gear TECHNOLOGY®

JULY 2022

MACHINING TECHNOLOGY

- IMTS PREVIEW
- GEAR SKIVING

3D PRINTING

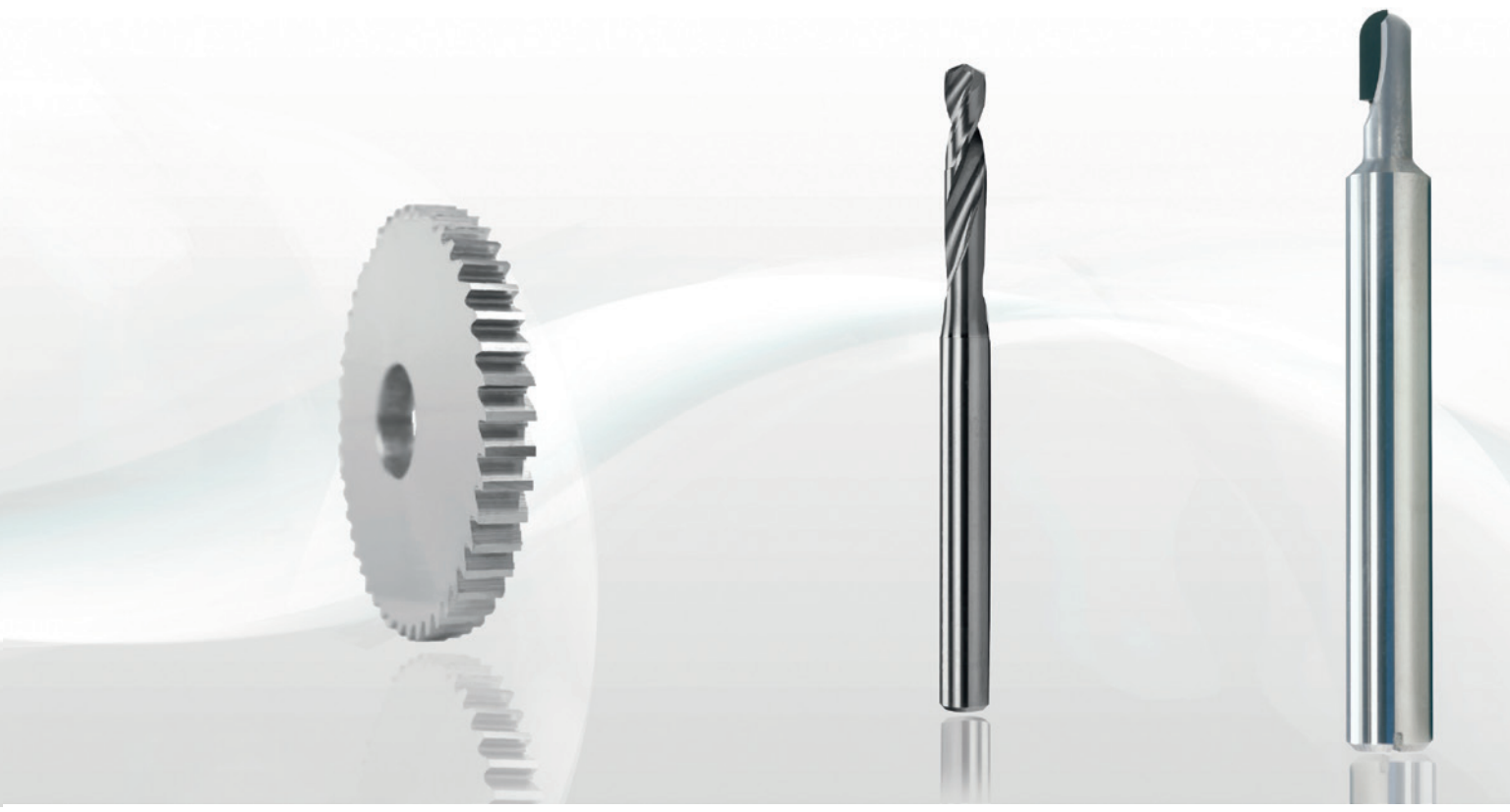
SUPERFINISHING

www.geartechnology.com

Expanding Your Precision into Smaller Applications

Phone: 847-649-1450 | www.star-su.com
5200 Prairie Stone Pkwy. | Ste. 100 | Hoffman Estates | IL 60192

LOUIS BELET®
Swiss Cutting tools



Star SU Partners with Louis Bélet Swiss Cutting Tools

We've added Louis Belet to our offering, bringing you even more capability for precision applications. Based in Swiss Jura, the hub of micromechanics and high-quality precision, Louis Bélet manufactures standard and custom precision cutting tools for various markets including watchmaking, medical, aerospace and automotive. Its suite of tools includes drills, end mills, thread and gear cutting tools including hobs or skiving tools for micro gears, and more.

This innovative offering, combined with Star SU's existing portfolio and market presence, enables us to offer you the highest quality micro cutting tools for your precision applications.

FFG Profilator

IMTS 2022
POWERED BY AMT

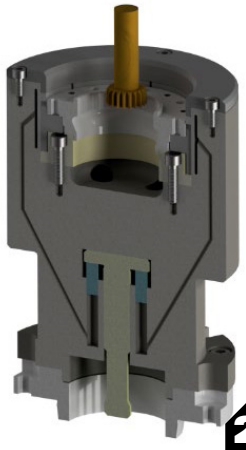
Visit us at Booth #237013
www.star-su.com

gear TECHNOLOGY®

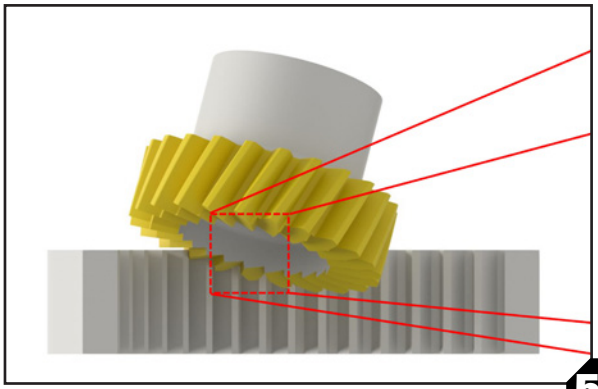
contents

JULY 2022

A Publication of
The American Gear Manufacturers Association



20



50

features

technical

Stay Connected

Join the Gear Technology Facebook group at
www.facebook.com/groups/geartechnology

Follow us on Twitter
twitter.com/Gear_Technology

Connect with us on LinkedIn
www.linkedin.com/groups/3893880/

Subscribe Online
www.geartechnology.com/subscribe.htm

Vol. 39. No. 5 GEAR TECHNOLOGY. The Journal of Gear Manufacturing (ISSN 0743-6858) is published monthly, except in February, April, October and December by The American Gear Manufacturers Association, 1840 Jarvis Avenue, Elk Grove Village, IL 60007, (847) 437-6604. Cover price $7.00 U.S. Periodical postage paid at Arlington Heights, IL, and at additional mailing office (USPS No. 749-290). The American Gear Manufacturers Association makes every effort to ensure that the processes described in GEAR TECHNOLOGY conform to sound engineering practice. Neither the authors nor the publisher can be held responsible for injuries sustained while following the procedures described. Postmaster: Send address changes to GEAR TECHNOLOGY. The Journal of Gear Manufacturing. 1840 Jarvis Avenue, Elk Grove Village, IL, 60007.

DVS TECHNOLOGY AMERICA

WMZ WERKZEUGMASCHINEN

Skiving

V300

The all-rounder for geared shafts

MEET US AT IMTS2022
12.-17.09.2022 Booth: 236920 Chicago IL/USA

Modular multi-functional machining

INCREASED PRODUCTIVITY WITH ADDITION OF SKIVING TECHNOLOGY
The combination between skiving, hobbing, drilling, turning, and other technologies ensures productive and flexible processes. With the possibility of finishing one part completely on one machine, investment costs decrease and component qualities increase. Gearing quality of AGMA 10 is reached and with our unique hard skiving technology, even higher is possible.

CUSTOMIZED MACHINE
Using a rigid machine basis with up to 4 cross slides and 2 spindles allows machine configurations for all needs. Setup times and idle times are reduced due to spindle and counter spindle concepts. Manufacturing with up to 8 axes optimizes the capacity planning of the machine. An extra advantage is the use of our center drive where shaft ends can be manufactured simultaneously.

TURNKEY SOLUTION WITH WMZ AUTOMATION
With multiple automation solutions WMZ can supply the customer with a perfectly balanced turnkey solution. A replacement tool in the tool magazine allows longer manufacturing and less setup time.

GET IN CONTACT WITH OUR LOCAL SALES & SERVICE TEAM
sales.america@dvs-technology.com . + 1 734 656 2080

WMZ-GMBH.DE
DVS-TECHNOLOGY.COM

gear TECHNOLOGY®
Vol. 39. No. 5

departments

A CUT ABOVE

Vertical Hobbing, New Heights

The next level is now in reach...

The SH Series of vertical hobbing machines from MTB are what you've been waiting for: highly productive, extremely affordable solutions for parts up to 410 mm in diameter.

All available in an extremely rigid, compact platform with options for custom automation, on-board chamfer/deburring and hard skiving to save you precious time and money on every job.

Even better, MTB can have your SH up and running in just 3-5 months, or sooner, with an in-stock solution.

Why wait?
Contact MTB today.

- SH-210, 310 and 410 models, for workpieces up to 410 mm in diameter
- Wet or dry hobbing; compact, rigid and highly affordable
- Available with custom automation, on-board chamfer/deburring and quick change tooling
- Hard skiving option
- Fanuc or Siemens CNC

HAMAI | SMG | fg TEC for GEARS | BURRI | d+p

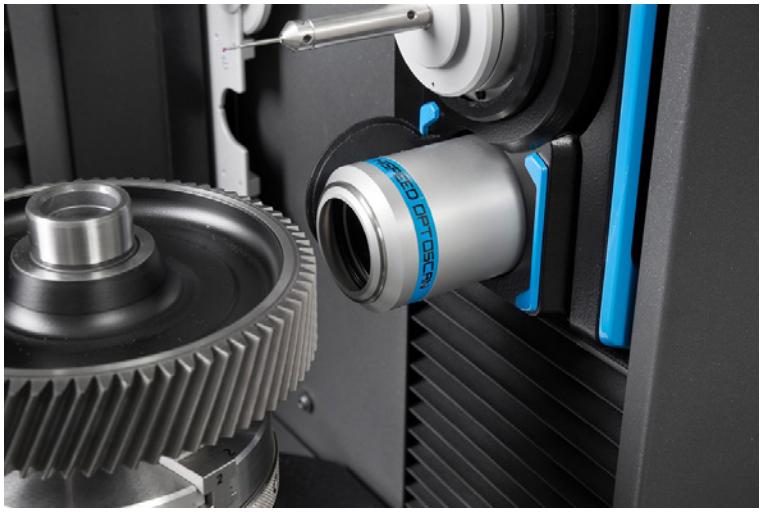
MTB Machine Tool Builders
REBUILDING • RECONTROLLING • SERVICE

machinetoolbuilders.com
(815) 636-7502

THE GEAR INDUSTRY'S INFORMATION SOURCE

www.geartechnology.com

GT Revolutions

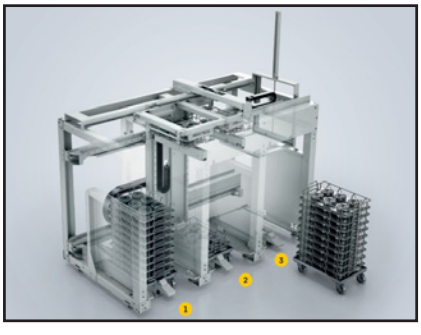


Making Gear Noise Visible

The development of electric powertrains has pushed the importance of noise behavior for gears even further. This development results in tighter geometrical tolerances and the need to access the noise behavior directly as an additional quality criterion including tolerances. Learn about Klingelnberg's latest inspection and metrology systems to combat gear noise in automotive applications:

geartechnology.com/blogs/4-revolutions/post/29926-making-gear-noise-visible

GT Videos



Liebherr Palletizing Cell

This video details how a Liebherr palletizing cell is used for automatic machine loading. Parts are fed in stacks, offering a buffer storage and enabling unmanned production. This makes the operator's life easier, maximizes machine runtime and boosts productivity.

geartechnology.com/media/videos/play/241-liebherr-palletizing-cell

Ask the Expert

Do you have a technical question about the design, manufacture, or standards of gears? We invite you to submit questions for our Ask the Expert column. Please submit your questions to Senior Editor Aaron Fagan at *fagan@agma.org*. Read some of our most recent Ask the Expert columns here:

geartechnology.com/topics/426-ask-the-expert

gear TECHNOLOGY®

AGMA MEDIA
1840 JARVIS AVENUE
ELK GROVE VILLAGE. IL 60007
(847) 437-6604
FAX: (847) 437-6618

EDITORIAL
Publisher & Editor-in-Chief
Randy Stott. Vice President Media
stott@agma.org

Senior Editor
Matthew Jaster
jaster@agma.org

Senior Editor
Aaron Fagan
fagan@agma.org

Technical Editors
William (Bill) Bradley. Robert Errichello. John Lange. Joseph Mihelick. Charles D. Schultz. P.E.. Robert E. Smith. Mike Tennutti. Frank Uherek

ADVERTISING
Associate Publisher & Advertising Sales Manager
Dave Friedman
friedman@agma.org

Materials Coordinator
Dorothy Fiandaca
fiandaca@agma.org

CIRCULATION
Circulation Manager
Carol Tratar
tratar@agma.org

ACCOUNTING
Accounting
Luann Harrold
harrold@agma.org

MANAGEMENT
President
Matthew E. Croson
croson@agma.org

FOUNDER
Michael Goldstein founded Gear Technology in 1984 and served as Publisher and Editor-in-Chief from 1984 through 2019. Thanks to his efforts. the Michael Goldstein Gear Technology Library. the largest collection of gear knowledge available anywhere. will remain a free and open resource for the gear industry. More than 36 years' worth of technical articles can be found online at *www.geartechnology.com*. Michael continues working with the magazine in a consulting role and can be reached via e-mail at *michael@geartechnology.com*.

The choice is CLEAR...

ATLASBRONZE
A MARANATHA NOW COMPANY

For all your BRONZE needs.

