS</td>
</tr>
<tr>
<td>All Metals &amp; Forge Group</td>
</tr>
<tr>
<td>Allen Adams Shaper Services Inc.</td>
</tr>
<tr>
<td>Amorphology</td>
</tr>
<tr>
<td>ASM International</td>
</tr>
<tr>
<td>Avers Machine &amp; Gear</td>
</tr>
<tr>
<td>Forest City Gears</td>
</tr>
<tr>
<td>Gleason Corporation</td>
</tr>
<tr>
<td>KISSsoft USA LLC</td>
</tr>
<tr>
<td>Koro Sharpening Service</td>
</tr>
<tr>
<td>Machine Tooling Technology</td>
</tr>
<tr>
<td>McInnes Rolled Rings</td>
</tr>
<tr>
<td>MicroGear</td>
</tr>
<tr>
<td>Mitsubishi Heavy Industries America Inc.</td>
</tr>
<tr>
<td>New England Gear</td>
</tr>
<tr>
<td>Nordex Inc.</td>
</tr>
<tr>
<td>Oelheld</td>
</tr>
<tr>
<td>Piselli Enterprises Inc.</td>
</tr>
<tr>
<td>RHH Inc.</td>
</tr>
<tr>
<td>Southern Gear &amp; Machine Inc.</td>
</tr>
<tr>
<td>STD Precision Gear &amp; Instrument</td>
</tr>
<tr>
<td>Toolink Engineering Inc.</td>
</tr>
</tbody>
</table>

### GEARING AHEAD TO MEET INDUSTRY’S DEMAND FOR PRECISION

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“We have done a lot of work with merging the companies together, and as a result, we’ve seen a major increase in sales.”

Innovative Rack & Gear recently became a part of Avers Machine. What advantages does this bring to Avers Machine?

Innovative Rack’s customer list is completely different than our existing customer base. We really do not have any contacts that overlap, which gives us much better diversification. Together, we now have our product offerings being manufactured and supplied across more industries, and that makes our company stronger. Being in more diverse markets allows us to have a good balance of business when some industries are up while others are down.

In addition, the most amazing synergy the merger has brought, for every rack that is manufactured, we can reach out to that customer and make a mating gear or other machined component that would be used in the customer’s assembly. The new opportunities for our company are exciting and abundant.

What was the process in adding Innovative Rack & Gear to the Avers Machine family?

We worked through a business broker. Our company has been actively pursuing an acquisition for the last 24 months. We looked at many different companies in similar industries as ours but did not act until recently. Our goal was to try and find a company that had different customers and processes than ours but would still allow us to merge them with our operations. Finally, after a lot of effort and searching we came to this opportunity, Innovative Rack & Gear. It was almost too good to be true as it matched so well with our machining and gearing background.

How has the merger affected the different companies’ departments and equipment consolidation?

One of our strengths is milling, and Innovative does a tremendous amount of milling because every rack blank needs to be milled or surface-ground before the rack-cutting process can begin. By merging our milling departments, we were able to get our Mastercam programmers and lead men working together to gain machining efficiencies. In addition, we are able to link jobs that have longer cycle times with shorter cycle jobs, which allowed us to better utilize our equipment by running multiple machines with each operator.

There was a lot of extra equipment at both facilities that was underutilized. Some of the pieces were similar or duplicates. We identified which equipment was in better condition, newer vintage, or more efficient and then auctioned off the surplus equipment.

Other departments worth mentioning pertains to the front office. Innovative Rack had a less efficient system that handled their order processing and accounting functions. We are on a newer updated M1 ERP system, so when we merged the companies, we were able to input all their open transactions onto our system within the first month and get more done with less resources. Our average processing time for new orders and quotes has typically been cut in half.

What’s been the industry response to Innovative joining Avers?

It has been very favorable. A lot of the people in the industry were surprised that Innovative Rack was even available to acquire. The response from the companies we do business with in the gear industry has been the same in that they’re very excited for us. The comments have been in line with our thinking that this was a golden opportunity for our team that has great growth potential.

Additionally, we have done a lot of work with merging the companies together, and as a result, we’ve seen a major increase in sales. Also, our on-time delivery is up and measuring 93-percentile range. Customer responses have been very favorable. We have retained existing customers and gained new ones.

What kinds of positive aspects do you expect the merger to bring to future jobs?

Most of Innovative’s management and even some of their supervisors were engineers. Over on our side, engineering was an area we felt could be improved. By bringing their people on board with ours, it strengthened us as a whole. We have become a lot more technical and have picked up a lot of very good experience. That is going to strengthen us going forward.

We are also going to be more efficient. Innovative had a second shift, so we can now run extended hours on critical jobs. Those are all things that are going to make us a very strong company for years to come.

Another thing was Innovative has milling machines that can run a much larger part. On the Avers side, we had size constraints because our business is primarily what I would call small to medium. A lot of their equipment would run medium to large. Those are things that we did not have to really invest heavily into getting, and the new machine capacities are marketed to our entire customer base. With the acquisition, we brought in that equipment and the business that came with it.

We have put a lot of money into our QC department, and pretty much all the equipment that we have in QC, we’ve been able to use for the rack product line. This has been very helpful with gaining some efficiencies and providing customers with accurate inspection data.

The only other thing that I would like to mention is we have been able to utilize our machining expertise and develop some different fixtures for parts where they were doing one piece in a vise needing flipping for multiple-sided machining. Now, parts are run eight pieces on a fixture and are being machined in one operation. This has improved efficiencies for some jobs as much as 60 to 70 percent.”

www.aversmachine.com
Fellows Model 10-4 CNC 3-axis Gear Shaper with Fanuc Controls, Motors & Drives

Gleason Phoenix Model 275HC II CNC Bevel Gear Cutting Machine

2007 Gleason Phoenix Model 275HC II CNC Bevel Gear Cutting Machine

2009 Gleason Pfauter Model P-350 6 Axis CNC Gear Hobber 16" diameter capacity

2007 Kapp Model KX-300P CNC Generating-Style Gear Grinder with Loading

2007 Liebherr Model LC-180

2007 Liebherr Model LFs 220 CNC Gear Shaping Machine, Siemens 840D Control

2007 Liebherr Model LC-180

2007 Liebherr Model LFs 220 CNC Gear Shaping Machine, Siemens 840D Control

2013 Gleason Model 210H 6-Axis CNC Hobber, Siemens 840D Control

2006 Mitsubishi Model SE25A CNC Gear Shaper with Autoloading

2004 Gleason Model 600 HTL CNC Turbo Lapper Fanuc 160i-M Controller

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