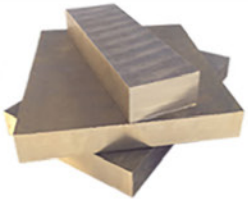
sales@atlasbronze.com

800•478•0887

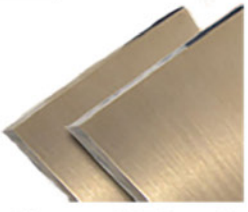
WE OFFER

Bronze Bar Stock

Cast & Wrought Alloys



Standard Plate



Ground Plate/ Wear Plates

Big Block Plates ASTM B505 & B22

Stock & Custom Bushings

Centrifugals

Forgings

Sand Castings

Made to Order Parts

Alloys Available*:

C46400 • C51000 • C54400 • C61400 • C62300 • C63000 • C64200
C65500 • C67300 • C83600 • C84400 • C86300 • C86500 • C89835
C90300 • C90500 • C90700 • C91100 • C92200 • C93200 • C93700
C95400 • C95500 • C95510 • C95800 • C95900 • SAE 841 Sintered Bronze

*If your alloy is not listed, send us your drawing and/or alloy requirements and we can help.

No, Really. I Mean It.

Publisher & Editor-in-Chief
Randy Stott

Last issue I asked you all for a special favor. Thank you to those of you who responded. But for the rest of you...well, we could still use your help. The success of *Gear Technology* depends on our ability to know who you are, where you work and how you're involved in the gear industry. That means subscribing or renewing your subscription.

It's fast. It's easy. If you give us your e-mail address, we'll match it up with what's in our system and fill out most of the form for you. All you have to do is double-check the info, correct anything that's changed and click submit.

Please help us continue being the world's best resource for the gear industry by visiting **https://admin.geartechnology.com/subscribe.php** and filling out the form. It will only take a minute or two, and you'll be doing your part to help us stay on top of our game.

It's important to do this, even if you think you've recently subscribed. Our goal is to make sure we have the most accurate, up-to-date information possible, and we can't do it without you.

If you have the time, you can help us even more by sending this QR code to your coworkers and colleagues in the gear industry. Help them take advantage of "The Gear Industry's Information Source," too.

Thank you for your continued support.

Randy Stott

Nidec GEAR GRINDER SALE!

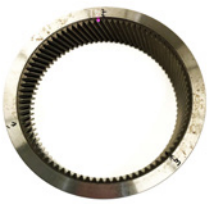
Nidec Machine Tool America

For a limited time only:

$0 down, and pay nothing for 90 days after delivery.

Call us for details:
Scott Knoy 248-756-5017 or Dwight Smith 248-756-0894

ZE26C Gear Grinder-automotive, industrial, truck



ZI20A-G Internal Generative Grinder-for quiet EV planetary ring gears

ZE16C Gear Grinder-fast and accurate

ZE40A Gear Grinder-profile and threaded wheel versatility

All machines will be proposed F.O.B Savannah, GA. All sales subject to credit check. Offer good until Nov. 30th, 2022.

Visit **www.nidec-machinetoolamerica.com** and call our sales department at **248-669-6136**

LEGENDARY RELIABILITY

Metal Cutting Robots

KADIA OFFERS DEBURRING ROBOT CELLS FOR GEAR AND GENERAL MACHINING REQUIREMENTS

Kadia has been designing deburring robot cells based on 6-axis industrial robots for many years. In the meantime, a new trend is now emerging, solutions with an even higher value-added component, i.e., with general machining processes such as milling, drilling or thread cutting. The robot is thus no longer just part of a deburring machine.

The Nürtingen-based company pursues two concepts with its Deburr-Robot-Cells: Either the robot grips the workpiece and moves it to fixed tools—often brushes—or it guides the tools itself, such as milling tools. The latter case is the bigger challenge. One example is the deburring of large gears (Fig. 1). The term deburring is no longer quite appropriate for this application; it is more a matter of edge shaping. The gears are given chamfers of up to 5 mm. The tool used for this is a solid carbide end mill. Programming is complex because the cutters follow the involute contour of the tooth flanks.

A further development in recent years has been Deburr-Automation-Cells in which the robot performs comprehensive handling tasks in addition to deburring. In this constellation, for example, it works together with machining centers, i.e., it places the components, removes them again and, if necessary, also acts as an interface for neighboring system parts such as quality or washing stations. Deburring is then just one task among several.

And these tasks are joined by others. That's why Kadia is now offering a third category of robot systems as an application: Machining-Robot-Cells. "More and more customers are asking whether it is possible with the robot, for example, to also apply a thread or a flat surface," explains Jannik Weiss from deburring machines sales at Kadia. The customers' plan: They want to avoid reclamping operations. If the deburring robot, which often continues the process chain after mechanical processing, can take work away from the other processing machines, a lot of time can possibly be saved. "We are repositioning ourselves a bit as a result," explains Henning Klein, managing director at Kadia. "Since we have accumulated many years of know-how with our automation solutions with robots or with our Deburr-Robot-Cells, the step to becoming a supplier for robot-assisted mechanical processing is no longer a big one."

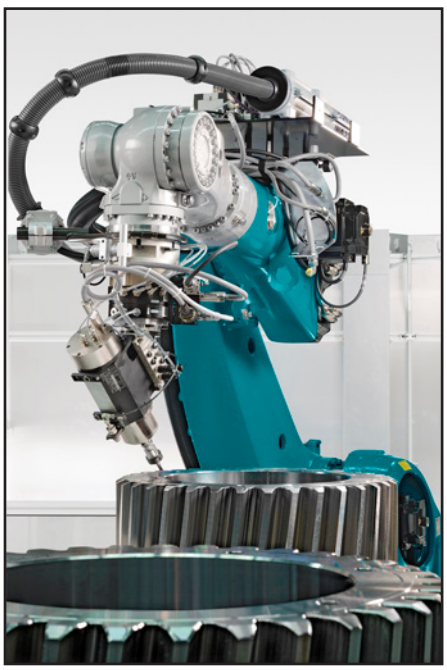


Figure 1 Using solid-carbide cutters, the robot provides the teeth with chamfers of up to 5 mm. It follows the involute contour of the tooth flanks exactly (all images by Kadia).

Cost-effective machining solution

In principle, a 6-axis industrial robot is suitable for a wide range of machining technologies: Drilling, milling, thread cutting, etc.; dry, wet or using minimum quantity lubrication is possible. The main advantage is that the robot is a comparatively low-cost machining solution. With it, all exposed sides of a cubic workpiece can be easily reached. If the same number of degrees of freedom is to be achieved with a machining center, much more complex 5-axis machine concepts are required, which results in high costs. In addition, a robot can alternately pick up grippers and tools and is therefore suitable for multifunctional scenarios.

The limitation of a robot for mechanical processing is its comparatively low rigidity. It cannot offer the repeatability of precision guides available on a machining center. The further the arm reaches out, the less accurate the result. Its use is therefore limited to applications with correspondingly large tolerances and small chip depths. However, there are certain adjustments and parameters that can influence the results.

The programming can compensate for deviations from the ideal path at the reversal points within certain limits. "The process development department at Kadia determines which parameters

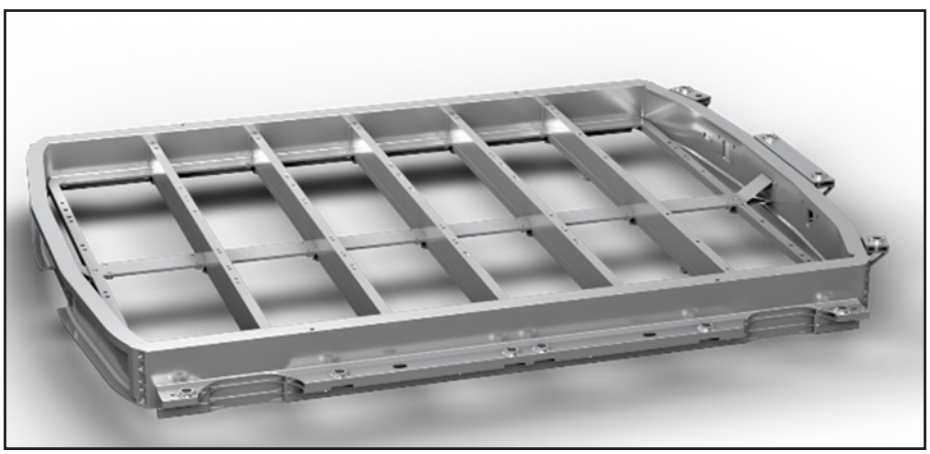


Figure 2 Tray construction made of aluminum profiles for holding vehicle batteries. The task of the robots is milling over the connecting surfaces for a cover to be attached later.

need to be optimized and how. We take the necessary time for this so that we can give the customer a capable process at the end," says Weiss.

Example: Milling of car battery housing trays

One application for which a robot is ideally suited is the machining of the parting surfaces on aluminum housing trays for holding vehicle batteries. These housings, made from extruded profiles with crash protection structures, are effectively the successors to fuel tanks. The quantities required are increasing rapidly. Due to the required surface requirements and tolerances, a machining center would be oversized. A robot, on the other hand, meets the dimensional accuracy requirements and fully exploits its cost advantages as well as its flexibility.

Kadia recently developed a corresponding machining concept for an automotive manufacturer. The task in detail: milling of the parting surfaces with subsequent brush deburring so that the frames can later be bolted and sealed with a steel cover (Fig. 2). An important detail of the customer's requirement was flat-milled surfaces with low waviness. The customer specified the quality of the surfaces with Rz < 20 µm / Ra < 4 µm.

The solution: one cell with three robots (Fig. 3). To meet the cycle time, two robots are required on one side of the workpiece—where the machining volume is larger—and one is sufficient on the other side. The setup requires less than 80 seconds for complete machining, i.e., milling including brush deburring. In case a future workpiece variant with further details would have to be machined, the cell still offers space for a fourth robot.

Tests carried out in advance with milling tools (Fig. 4) showed that minimization of vibrations is the big issue when defining almost all machining parameters in robotic cutting. The cutting geometry—macro- and microgeometry, for example—are important adjusting screws, since they have a decisive influence on the cutting forces. Among other things, the depth of cut is a key criterion; the application engineers limited this to 2 mm to reduce vibrations. At the same time, they optimized the cutting

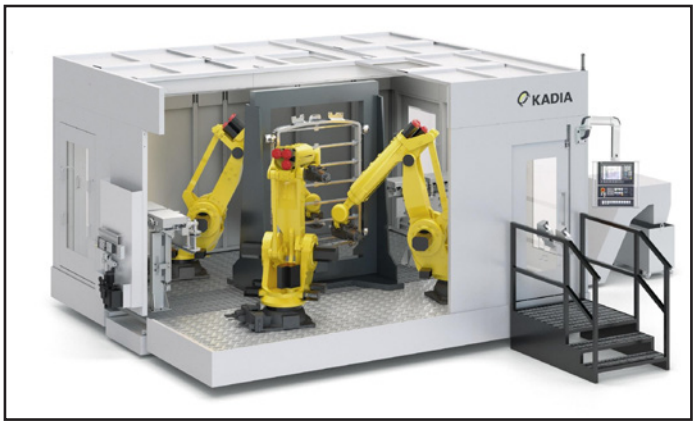


Figure 3 Robot cell for battery trays.

speeds and feeds so that chatter marks are avoided (Fig. 5). The cutting edges are cooled during machining by means of minimum quantity lubrication.

Programmable spindle units mounted on the robotic arms are responsible for analyzing the cutting data. They form a 7th axis. The solution described above achieves a surface finish of Rz = 10 µm / Ra = 2 µm. The required surface finish by the user is thus undercut by a factor of two.

Simple operation

At first glance, a cell with three robots is a complex system. However, its operation is simpler than expected. Kadia designs the cells with usability in mind; the operating staff does not need to be a CNC programmer or a robot specialist. Weiss continues, "Any skilled metal worker who understands a technical drawing is able to operate our robotic cells. Only one master point is defined for each machining detail. This is easy to correct. The approach paths and transition movements to the next feature are predefined. Every process-relevant dimension on the workpiece can be read in plain text from the drawing."

It follows that if a workpiece is out of tolerance, the operator can quickly and easily correct the corresponding workpiece and tool coordinates on his own.

kadia.com

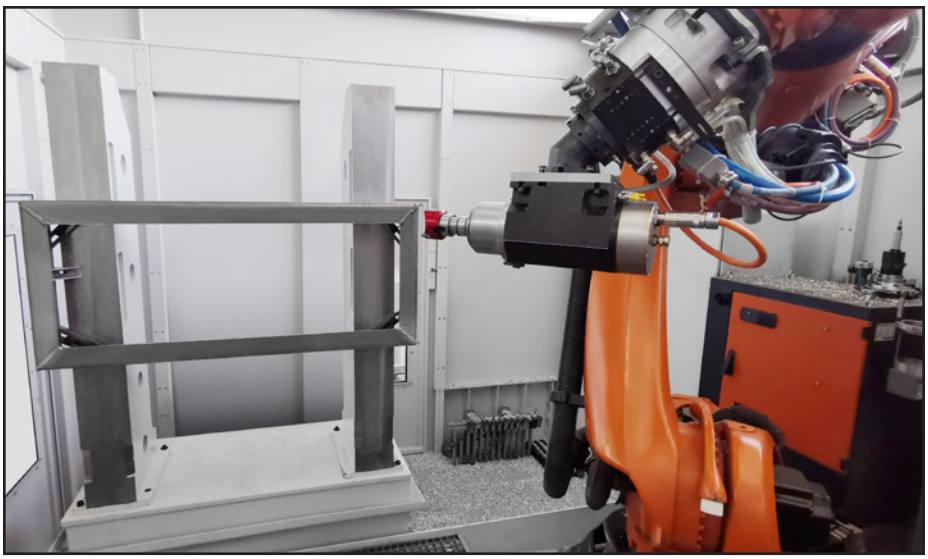


Figure 4 Kadia carried out extensive test machining on dummy workpieces in advance. This enabled the optimum machining parameters to be determined.

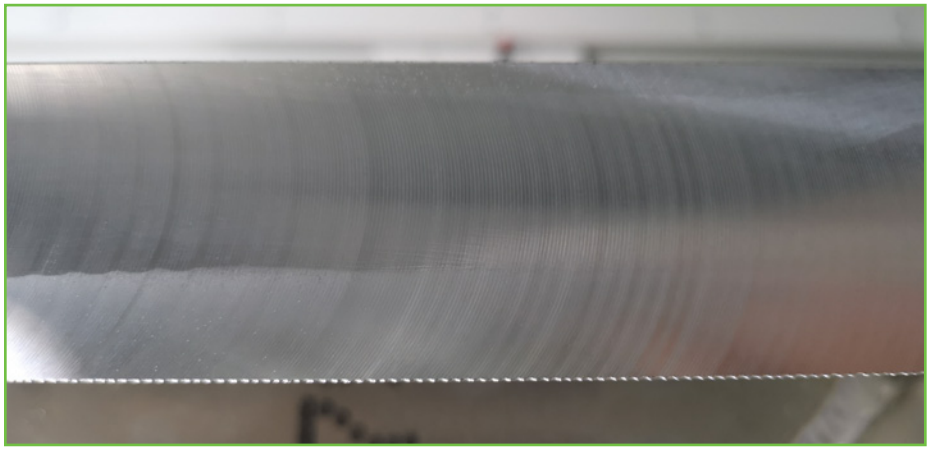


Figure 5 With the optimum combination of cutting speed, feed rate and depth of cut, the robot produces better surfaces than required. Chatter marks remain absent.

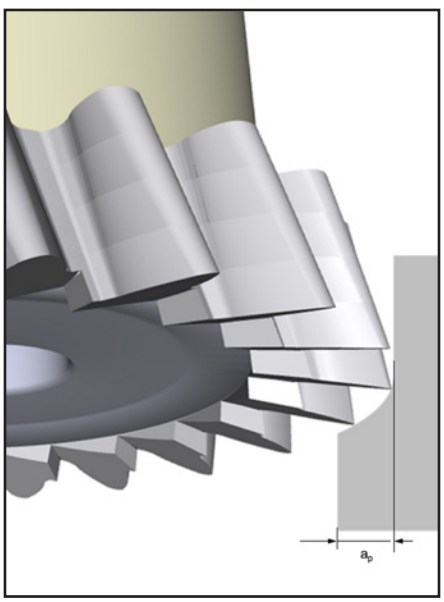
esco GmbH

EXPANDS SKIVING SOFTWARE PORTFOLIO

The company esco, a technology partner for process digitization in the gear and cutting tool industry, is adding a technology module to its software for the skiving process chain.

The technology module provides relevant information for efficient use such as the analysis of the effective rake and clearance angles, the boundary conditions for the cut distribution and the main machining times. It also answers the question of how far the respective skiving cutter can be resharpened: setting data for use in the reground state will be optimized; and the profile analysis for the gear shows when tolerances are being exceeded.

For skiving as an economical and flexible gear manufacturing process, the focus is on internal gears and gears with process-limiting interference contours. The type of gears can be diverse: starting with any profile-corrected involute gear, spline profiles, profiles for timing belt pulleys or sprockets. Particularly when using skiving as a finishing operation, the achievable accuracy is important: with skiving cutters, gears in a module range of about mn = 0.3 to mn = 8 mm in DIN quality 5 can be produced.



Snapshot of skiving cutter in one position (courtesy esco).

Digitalization solutions

Digitize the future with us: open, versatile, transparent

www.liebherr.com

LIEBHERR

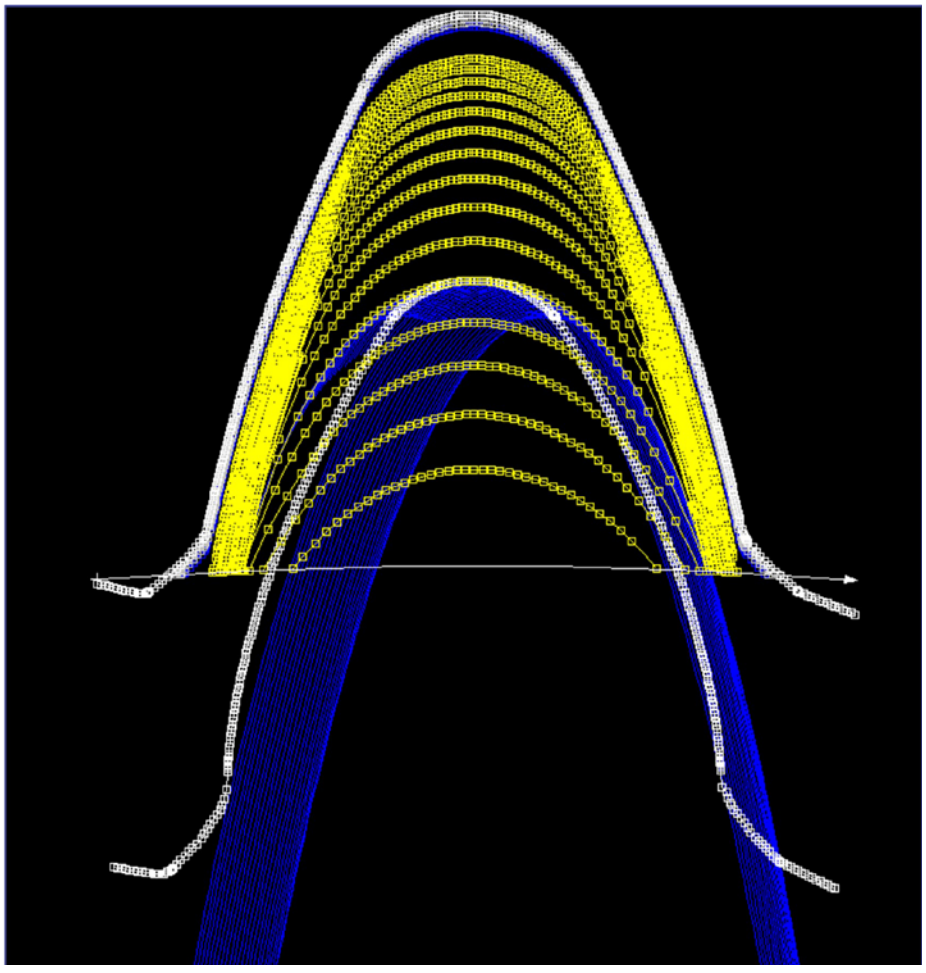
Gear technology

Modular products for your digitalization projects

With a wide variety of products consisting of data profiles, protocols and the LHWebPlatform, we provide a modular system for an individual infrastructure for the acquisition, transmission, storage, processing, preparation and visualization of machine, operating and production data.

- Selection of extensive data profiles with over 1000 signals
- Networking with existing system, e.g. via OPC UA
- LHWebPlatform for increasing productivity using data-based reports
- Digital data exchange between gear cutting machine and gear inspection machine via GDE (Gear Data Exchange)

Liebherr Gear and Automation Technologies, Inc. • 1465 Woodland Drive • Saline, MI 48176-1259
Phone +1 734 429-7225 • info.lgt@liebherr.com • www.liebherr.com/LHWebplatform



2D representation of cut distribution and rolling motion within one defined infeed position (courtesy esco).

However, the design and production of high-quality skiving cutters put high demands on development, manufacturing technology and quality assurance. Powerful software tools that can be used consistently in these areas are crucial for success. By using the esco software, including the new technology module, tool manufacturers can offer their customers the optimum tool in the best possible way and convincingly prove the benefits in terms of cost-effectiveness in use. By optimizing the influencing variables for wear and tool life, it is also possible to minimize the tool costs per manufactured part—providing the conclusive facts to decide for this specific cutting tool and the skiving process.

In the same way as the technology module is used as powerful assistance for the tool layout, esco supports application specialists by providing a seamless and matching working software tool—the application module—for on-site use. If the test results under real machining conditions should require a final geometry optimization, the corresponding data to be changed can be fed back directly to the design department.

esco-aachen.de

Ipsen USA

PROVIDES VACUUM FURNACE TO ITALIAN COMMERCIAL HEAT TREATER

Ipsen recently installed the second Turbo2Treater vacuum furnace at Temprasud, a commercial heat treater in Fresagrandinaria, Italy.

"With the addition of this vacuum hardening and low-pressure carburizing furnace, we can offer our customers greater flexibility and production capacity," said Temprasud CEO Michelangelo Del Vecchio.

Their first Turbo2Treater was purchased in 2017 and allowed Temprasud to expand services, improve part quality and reduce cycle times. The new furnace will help them continue to grow business in the automotive market, with anticipated expansion into aerospace. They also have a large customer base in the construction equipment, wind energy and agricultural machinery industries.

Temprasud cites Ipsen's technical expertise and excellent customer service as motivators in their decision to continue ordering Ipsen equipment. In reference to the Turbo2Treater, they say it produces parts with optimal hardness, bright surfaces and minimum distortion.

"Ipsen provides innovative treatment systems and technologies that guarantee the best results in terms of quality," said Del Vecchio.

Temprasud also has two Ipsen VDR furnaces for nitriding and nitrocarburizing in their plant. Their Ipsen furnaces have helped to reduce the environmental impact of production with better temperature uniformity and faster processing speeds. This helped Temprasud receive ISO 14001 certification, which is the international standard for environmental management systems.

ipsenusa.com

SMW Autoblok

OFFERS PLUG AND PLAY ELECTRIC CHUCK

SMW Autoblok recently introduced the CC e-motion electric 4-jaw chuck featuring wireless power and signal transmission (up to a 20 mm distance) utilizing an F180 Ethernet base inductive coupler system and high repeatability of < 5 µm.

The CC e-motion offers accuracy and flexibility for high or low volume turning, inspection and finishing operations while providing fast, seamless machine integration. Optimum for either heavy duty or precision machining of any workpiece geometry, the chuck allows users to not only program the cutting cycle, but the jaw movement and gripping cycle as well.

Whether the application requires highest accuracy or high-low chucking, the individual electro-mechanical single jaw drive of the CC e-motion allows grip force setting to any value as well as automatic radial fine adjustment of the workpiece. Plus, the ability to handle any workpiece shape and configuration of parts means fewer changeovers and vastly reduced downtime with dramatically improved part quality.

Designed to meet the demands of manufacturing automation and Industry 4.0, CC e-motion includes redundant safety monitoring that displays the status of the chuck while in operation, letting the user know if the chuck is open, closed, improperly clamped or has insufficient clamping force.

Each jaw of the CC e-motion is independently controlled and monitored by a single mechatronic drive providing automatic correction function and the ability to change the grip force in process without removing the part. The chuck body and internal parts are case hardened for increased chuck life and highest rigidity, precision, and durability, and accept standard inch serrated top jaws.

The plug and play CC e-motion uses the F180 Ethernet base coupler system that transmits up to 400 W of energy and data contact-free through an air gap of up to 20 mm between rotating and stationary components. The IP67 rated coupler is wear and maintenance free and is ideal for use as slip rings or connector replacements as well as other applications.

smwautoblok.com

KISSsoft

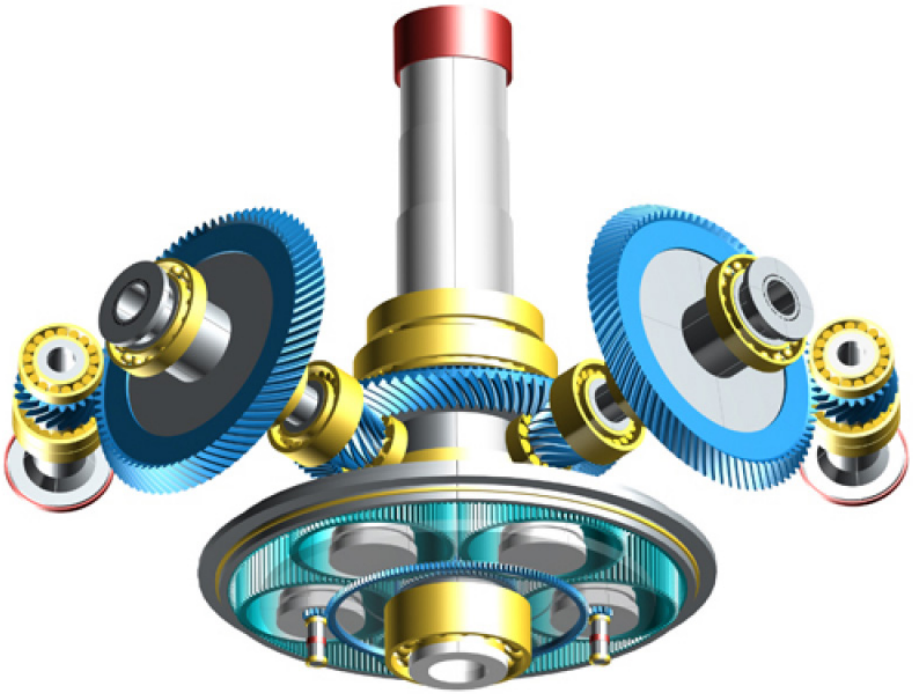
2022 NOW AVAILABLE

The new *KISSsoft* release 2022 provides numerous innovations—amongst others, in order to include the tooth fatigue limit in the verification, the information can be generated from time series.

The determination of load spectra from time series (torque-speed-time) is now an independent module ("Load spectra"), which can be used to calculate load spectra for gears and for shafts/bearings. In addition to detailed reports, many graphics are now available for displaying the results.

Positive and negative torques result in alternating load in the tooth root. The Rainflow method is used to determine the number of cycles with a shift from high to low torque. Based on this, the alternating bending factor YM, according to ISO 6336-3 (extended), is determined additionally for the load spectrum in the gear calculation of each element.

kisssoft.com



Solar

PUTS VOQ FURNACE INTO FULL PRODUCTION

A newly designed Vacuum Oil Quench (VOQ) furnace, purchased by Solar Atmospheres of Western PA, recently entered into full production after passing a vigorous start up protocol. The initial temperature uniformity survey, compliant to AMS2750F, produced +/- 10°F results at all setpoints. Most importantly, the critical lift and place transfer mechanism worked flawlessly. This robustly designed system delivered hot 2,000-pound loads to the internal oil quench tank seamlessly time after time. With a quench system that is entirely self-contained and vacuum tight, the typical positive pressure "flare and smoke-ups" during each quench cycle was nonexistent.

Other features of this unique furnace include the ability for the customer to attain the actual work temperatures within the 36" x 36" x 48" hot zone. Additionally, with an atmosphere totally

devoid of oxygen there is no need to use problematic oxygen probes. Material surfaces are free from intergranular oxidation (IGO) along with zero evidence of decarburized or carburized surface conditions. Heat treated components emerge from the quench oil bright and clean! With carbon potential issues totally eliminated, alloys of dissimilar carbon contents with comparable cross sections and austenitizing temperatures, can all be treated within the same load.

Bob Hill, president of Solar Atmospheres of Western PA states, "Most recently insurance companies are reluctant to write policies for commercial heat treaters simply because they see a single flame or evidence of smoke. In the past, unfortunate accidents have occurred with explosive endothermic atmospheres and flammable oils. I am convinced that this new Solar Manufacturing furnace is a much safer and greener way to oil quench parts. In my opinion, this furnace is the future of oil quench heat treating."

solaratm.com

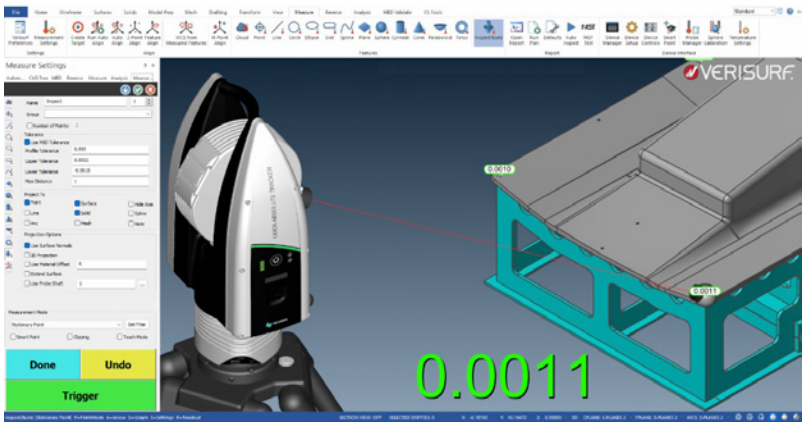
Verisurf Software

NOW SUPPORTS HEXAGON LASER TRACKERS FOR 3D MEASUREMENTS

Verisurf Software, Inc. announces support for the new Hexagon, Leica AT500, and B-Probe plus CMM. Verisurf interfaces with Leica Laser Tracker Systems for data collection and 3D measurement workflows, including alignments, inspection, tool building, assembly, scanning, analysis, reporting, automation, and reverse engineering.

Verisurf Software offers development and support of metrology software solutions rooted in Model-Based Definition (MBD). At the heart of MBD is the intelligent CAD Model, the absolute authority to define a part or entire product by supplying a defined 3D data set, including all necessary GD&T annotations.

"The AT500's enhanced measurement speed and increased pitch angle,



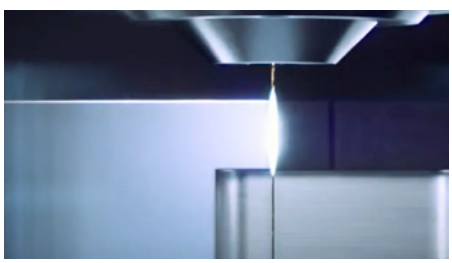
combined with the working range of B-Probe plus make it a fantastic match for Verisurf's industry-known 'Build Mode' to achieve real-time tolerance condition feedback," says Nick Merrell, executive vice president of Verisurf. "Our latest Verisurf Device Interface (VDI) also includes a digital bubble level to support using the AT500 for level and plumb operations."

verisurf.com

GF Machining Solutions

IWIRE ADAPTS TO EDM CUTTING CONDITIONS

The new iWire function from GF Machining Solutions automatically identifies and adapts wire speed to changing erosion height conditions during the wire EDM process. This capability eliminates wire breakage while reducing overall wire consumption per job, in some instances by as much as 29 percent.



Featured on the new GF Machining Solutions' CUT P Pro Series wire EDMs, the iWire function works in tandem with the company's Intelligent Spark Protection System (ISPS), both of which are part of the company's Uniqua control.

What started with GF Machining Solutions Spark Track technology four years ago has advanced to the company's ISPS and now iWire technologies. Building on its amassed technological knowledge from decades of experience in EDM, the company can not only recognize exactly where the sparks of a wire EDM are happening during the process, it can also measure and identify the position of each spark along the length of an EDM's wire.

Knowing the exact location of a spark allows iWire to automatically adapt the wire spool speed accordingly. Such capability reduces the chances of wire breakage during unattended operations when EDMing parts with steps and other features that vary the erosion height – the length of the actual surface areas where the wire is eroding/cutting.

Both ISPS and iWire help prevent wire breakage in any conditions while also lowering wire usage to reduce consumables costs and increase EDM productivity. In testing, iWire working with ISPS prevented wire breakage on a part with numerous features with varying erosion heights. The cut started at a standard spool speed, then when the cutting height lessened, the speed slowed. As a result, wire savings equated to about 480m or 0.2kg, and overall process time savings amounted to 28 minutes for a 30 percent overall reduction.

In another customer test, ISPS and iWire reduced wire break areas from nine to zero. The customer reduced wire consumption by 29 percent and eliminated machine stoppages due to wire breakage.

gfms.com

Velo3D

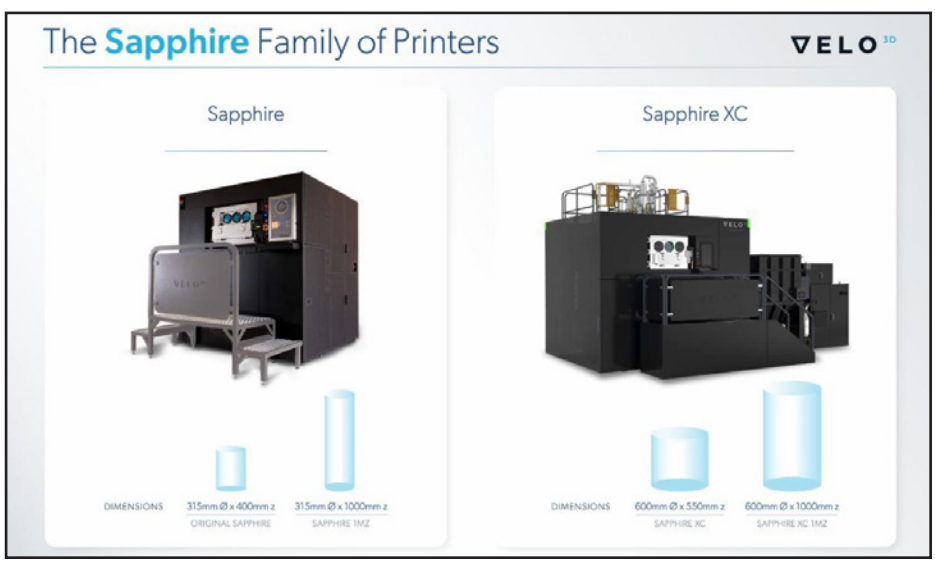
ANNOUNCES ADDITION TO SAPPHIRE LINE

Velo3D, Inc. has announced a new addition to its Sapphire family of printers with the Sapphire XC 1MZ. The new printer allows customers to print parts one meter in height—with a total build volume that is twice that of the Sapphire XC and nine times larger than the original Sapphire—increasing the addressable use-cases of Velo3D's end-to-end metal additive manufacturing solution.

The Sapphire XC 1 MZ system combines Velo3D's innovative geometric capabilities with the repeatable, standardized processes and validated material properties necessary to achieve distributed manufacturing in a larger format. The Sapphire XC 1MZ was designed based on feedback from customers in the aerospace, energy, and defense industries, with the first systems expected to be delivered to several aerospace companies in late Q3 2022.

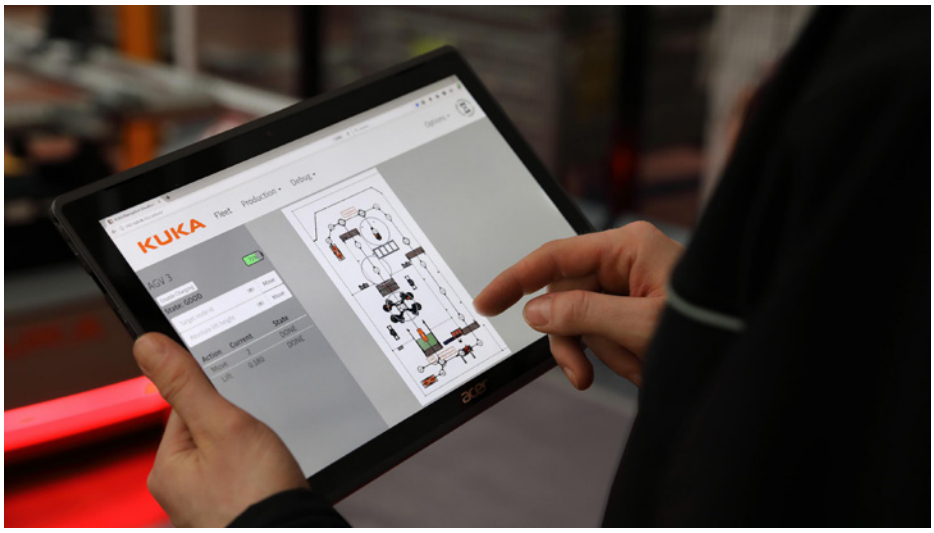
"Without advanced metal additive manufacturing it would be difficult to impossible to build many of the technologies that are shaping the future of our world," said Benny Buller, Velo3D CEO and founder. "Our innovative customers have a clear understanding of how the technology can unlock new capabilities for their businesses and transform their product offerings. New systems, like the Sapphire XC and Sapphire XC 1MZ, support that transformation by significantly increasing throughput up to 400% and lowering costs by up to 75% compared to the original Sapphire."

velo3d.com



KUKA

OFFERS WIDE VARIETY OF AUTOMATION SOFTWARE SOLUTIONS



KUKA software products include advanced automation planning software, *KUKA.Sim*; r*eady2_pilot*, a streamlined solution for robot teaching; and *KUKA. RoboTeam*, which enables multiple robots to cooperate as a team to efficiently complete complex tasks.

The future-oriented *KUKA.Sim* allows manufacturers to accurately plan their automation solutions before the system has even been put into operation. Robot motion sequences are programmed offline, depicted in real time, analyzed, and optimized to ensure that processes and work cell layouts can actually be implemented as planned.

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

KUKA's wireless *ready_2 pilot* quickly mounts to the robot and is used without complex programming. Manual guidance is all that is required to teach the robot the desired sequences, which can be done with a touch of a button and then fine-tuned if necessary. Operation is carried out using an intuitive 6D mouse that requires no training. Two buttons on the mouse provide quick access to freely selectable functions such as opening/closing a gripper, adjusting process parameters, or saving motions. *Ready2_pilot* is compatible with all standard KUKA robots, like the KR 8 CYBERTECH Nano used in the demonstration, and offers maximum freedom for operator control.

kuka.com

IMTS 2022 Booth Previews

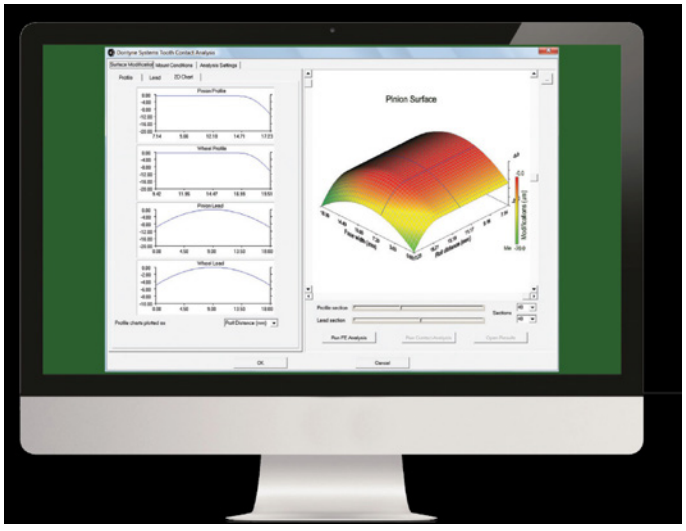
The World of Manufacturing Comes to Chicago

Matthew Jaster, Senior Editor

The metalworking community comes together during IMTS to celebrate and promote manufacturing technology. Pavilions include Abrasive Machining, 3D-Printing, Controls, Fabrication, Gear Generation, Machine Components, Metal Removal, Quality Assurance, and Tooling and Workholding. The show is co-located with Hannover Messe USA. The following article looks at a few of the products and technologies offered this September at McCormick Place in Chicago from September 12–17, 2022:

Dontyne Gears Ltd.—#237227 (North Building)

Dontyne Gears has introduced the *Dontyne Integrated Gear Gauging System (DIGGS)* for the Renishaw Equator. This is a bolt-on software package that enables the gauging of cylindrical gears and involute splines allowing customers to compare production parts quickly and accurately on the shop floor.



Dontyne Systems offers software and services aimed at the optimum production of gear components and their use in the transmission industry. Dontyne's range of products allows end-to-end control of the gear manufacturing process. *Gear Production Suite* updates include a manual license check-in/out and Machine Center and Inspection Center modules as standalone installation.

dontynegears.com

Euro-Tech Corporation—#432272 (West Building)

The company offers German-engineered tooling and workholding gages and accessories including mechanical and hydraulic expansion arbors and chucks; clamping sleeves; gaging for splines, gears, and other toothed profiles. These products enhance production for manufacturers in the automotive, aerospace, and small engine industries. They are the North American distributor for Mytec Hydraclamp, Frenco, and more.

High Quality Gearing for Electric Drives

The high degree of integration of components into modern motor vehicle electric drives requires a reevaluation of the production sequence, particularly regarding their efficiency. Important functions of highly integrated electric drive units can often only be tested once the assembly of the electric motor and the transmission is complete. The way to avoid higher costs due to entire systems failing at the end of the value chain is to use better-quality gears right from the start. A complete inspection of the components ensures low error rates.

Frenco has developed a rolling inspection instrument combining a high added value with very short cycle times. This new system is created through the combination of rolling inspection for dimensional deviations such as radial run-out and tooth thickness and concurrently recording the acceleration. This makes it possible to evaluate the noise generation of the individual components enabling reliable monitoring of production deviations at an early stage.

The new Frenco system records approximately ten revolutions of the gear, taking only two seconds per rotational direction. This along with the handling of the parts makes a cycle time of 15 seconds possible. Placing the system on a hard stone plate ensures the required precision, preventing higher stresses having a negative influence on the quality of the measurements. NC axes for the center distance and the vertical position are just as much mandatory as is the fully automatic inspection process and the connection to a loading system.

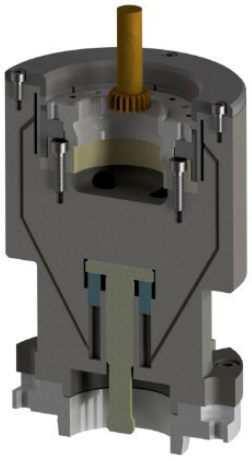
Mytec Hydraclamp

Today's solutions for efficiency and power density are often a combination of mechanical, fluid power, electric, and hybrid technologies. Today's gears and splines are precision items produced through special tools with very tight tolerances. When you need to inspect manufactured workpieces, you need even more accurate measuring and inspection equipment.

For over 40 years, Frenco has committed itself to the challenge of providing customized solutions for individual gear and spline inspection requirements. Mytec Hydraclamp expansion elements provide the and chucks with repeat accuracies of ≤ 0.005 mm (≤ 0.0002"). These are excellent for workholding where high forces are incurred or auto load applications where high clearance is required.

Skiving has been around for a long time, but recent advances

in technology have improved the speed and effectiveness of this gear-making process making it a more viable manufacturing option for gear producers. It has long been recognized that skiving would be a much more productive process than shaping for cutting many internal gears. Mytec Hydraclamp clamping tools are robust and rigid enough to minimize vibrations caused by the high spindle rpms and significant cutting forces generated by the new skiving process.



Today's demands also include clamping very thin parts for the robotic gearboxes (flex spline gearbox). Mytec Hydraclamp clamping tools are designed to clamp components the entire length of the clamping area. If the component is irregularly shaped, we clamp around it to achieve the highest accuracy. The company designed a hydraulic chuck in combination with a changeable back stop and slotted collet. This gives the customer options to clamp different diameters and components with one hydraulic chuck. This hydraulic chuck is used to machine the spline in the "gear shaping" process on a Liebherr machine.

Easier Internal and External Spline Inspection

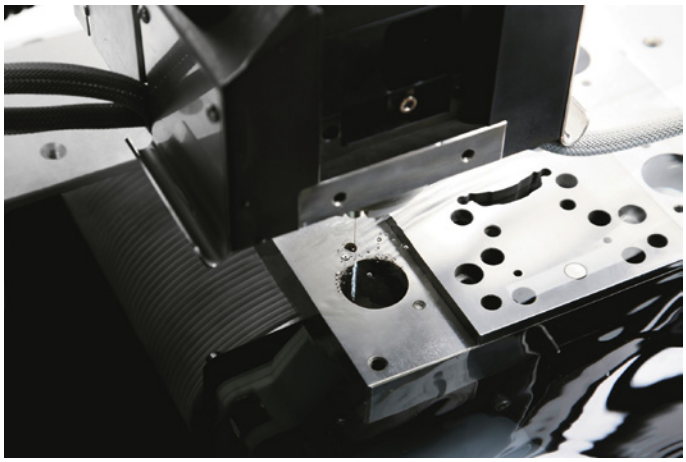
Frenco GmbH has introduced a new horizontal slide option for the inspection of internal and external splines with AVM and IVM gaging systems. Advantages of this new development are the easier handling of long workpiece shafts through adjustable V-blocks with longitudinal travel; and repeatability for MdK averages of ≤ 1.3 µm.

eurotechcorp.com

GF Machining Solutions—#338376 (South Building)

GF Machining Solutions will highlight advances in EDM technology, service, support, automation, and tooling designed to help shops power through their unique manufacturing challenges with complete solutions and holistic support. Plus, System 3R will highlight tooling solutions to reduce setup time and automation solutions to maximize machining hours.

For customer growth and success, these integrated problem-solving solutions include the new CUT X 500 and CUT P 350 Pro wire cutting EDM machines for precision part generation. To maximize machine-tool value and competitive readiness, the company's new Success Packs feature comprehensive customer support as well as digital services that add connectivity for remote machine monitoring and troubleshooting from GF Machining Solutions experts. Rounding out the lineup of live demonstrations will be an automated cell featuring a MILL 400 U and FORM P 350 with a FANUC Robot. There will also be a System 3R WorkPartner 1+ modular pallet system connected to a GF Machining Solutions LASER P



400 U laser texturing machine.

With Intelligent Power Generator (IPG) technology, the CUT P 350 Pro delivers surface finishes as smooth as Ra 0.08 µm and heightens accuracy with integrated thermal regulation that maintains temperature at ± 0.2°C. To accommodate heavy workpieces, the machine's QUADRAX mechanical system keeps the table, work tank and dielectric liquid stable.

Capitalizing on more than a century of EDM technology, the CUT P 350 Pro and CUT X 500's new Uniqua human/machine interface (HMI) delivers optimal functionality and ergonomics in a 19" vertical touchscreen, full keyboard, and mouse. Abundant automation options add to the machine's scalable flexibility, with optimized production for electronics, automotive, medical and mold and die manufacturers through more than 600 pre-programmed cutting processes.

The AgieCharmilles CUT X series holds extreme accuracies in machining positioning and pitch. Developed to provide high precision and thermal stability in large runs of complex components, including stamping tools, multi-cavity molds and micro components, the CUT X 500 and all other CUT X machines feature adapted mechanical structures, dedicated machine calibration and testing to deliver pitch accuracy as low as 1.0 µm. High-precision axes, short measurement loops, dual measurement on all axes, consistent isolation of the EDM area from heat sources and submerged working areas optimize conditions for micro applications. Two-spool Automatic Wire Changer technology and an onboard Job Management System help further reduce processing time and simplify job prioritization.

gfms.com

Haimer—#431510 (West Building)

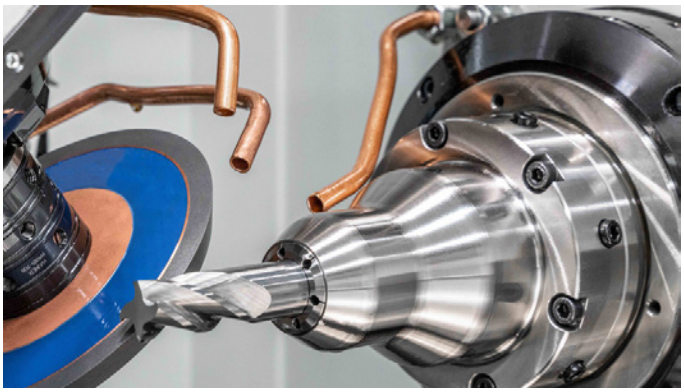
Today, Haimer, is doing a lot of research in milling, turning, and grinding tools, and their optimal use. Among other things, this is demonstrated by a complete range of grinding wheel adapters for tool grinding machines of for Vollmer, Walter, UWS Reinecker and Rollomatic.

Haimer also offers a wide range of suitable grinding wheel adapters for the innovative high-precision multi-task machines, which unite milling and turning, as well as grinding technology. These holders are available in HSK-63 spindle coupling as a monoblock version or in multi-part with one or four clamping screws. A corresponding offer is also available for the HSK-A100 and PSC 63 spindle interfaces.

In addition, Haimer supplies special customized grinding wheel adapters for clamping diameters from 56 mm to 280 mm which can be equipped with various efficient cooling options for the grinding wheels.

The latest innovation in the Haimer program is the high-precision clamping system for round shanks "High Precision Clamp Master" which can be used on many well-known cutting tool grinding machines with drawbar clamping. The flexible system is perfectly suitable for automated blank changing. It pays off quickly, especially for small batch sizes with automatic loading, as the machine is ready to grind again in a very short time.

The Haimer High Precision Clamp Master is characterized



by the highest level of accuracy. The runout and wobble can be adjusted in the machine and the highest runout repeatability of < 0.002 mm is guaranteed when changing the collets. A time-consuming adjustment of the runout is no longer necessary.

A core product in the Haimer portfolio since 1996 have been the Tool Dynamic balancing machines that compensate the unbalance from milling and turning tools, but also from grinding wheels. Even if balancing seems complicated at first glance, with Tool Dynamic machines it is easy to handle and affordable to everyone.

haimer-usa.com

Hainbuch—#431636 (West Building)

Hainbuch offers a mandrel with a hexagonal pyramid shape instead of a round taper, designed with stringent manufacturing requirements and process reliability called Maxxos.

Thanks to the hexagonal pyramid clamp, maximum torque transmission can be achieved. Up to 155 percent more transmissible torque and up to 57 percent higher bending stiffness compared to the classic Mando T211 mandrel. This makes it possible to achieve higher process parameters and consequently improve the yield of finished parts. Greater process reliability is facilitated by the spacious layout between the clamping bushing and the clamping pyramid. Even during the clamping process, this design prevents virtually any dirt getting onto the surfaces. This significantly cuts down the frequency of maintenance times for cleaning and lubrication. Overall, the mandrel has a clamping diameter range of 18 to 100 mm. The clamping areas of each size are designed to overlap. This has the advantage that

users can choose from up to three mandrel sizes depending on the clamping diameter. The larger the mandrel is, the greater its stability and rigidity. Smaller mandrels may be able to handle more of the customers smaller workpieces. The aligned, segmented clamping bushings have a minimum concentricity of 0.01 mm and can even be supplied in a high precision version.

hainbuchamerica.com

Heidenhain Corporation—#135716 (East Building)

Heidenhain will feature the new TNC7 in North America. This standard-setting CNC control supports users from initial design to final machining, from one-off jobs to serial production, and from simple slots to complex contours. Its control platform lets machine manufacturers adapt the user interface to their machines and offers dynamic development potential for even greater functionality.

Along with easy and intuitive operation, users enjoy support from a virtual simulation of the machined part and work envelope. It will be the basis of future control generations from Heidenhain. The control features high-quality hardware components including a 24-inch full HD touchscreen monitor and an advanced, individually adaptable user interface. Its entire operating concept was redesigned from the ground up.

The interface of the TNC7 was designed to help users achieve the best possible result with maximum speed and convenience. Different machining tasks call for individualized work environments, which is why users can adapt their screen content through personal favorites, their own home menu for a faster start. And thanks to its fast-operating speed, the control reacts immediately to data input.

The TNC7 enhances familiar Klartext programming with smart functions and newly developed graphical programming. Users can draw contours directly on the touchscreen and convert them into dialog guided TNC Klartext programming code. Cycles and older contour programs can still be used, including already existing NC programs. A diverse package of functions, intelligent probing cycles, and graphical guidance for

determining the position of clamping devices completes the next level of smart programming.

Not only will the TNC7 be on display at the IMTS Heidenhain **Booth #135716** (East Hall), but also at the IMTS Student Summit **Booth #215600** and Hermle USA **Booth #339119** (South Hall) in action on its Hermle C250 High Performance line five-axis milling machine tool.

heidenhain.us

Jergens—#432154 (West Building)

Jergens announces its first preview of several new workholding products that will be on display and demonstrated at this year's IMTS.

First among them will be additions to the company's tooling columns made in the United States and constructed of single piece cast iron for maximum rigidity. These columns open horizontal machining potential and are a solid basis for custom workholding to suit specific customer needs. Several new styles include square, cross, and rectangular. Additionally, three mounting options are available—center pin, edge and ZPS—and the new columns are fully customizable.

A second new product introduction is Jergens new five-inch heavy duty machine vise. Made of stress relieved ductile iron and flame hardened, the new vise provides very long usable life and predictable performance. They are also more easily moved and relocated by the operator due to the relatively small size and weight, but also ensure secure part holding and tight tolerances from general machining to high production. Additions include hardened jaw plates and a Ball Lock fixture plate quick-change kit. The vise is also made in the United States.

A third development is with the company's Quick-Loc pallet system (QL2). This will replace the existing product line and features an improved design that engages pull studs inside the receiver. QL2 has a hardened coating for long life and durability. The range is compatible with all existing top tooling. Quick Loc pallet systems are used for fixturing on horizontal, vertical, and rotary operations. These low-profile adapters and pallets ensure repeatability of 0.0003" and provide clamping forces of nearly 14,000 lbs.

Also included in these several expansions are two new ZPS installation choices for compact, light duty applications. SP140, the smallest clamping module on the market, and K02 pull studs utilize pneumatics and a mechanical spring in a small package. The combination offers quick-change solutions for vise or gripper jaws, electronic component manufacturing, packaging machines, medical technology, and automation.

Jergens also offers a washdown tool. This simple device provides 360 degrees of spray using coolant flow to reduce machine cleanup time after a cycle. The ball cleaner washes chips off exposed surfaces, cleaning the machine at scheduled intervals which helps support long machining cycles and lights out machining periods when no operator is present. The wash-down tool goes into the tool changer just like any other tool.

The full range of Jergens core products—including Ball-Lock, ZPS, Quick-Loc, Fixture Pro, and OK-Vise—will be on display throughout the exhibit.

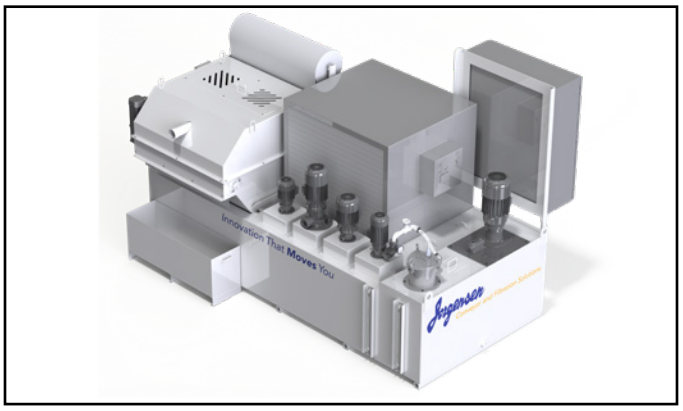
jergensinc.com

Jorgensen Conveyor and Filtration Solutions—#338164 (South Building)

Jorgensen Conveyor and Filtration Solutions will spotlight its new FlexFiltration line, including the company's new Flex G Series of modular filtration systems. The cost-effective systems feature pre-engineered modules that ensure fast, easy, flexible filtration configurations and add value for virtually any application.

FlexFiltration systems efficiently remove fine chips and grinding sludge to achieve coolant clarity down to 10 microns or less. They are especially well suited for challenging applications with materials that range from cast iron, steel and aluminum to composites and plastics.

Pre-engineered base configurations and numerous options



enable quick construction of FlexFiltration systems to meet specific coolant-flow requirements. Standard, low-profile and stainless-steel tanks make these systems ideal for machine tool OEMs and regular end users. Other modular options that complete a system include high-pressure pumps, auxiliary pumps,

tramp oil skimmers, coolant chillers, heat exchangers, liquid level sensors, temperature sensors and the ability to control/interface with existing pumps and other equipment.

Jorgensen's Flex G Series systems feature gravity media filters. The gravity media filtration option is the first one available in the FlexFiltration product line. Gravity filters are offered in 30, 60 and 90 gpm options and come standard with low media roll detection, no media alarm sensor and automatic roll advance. A variety of different disposable cloth medias are also available based on specific applications. Additional primary filtration options including bag filtration, cyclonic, and permanent media types will soon be offered.

jorgensenconveyors.com

LK Metrology—#135230 (East Building)

LK Metrology, Inc. will offer four different CMMs including: the LK ALTERA M SCANTEK 5 equipped with a Renishaw REVO-2 5-axis scanning system; the LK Multi-Sensor ALTERAC equipped with LK's new blue line laser scanner and a new surface roughness probe; the new ALTO 6x5 Bench Top CMM; and finally, a new COORD 3 UNIVERSAL CMM with a TP200 touch probe. CMMs with PH20 and PH10 probes will also be on display.

LK will be launching an advanced version of their *TouchDMIS* software as well as demonstrating the newest version of their well-known *CAMIO* programming and measuring

software. In addition, the new Industry 4 Metrology Gate, LK's portal for remote inspection monitoring, will also be shown and demonstrated. Other CMM software like *Renishaw Modus*, *Polyworks*, and *CMM Manager* that are frequently used with LK Metrology CMMs will also be available for demonstration.

Related accessory products to be seen will include LK's new SLK20 blue light line laser scanner; a new LK surface roughness probe; and a new LK FREEDOM V2 measuring arm with rotary indexing table.

lkmetrology.com

L. S. Starrett—#135044 (East Building)

The L.S. Starrett Company has enhanced its AVR300 Multi-Sensor Vision System with a large 2.36" (60 mm) FOV-dedicated 0.14x telecentric lens for micron-level resolution and accurate field-of-view (FOV) measurements. For greater efficiency and accuracy, more of the part can be viewed in every image on the new AVR-FOV 0.14X system. Due to "superimage" technology, which allows multiple images to be stitched together to form one larger image, together with the system's touch probe technology, the AVR-FOV 0.14X can accurately inspect a wide range of features on large or complex parts, as well as on multiple small parts.

The AVR-FOV 0.14X automated part programs deliver accurate results to the micron level in a matter of seconds with "Go/

No-Go" tolerance zones, and data are provided in one easy-to-interpret report. These features allow metrology users in manufacturing facilities or QC labs to produce accurate, fast, and repeatable results.

"Building on the success of the AVR300 multi-sensor system, now customers can measure and inspect a wider range of parts, including those that are complex with intricate features," said Mark Arenal, general manager, Starrett Metrology Division, "The interface on the AVR-FOV 0.14X is user friendly and intuitive so all users, including operators right on the shop floor, can complete the inspection process."

Equipped with the *M3* software package from MetLogix, a traditional mouse as well as a touchscreen monitor make user interaction easy and intuitive. Auto part recognition enables creating a part measurement program that comprises the desired features of a part for inspection, which can automatically be saved in the system or to a network. Programmable light output options can be built into the program as defined steps, including being called up as the part recognition program initiates. Once the program is created, placing that part within the camera's field-of-view allows for the saved program to

initiate and run the inspection. A Renishaw Touch Probe may also be utilized for quick acquisition of discreet points along a part's profile as well as Z-axis measurements.

The AVR-FOV 0.14X has an X-Y-Z travel of 12" x 8" x 8" (300 mm x 200 mm x 200 mm). The Starrett AVR-FOV 0.14X Multi-Sensor Vision System is made in the United States.

starrett.com

Mazak Corporation—#338300 (South Building)

Among the 19 machines in the Mazak booth will be models from the company's Ez, INTEGREX Multi-Tasking, new SYNCREX Swiss-Style and NEO Series in live real-world production demonstrations. Mazak also will feature automation systems, its MPower complete customer care program and Mazak Capital Equipment Financing (MCEF) for one-stop factory-direct financing.

Mazak's Ez Series of machines puts Mazak reliability, accuracy, and performance into shops of every size. The Kentucky-built Ez Series includes turning centers and vertical machining centers with compact footprints and numerous options.

At IMTS, Mazak will feature the QT-Ez 8MY Multi-Tasking CNC Turning Center with an 8" chuck and integral-motor spindle that handles a wide range of materials, along with milling capability and Y-axis functionality for single-setup processing of diverse parts. In live demonstrations, the automation-ready QT-Ez 8MY will pair up with a cobot to spotlight flexibility and productivity in unattended machining.

Mazak INTEGREX Multi-Tasking machines transform complex part production with single-setup convenience and performance for advanced machining. They unify the processing power of multiple machine tools for Done in One efficiency that easily accommodates automation and unattended versatility. At IMTS, Mazak's INTEGREX i-450H ST Multi-Tasking Center will show attendees how it delivers the combined processing power of a turning center and full-function machining center, with a second turning spindle and a lower turret with optional rotary tool capabilities to minimize fixtures, tools, handling and non-cut time.

Mazak's new SYNCREX Series of Swiss-style machines come in four bar capacities ranging from 20-38 mm. The machines are available in seven, eight and nine-axis configurations. A nine-axis model with full B-axis contouring is also available. SYNCREX machines feature Mazak's new MAZATROL SmoothSt CNC control that provides fast, easy job setups. Mazak Swiss Set-up Assist (MSSA) along with the Mazak Dynamic Chip Control (MDCC) features help reduce set-up times and part production.

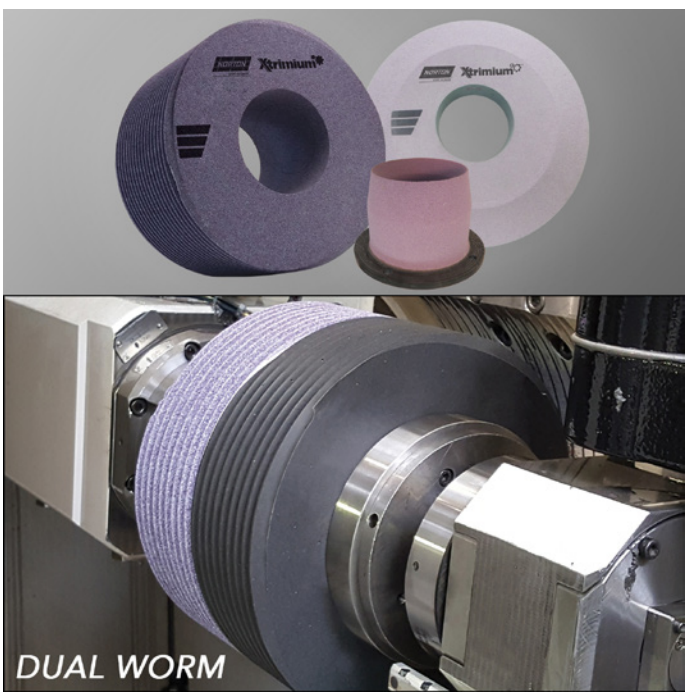
mazakusa.com

Norton|Saint-Gobain Abrasives—#237042 (North Building)

Norton|Saint-Gobain Abrasives will offer a portfolio of gear grinding products specifically designed by category to provide higher profile accuracy, supreme form holding and burn-free grinding in worm, profile, and bevel applications. Highlighting the range is an innovative dual-worm wheel design that enables two operations in one grinding wheel, substantially saving time and cost.

"In today's increasingly stringent industry requirements for higher accuracy and improved surface finishes, our high performance Xtrimium grinding wheels are engineered to deliver the highest quality gear grinding solutions" said Josh Fairley, product engineer, Norton | Saint-Gobain Abrasives.

Norton Xtrimium Dual-Worm Grinding Wheels feature a unique design with a high-performance vitrified bond section for grinding and a fine-grit resin section for polishing



the gear teeth, enabling one wheel to perform what traditionally required two wheels. Substantial savings in wheel costs and productivity via the elimination of wheel swapping, can be achieved with the Norton design. In addition, improved surface finishes of Rz = 1.0 mm and Rpk = 0.05 mm, and reduced harmonics (noise) are realized. The Norton Xtrimium Dual-Worm Grinding wheels can also be adapted to existing machines.

The Norton Xtrimium Gear Grinding Platform also covers the whole range of gear grinding processes and leverages the whole spectrum of Norton grains and bond technologies to match each customer's requirements, whether with:

- Worm Grinding Wheels featuring micro-structured ceramic grain and providing free cutting action and wheel homogeneity, allowing constant performance throughout the wheel thickness for the life of the wheel. Superior grinding rates and increased form holding without burn are achieved with these worm grinding wheels.
- Profile Grinding Wheels which are ideal for deep profile gear grinding. The wheels feature high porosity and permeability, create exceptionally high material removal rates, and friction-free grinding.
- Bevel Grinding Wheels featuring a highly porous bevel formation for extremely fast, burn-free cutting.

nortonabrasives.com

Rego-Fix—#431822 (West Building)

Rego-Fix will showcase innovations that extend the company's Swiss precision beyond toolholding. Featured technologies include the 3D-EdgeMaster measuring device and MasterBar test arbors—two new product entries for setup and test measurement. Other spotlighted innovations are expansions to the company's existing lines of internal coolant retrofit systems with additional flexibility for high-speed spindles and for turning centers along with the company's new powRgrip CoolBore collets that offer peripheral cooling in a form-fitting tool grip, and powRgrip Sealed Cap Collets to protect tools from contaminants and dust.

To add Rego-Fix precision to setup measurements, ergonomic 3D-EdgeMaster centering devices shorten setup time and ensure part accuracy in an IP 67–compliant shockproof and splashproof design for demanding applications. Designed to set zero points, probe reference edges and workpieces, calibrate measuring paths, center machine axes and determine bore centers, these new devices feature repeating accuracy of ≤0.01 mm. 3D-EdgeMaster is available in metric and inch sizes and with short or long probes, all individually serial numbered, with fully traceable inspection and performance certification for demanding industries.

Shops can minimize spindle-damage risks and maximize process reliability with MasterBar test arbors, available with HSK, steep-taper ST, BT and CAT interfaces for correct machine tool setup and spindle precision with every use. Ground to the same exacting specifications as Rego-Fix toolholding products and supplied with full technical certification, these devices check spindle runout, spindle and arbor alignment, and arbor length to boost part quality, reduce scrap and recheck for changes in runout and parallelism after a crash.

Hi-Speed reCool (RCR-Hi) quickly and easily retrofits high-speed and high-frequency spindles up to 40,000 rpm for precise internal coolant delivery at 100 bar maximum pressure with emulsion and oil-based coolants. This patented solution makes full use of high-performance equipment, with a ceramic coating for reduced friction and support for ER(M) 11 and 16 sizes in 3–10 mm tool shank diameters.

Now turning centers can benefit from the increased productivity, longer tool life and greater chip-evacuation efficiency with the quick-installing internal coolant conversion of externally threaded reCool (RCR-AX) for internally threaded live tools. Designed for lathes up to 12,000 rpm, this solution supports 100 bar maximum pressure with emulsion or oil-based coolants and 3–20 mm tool shank diameters. A copper-like coating reduces friction for higher performance.

For the highest gripping force of any Rego-Fix coolant collets, form-fit powRgrip CoolBore Collets (PG-CB) deliver high-pressure peripheral coolant for optimized chip removal in medium to high-performance applications. These collets change out quickly with other powRgrip coolant collets and provide maximum coolant output pressure for PG 25 (including short collets) and PG 32.

Shops that machine ceramics, sintered carbide, graphite, glass and other complex materials can protect their tools from contaminating chips and dust particles with powRgrip Sealed Cap Collets (PG-SC). These quick-change collets provide ultra-low total system runout of ≤3 µm at 3 x D, with equally high vibration damping for long toolholder life and consistent performance. Also available with optional cooling channels, these completely closed heads and sealed caps are a must with today's demanding materials.

regousa.com

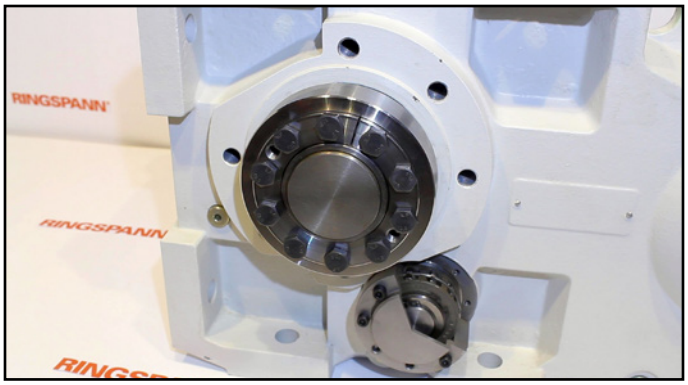
RINGSPANN—#431968 (West Building)

RINGSPANN has recently consolidated its position as an OEM supplier for machine tool manufacturers. Now the Germany company offers high-performance diaphragm and taper sleeve clamping systems that are specially tailored to the requirements of the skiving process to produce high-precision external and internal gears.

The diaphragm and taper sleeve clamping systems are particularly predestined for the internal gear cutting of thin-walled workpieces that must not deform under any circumstances during machining—for example weight optimized toothed rings for planetary gears. In this application, they replace conventional jaw chucks.

"Both versions of RINGSPANN's skiving clamping systems are based on fundamental functional principles that have proven themselves in gearing technology over a number of years," says Volker Schlautmann, head of the company's Clamping Fixtures/Shaft-Hub-Connections customer team. Typical of their design is a relatively open construction, which enables rapid chip removal.

Characteristic of the diaphragm clamping systems are a short overall length and a very uniform application of the clamping forces on the workpiece. They also offer the possibility of clamping on the shortest clamping surfaces. The key features of the taper sleeve clamping systems, on the other hand, are the large clamping depth and an impressive degree of rigidity.



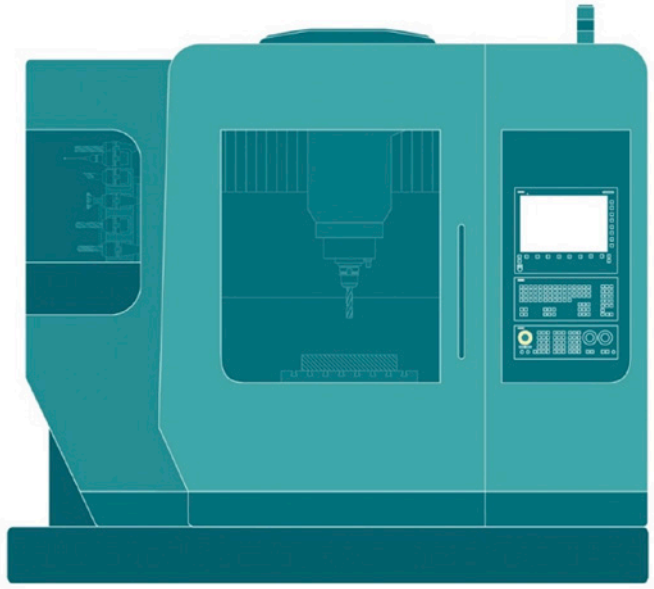
In both cases, the frictional connection is made via workpiece encompassing clamping elements, which can be quickly and easily exchanged during changeover. RINGSPANN supplies both versions ready for use, balanced and, if required, with air system control.

ringspanncorp.com

Siemens—#133346 (East Building) and 433028 (West Building)

Siemens will present its hardware automation and software technology portfolio, highlighted by the first-ever, digital-native CNC platform, Sinumerik One, for machine tool applications. In addition, Siemens will present its solutions and services for the industrialization of additive manufacturing. In booths 133346 and 433028, the company will highlight how machine users can quickly and easily embark on their digitalization journeys—from part concept to design, digital twin to simulation, part and machine production, as well as total integration of these processes into the digital enterprise for job shops and production departments alike.

In the Controls and CAD-CAM pavilion, Siemens will demonstrate the end-to-end production and installation of a transmission housing and bracket for the eRod, an autonomous electric vehicle that will be in the booth for visitor inspection. The parts are made by additive and subtractive machining processes. At every stage of the part's development, including machining, display kiosks will take visitors through the digital process. From the *Siemens NX CAM* design software, which enables the use of 3D models, data and processes to seamlessly connect planning and shopfloor operations on a digital thread to the Sinumerik One,the digital-native CNC that permits a digital twin of the machine and its full operation in production,Siemens has streamlined machine shop operations as well as leading automotive, aerospace, off-highway and medical part production facilities worldwide.



In the Additive pavilion, Siemens will demonstrate its CNC implementation into the additive and additive/subtractive production worlds, displaying part production processes from design to the finished part. Visitors can discuss their manufacturing challenges with Siemens to determine the optimum method of part design and manufacturing, whether one-off or full production runs, all performed with digitalization methods for validation and time/cost containment.

siemens.com/us/en.html

Unisig—#339159 (South Building)

Unisig will showcase the technologies that make it an industry leader in extreme depth-to-diameter hole drilling, including the ability to create holes with outstanding precision. The company's UNE6 Series small-diameter gundrilling machines excel at drilling deep holes in demanding materials, including high-strength titanium and surgical-grade stainless steel, and achieve superior concentricity through tool and workpiece counter rotation.

At the show, Unisig will highlight medical production on the UNE6-2i that features two independent high-speed spindles for production of 10" or 30" maximum part lengths and available integrated automation onboard. The machine's high accuracy allows it to drill hole diameters from 0.03–0.25" (0.8–6 mm) and depth-to-diameter ratios from 20:1 to more than 100:1 in workpieces up to 11 lb. (5 kg). With 28,000 rpm total drilling speed and a 3,000 psi (207 bar) flow-based coolant system, the UNE6-2i combines exceptional process control with an intuitive smart control interface.

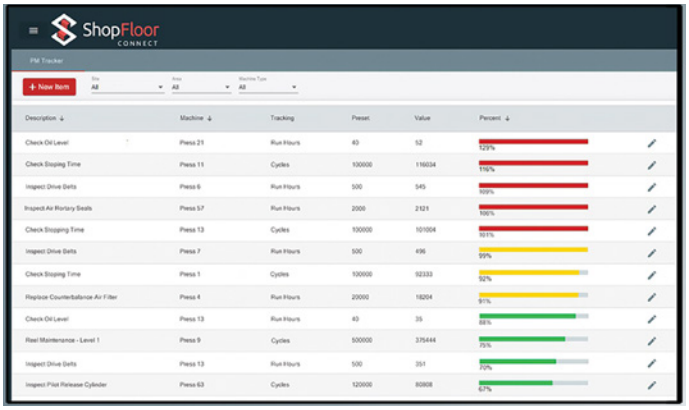
Customers in industries that include aerospace, automotive, energy, firearms, hydraulics, defense, and oil and gas, as well as medical and moldmaking, can consult with application engineers and technical sales staff at IMTS to discuss optimization of applications including drilling and beyond.

unisig.com

Wintriss Controls Group—#135073

Wintriss Controls Group has announced it will be demonstrating new, advanced features in its *ShopFloorConnect OEE* and *Data Collection* Software at IMTS. The latest functionality in ShopFloorConnect gives manufacturers efficient and easy-to-use software for increased efficiency and reduced downtime, including when remote monitoring is required. The software can significantly increase manufacturing capacity and profitability by identifying and quantifying excessive production losses and bottlenecks.

Advanced ShopFloorConnect OEE and *Data Collection* Software collects downtime and production efficiency data from every machine, ranging from CNC machines to presses, fabricating machines and more, in all areas of discrete manufacturing. Data is displayed in real-time, and indispensable manufacturing reports are produced, including detailed OEE reports in a variety of formats. At IMTS, Wintriss will showcase the new *ShopFloorConnect* PM Tracker which enables users to track important machine preventative maintenance (PM) items by run hours or machine cycles, issues targeted alerts when an



item requires PM, and tracks the maintenance work history for all machines.

ShopFloorConnect 6.0 also features a new Universal Interactive Application Program Interface (API) that enables users to quickly set up two-way data sharing with any ERP or MES software.

shopfloorconnect.com

For Related Articles Search
IMTS
at www.geartechnology.com

Preview of 3D Printing at IMTS 2022

A sneak peak into the booths of JEOL USA, Nidec Machine Tool, and Fortify

Aaron Fagan, Senior Editor

Additive Manufacturing (AM) is a space that is maturing at insensate speed—the growth and innovation in materials and technology are staggering. Because of the inherent process of 3D printing, it may allow for a renaissance in the physical design of gears (i.e., integral channels for cooling, lightweighting, and other possibilities) but also holds the potential for gear repairs. *Gear Technology* spoke with JEOL, Nidec, and Fortify about the technologies they will be on-site to discuss at IMTS 2022.

JEOL USA—#432510 (West Building)

JEOL USA enters a new era of innovation with the introduction of Additive Manufacturing technology for 3D printing. JEOL, Ltd. (Akishima, Japan) has developed and introduced a new Electron Beam Metal (EBM) AM machine that significantly improves quality and manufacturing time to produce stronger and lighter parts for a variety of applications. This new technology currently used in 3D printing production in Japan is now available to manufacturers in the Americas.

What makes the new EBM system, the JEOL JAM-5200EBM, unique in this growing field is JEOL's decades-long expertise in the development and production of advanced electron optics technology used for research and industrial applications. JEOL is the market leader in electron optics systems involved in a variety of related 3D printing applications from materials characterization to particle analysis in the pre-production stream to imaging, energy dispersive spectroscopy (EDS), and electron backscatter diffraction (EBSD) analysis. Additionally, the JAM-5200EBM's electron beam technology is solidly based upon JEOL's 50+ years of experience in the development and production of generations of mask writing and spot beam lithography tools with unique vacuum technology.

Jeol USA's JAM-5200EBM is an electron beam melting (EBM) powder bed fusion (PBF) machine which is said to significantly improve productivity, quality and reliability to produce stronger and lighter parts for a variety of applications.

EBM technology makes it possible to reduce fuel consumption, increase output, reduce cost, improve efficiency, and shorten development time through high-quality and high-repeatability modeling, integration of multiple parts, and weight reduction.

Advantages of JEOL 3D-printing technology include:

- Emphasis on total system uptime, with a long-life cathode over 1,500 hours. The full cathode life and manufacturing quality are maintained in the system's clean manufacturing environment.
- A clean, helium-free environment and "e-shield" that eliminates smoke events during manufacturing. JEOL's unique powder dispersal prevention system avoids the scattering phenomenon.
- Focus and spot shape of the electron beam are automatically corrected according to the irradiation position. This technology was developed in-house, based on our market-leading electron beam lithography systems for semiconductor manufacturing.
- Remote monitoring of conditions and manufacturing status.
- Eco-friendly. The system can build multiple parts in a single run.
- Manufacturing capacity of 250 mm (diameter) x 400 mm (height).
- JEOL USA's extensive service network of over 180 field service engineers will provide after-sales support.

JEOL USA has begun working with pilot sites in the field of additive manuf to integrate 3D printing technology into mainstream production.

Gear Technology: How do you see JEOL's JAM-5200EBM serving the gear industry?

Robert Pohorenec, JEOL USA President: Many people are surprised when they learn their company is already a JEOL customer. A high technology capital equipment company in business for 72 years has opportunities to provide an array of technical solutions to customers' challenges. We see the JAM-5200EBM operating in the bay next to the JSM-700HR, for example, our scanning electron microscope which can support a 15-lb. gear, to provide high-resolution imaging and characterization information. JEOL is investigating super steel for tool and gear production. We believe these new alloys will have great advantages for gear and tool manufacturers.

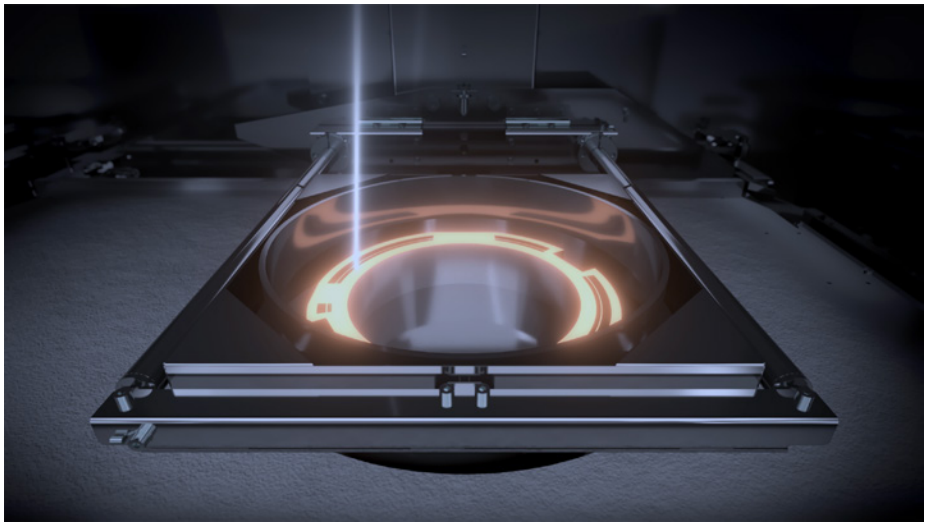
A cross-section view of a titanium metal gear fabricated by the JEOL JAM-5200EBM 3D printer.

GT: Is AM a new direction JEOL? How did this come about?

RP: Additive manufacturing is a new and exciting direction for JEOL. In 2014 we were one of twenty-five Japanese manufacturers and universities that formed the Technology Research Association for Future Additive Manufacturing, or TRAFAM, for the purpose of developing and commercializing next-generation additive manufacturing machines for industrial use. This paved the way for the global product release of our JAM-5200EBM in March 2021.

GT: JEOL has a long history of electron-based technologies, how does that expertise serve to distinguish your EBM solution from other Powder Bed Fusion technologies?

RP: Electron optics and electron beam control are within the "DNA" of the JAM-5200EBM. That inherent IP provides the best-in-class performance in beam control, automation, and emitter lifetime.

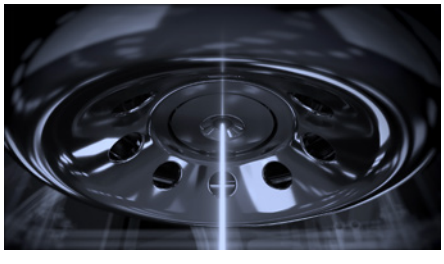


JEOL's unique helium-free, powder-dispersal prevention system avoids the scattering phenomenon. That not only allows parts to be manufactured in a clean space at a low-cost, the surface of the cathode is also less susceptible to damage, allowing the electron beam to remain stable.

GT: Is your Automatic Electron Beam Correction technology a feature unique to JEOL's EBM solution?

RP: Our Automatic Electron Beam Correction technology was ported over from our JBX E-Beam lithography systems. JEOL released the first computer-operated EBL system in 1967, so there is deep IP even within the subsystems of our EBM solution. Our Automatic Electron Beam Correction technology provides confidence to our users the system will operate as intended for long periods of time without user intervention. Last year during the winter break, one of our EBL users at a National Lab wrote a pattern meeting tool spec for 360 hrs (15 days) nonstop. This Automatic Electron Beam Correction technology is at the core of our reliability and day-to-day repeatability.

GT: Please describe the "scattering phenomenon" and how your e-shield and helium-free environment serve as a solution?



The long-life cathode, which lasts over 1,500 hours, can greatly reduce downtime for cathode replacement. The secret is JEOL's original vacuum technology, developed in the manufacturing of electron beam related equipment.

RP: The "scattering phenomenon" occurs when a powder particle does not have adequate adhesion to the build platform. The e-shield prevents energized particles to pass to a powder particle outside the designed build area. Without e-shield, unintended artifacts are created and damage to the system could occur if the "scattering phenomenon" is not controlled. The patented e-shield and our unique scan strategy helps eliminate the "scattering phenomenon" or "smoke events". This strategy removes the need for helium, an expensive and limited natural resource, and any other gases.

GT: What role do you see AM playing in the gear industry as the technology achieves more mainstream adoption?

RP: We think AM can make the gear industry more efficient and bring new solutions to its customers at a faster rate due to the inherent advantages of AM. There are cases where traditional manufacturing and additive manufacturing are complementary, giving gear manufacturers the possibility to mix and match these technologies for their optimum solution.

We believe our long history of development and production of advanced, field-proven electron microscopy and electron beam technology, combined with JEOL's extensive service and support network, is an opportunity to integrate quality and reliability into the employment of this novel technology.

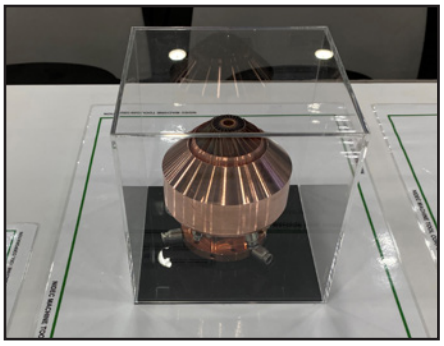
jeolusa.com

State-of-the-art local shield nozzles with enhanced shield performance. The optimized shield gas jet expands the shield region area up to 45 times the conventional size. The local shield function eliminates oxygen in the environment around the molding process to prevent the oxidation of molten metal.

Nidec Machine Tool—#237036 (North Building), #338252 (South Building)

DED, or directed energy deposition, as implemented in the Nidec LAMDA 3D printing systems, utilizes a powerful focused laser beam to melt powdered metal that is supplied to the build area by a nozzle. As the laser heats the powder, it melts and sinters to the baseplate or layer below.

There are three powerful technologies integrated into the LAMDA's

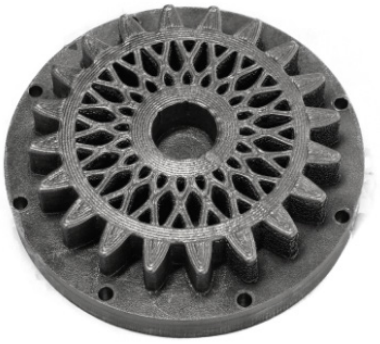


Nidec Machine Tool's LAMDA2000 3D metal printer is a direct energy deposition additive manufacturing system.

state-of-the-art control. First, by monitoring and controlling the laser power in real-time, the size and temperature of the melt pool is constantly controlled to permit accurate deposition and full integration of metal onto the part being printed. This monitoring system also provides a fully verified quality control record of the build.

Secondly, when printing materials that are reactive with oxygen, inert argon gas is used by the LAMDA Local Shield. This excludes oxygen from the melt pool and allows large components to be 3D printed without the need for an expensive atmospheric chamber. This also greatly reduces the cost of operation by not needing to purge large quantities of this inert gas.

The third important technology brought to additive manufacturing detects potential problems before the process fails. To build large items defect-free, LAMDA has deep learning AI for anomaly detection. The machine knows and can detect many anomalous patterns at installation, and the machine will "learn" additional new anomalies as they occur. This image processing occurs at 300 images per second, which is faster than the speed of the CNC control unit.



A LAMDA DED-printed gear made of AISI 304 stainless steel demonstrates lightweighting design potential.

Applications for DED include uses beyond full 3D printing builds. The ability to apply material to an existing part is a valuable repair option for expensive, hard-to-make, and long-lead-time components. The ability to use two different materials, for example, titanium and Inconel, on the same part opens even more possibilities for repair and solving problems.

The range of materials that can be used with DED is quite amazing. Stainless steel, maraging steel, Inconel, titanium, and even aluminum can be used without an atmospheric chamber.

For gear manufacturing and gearbox repair, having the ability to add material back to a large (expensive) gear or shaft can be a game-changer. Printing workholding components, robot grippers and a vast array of tooling is another example of DED providing value to the gear-making community.

nidec.com/en/nidec-machinetool

Fortify—#433114 (West Building)

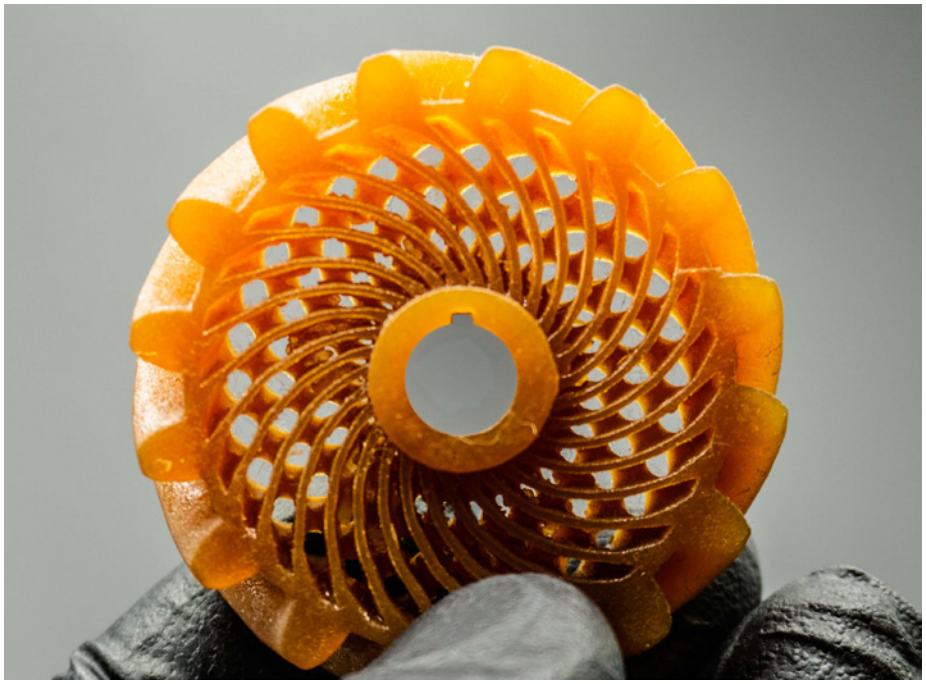
Fortify developed Digital Composite Manufacturing (DCM) to unlock new material properties that cannot be achieved with today's 3D-printed photopolymers. They achieve these properties by suspending and aligning Functional Additives (particles and reinforcing fibers) in a resin matrix during printing. Fortify's open materials platform allows for a wide range of material properties that can be

architected to meet the most stringent application needs.

In DCM, functional additives must be uniformly distributed to achieve consistent material properties. Fortify's Continuous Kinetic Mixing (CKM) addresses this issue by blending, recirculating, and heating the resin-additive matrix as required throughout the printing process.

Fortify partners with the world's leading chemical companies to architect specific material properties based on the need of a particular application and solve printability challenges that are barriers to commercialization on other photopolymer platforms:

- High Deflection Temperature (HDT) and high strength and stiffness ceramic-fiber reinforced photopolymer tuned for use in tooling applications.
- Low-loss dielectric materials for use in high-bandwidth, high-frequency communications systems.



A 3D-printed gear made with Fortify's HTS resin.

- Technical ceramics with low shrink for high-temperature and radio-frequency applications.
- High-temp electrostatic discharge (ESD) material for tools, jigs, and fixtures that can be placed directly into a solder reflow oven.
- Resins with 10x the thermal conductivity of any other photopolymer with electrical insulation for sensitive heat transfer applications.

Fluxprint is Fortify's fiber alignment module. In DCM, during the printing of each layer, a magnetic field is applied across the build area. This aligns all fibers throughout the layer in the target orientation. Individual regions of this layer are then cured with UV light. This locks the orientation of fibers only in those regions. This process of orienting and locking fiber is repeated as needed within each layer and for the subsequent layers. This unique ability to control fiber orientation throughout a part allows for precise tuning of material properties and is unprecedented in any manufacturing technology.

Fortify's FLUX Series printer lineup.

Ben MacDonald, Senior Applications Engineer, said the following about Fortify's high-temperature and strength (HTS) resin, a particularly strong material candidate for gear applications: "HTS is a resin that is uniquely suited for printing gears due to its strong wear resistance properties which enable gears printed in HTS to significantly outlast alternate materials. This wear resistance is paired with a high HDT allowing for these gears to operate in harsh conditions while maintaining structural integrity."

fortify.com

For Related Articles Search
3D Printing
at www.geartechnology.com

Our Librarian Will Never Shush You

at the GT LIBRARY

That's because the MICHAEL GOLDSTEIN GEAR TECHNOLOGY LIBRARY is all online and you can visit it anytime. Just go to *www.geartechnology.com* and use the search box for access to 38 years of technical content focused on gears.

- **Every issue since 1984**
- **More than 2,000 technical articles**
- **More than 6,000 archived news items**

Addendum, Publisher's Page, Back to Basics and more

And the best news of all? You don't even need a library card. That's because the GT LIBRARY is open to everyone. Knowledge is free. All you have to do is go and get it.

www.geartechnology.com

Origin Story: How Standards Start

Phillip Olson, Director, AGMA Technical Services

Where would your business be without standards? Can you imagine if every gear manufacturer used different inspection and rating criteria? Or if you had to re-learn new gear nomenclature for each supplier and customer you talked to? Your costs and lead times would skyrocket whereas your quality and safety would plummet. Standards are the documented set of generally accepted practices, rules, guidelines, and requirements within an industry. They are meant to streamline the process, minimize overall cost and waste while improving quality, reliability, and overall customer satisfaction and fiscal health.

You may be wondering, where do these standards come from? And the answer, for U.S. gear standards, is from experts in the industry (like you!) serving on AGMA technical committees. Even though standards writing at AGMA began over 100 years ago, there is still work to be done in standardization today. As businesses continue to innovate and incrementally improve their existing products and processes, AGMA standards writing committees keep apace with that progress by developing new standards or revising existing ones to reflect the industry we serve.

The process of revising a standard, and the process of creating a new one, both start with industry stakeholders. AGMA always welcomes comments, suggestions for improvement, and inquiries about existing standards sent to *tech@agma.org*. Stakeholders can also comment on existing standards in the more formal reaffirmation process that happens for all standards every five years after initial publication.

Comments sent to *tech@agma.org* go through different levels of escalation depending on their nature. Simple comments are answered by AGMA staff, more technical questions are forwarded to the chairperson of the committee responsible for the standard. The chairperson may answer the question directly or decide to involve the entire committee in a formal request for interpretation process. The response to a formal request for interpretation must be agreed upon by consensus. In addition to sharing the response with the commenter, it will be shared on the AGMA website and filed for implementation in the next revision of the document. The final level of escalation, for comments that uncover a technical error, is either the issuance of a revision or an erratum to the standard. A limited scope revision that can be published within months is the preferred method to address a technical error. An erratum is generally issued when the committee doesn't have time to do a limited scope revision or feels that a revision project would take longer than six months to complete.

Besides correcting a technical issue, the other reason to revise a standard is to bring it into alignment with current industry practices. Generally, the need to bring a standard up to date is decided by the committee responsible for the standard after reviewing the formal reaffirmation comments. It should be noted here that standards, by design, will always be a few years behind the latest practices. Practices need to be vetted, proven,

and accepted by the industry before they can be developed as a standard on which both big and small manufacturers can reach a consensus. Having the standard set at a baseline gives room for companies to create better products and processes that exceed the standard.

The need for a new standard can come from comments sent to *tech@agma.org*, reaffirmation comments on a different standard, or from AGMA executive committees. Comments on topics not addressed by existing AGMA documents may be forwarded to AGMA's Technical Division Executive Committee (TDEC), which oversees all AGMA standards writing committees. The TDEC can assign an existing, or create a new, committee to discuss a new document.

Regardless of the catalyst that kicks off a new or revised standard, the project needs a clearly defined proposal before it is formally approved by the TDEC. This proposal needs to identify the scope and need for the document, list the stakeholders willing to support the development of the document, and a timeline for completion of the document. Limited scope revisions should be completed within six months, whereas new documents and revisions that are open to editing the whole document should be completed within four years.

Now that you have been familiarized with the process to start a new standards-writing project, you can get involved! Send your questions, comments, and suggestions for improvement to *tech@agma.org*, and if you'd like to see all the work that goes into actually writing a standard, please consider joining one of AGMA's standards-writing technical committees!

Hungry for More?

Everything you need to be a world-class gear manufacturer — the suppliers, the technical information and the market intelligence — can be found online

gear TECHNOLOGY

- **The Michael Goldstein Gear Technology Library includes a complete archive of back issues and articles, 1984-today**
- **Directory of suppliers of machine tools, services and tooling**
- **Product and Industry News updated daily**
- **Exclusive online content in our e-mail newsletters**
- **Calendar of upcoming events**
- **Comprehensive search feature helps you find what you're looking for — fast!**

FREE Knowledge Served Daily

www.geartechnology.com

IGS to Increase Wind Gearbox Torque Density

Ruben Carranza Fernandez and Thomas Tobie

Introduction

To increase cost efficiency in wind turbines, the wind industry has seen a significant rise in power density and an increase in the overall size of geared components. Current designs for multimegawatt turbines demand levelized cost of energy (LCOE) reduction, and the gearbox is a key part of this process.

It is feasible to reach beyond the current industry limit of 200 Nm/kg torque density barrier with a combination of technology, improved design, optimized materials, and surface engineering (Fig. 1).

Since fatigue failures nearly always occur at or near the surface, where the stresses are greatest, the surface condition strongly affects the gear life. Consequently, an improved surface condition effectively avoids major redesign or increased material cost due to an increase in part size.

Additional finishing methods such as shot peening (SP) and superfinishing (SF) significantly increase the gear load capacity, but these effects have not yet been adequately considered in the current ISO 6336 standard or in any other gear standards.

The combination of SP followed by SF will be described here as an "improved gear surface" (IGS).

Defining SP

The objective of SP is to induce compressive residual stresses in the near-surface layer of a part. This occurs by a propelled stream of spherical shots, often called media. Each impact of the shot media has the effect of leaving a small hemisphere or dimple and compressive residual stresses that occur from localized yielding of the base material at the point of shot impact.

SP is a controlled process, and according to ISO 6336-5 (Ref. 1), the recommended minimum control should be based on SAE AMS 2430 (Ref. 3), SAE AMS 2432 (Ref. 4) or SAE J 2441 (Ref. 5). SP should not be confused with mechanical cleaning operations or shot blasting.

There are four main parameters to specify and control SP: media hardness, media size, intensity, and coverage.

Defining SF

SF is a polishing process that removes surface roughness peaks due to a relative movement between the workpiece and an abrasive media in a vibrating barrel (bowls or tubes). The reduction in roughness depends on the initial roughness and processing time.

SF can be subdivided into mechanically and chemically accelerated processes.

Combined Effect of SP + SF (IGS)

SP can be detrimental to surface durability due to an increase in surface roughness. It may therefore be required to refinish the tooth flanks to achieve the specified surface finish and texture, as stated in ISO 6336-5 (Ref. 1).

Post-SP processes are allowed, but, in general, can alter the residual compressive stress obtained by SP.

SF reduces the surface roughness without significantly changing the residual stress state below the surface because of the small amount of material removed. Therefore, SF allows preservation of the compressive residual stresses induced by an SP process and improves flank surface roughness requirements.

Case Study Measurements and Results

An estimation of the torque density increase using SP followed by an SF process is studied in this paper based on surface and residual stress measurements for a multimegawatt case-carburized planet wheel gear of material 18CrNiMo7-6 with material

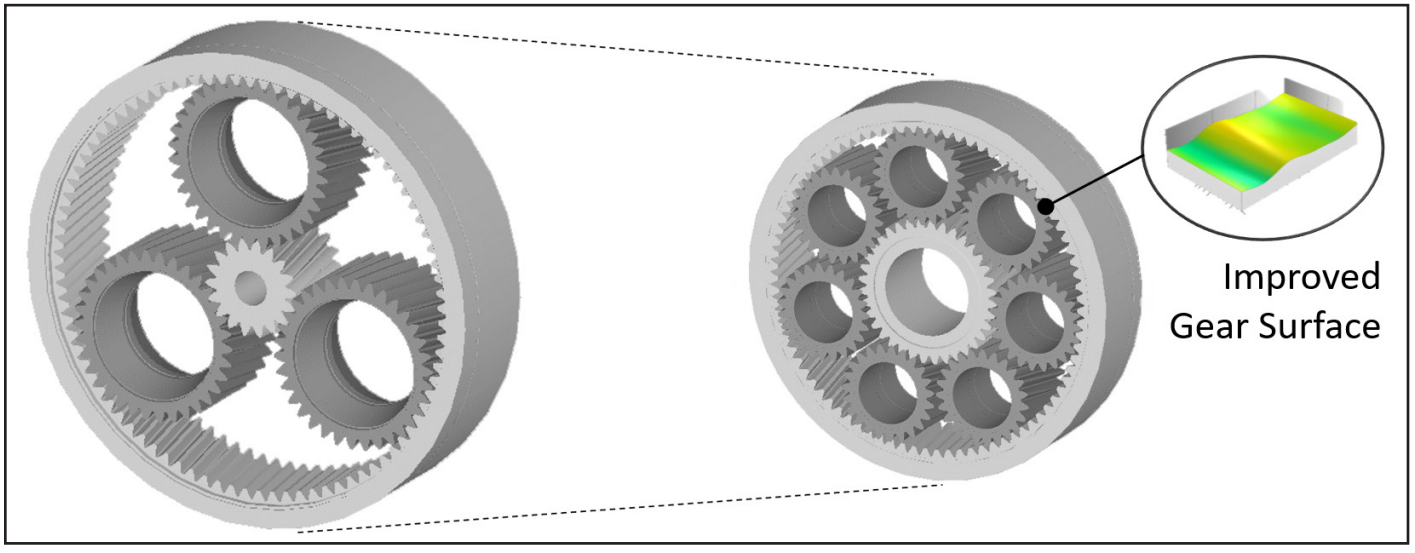


Figure 1 Gearbox torque density increase.

quality grade MQ-a according to ISO 6336-5 (Ref. 1) and gear module m_n=20.5 mm.

For these investigations, a standard ground finished planet gear wheel was divided into three sectors. Different surface conditions were then applied to compare the expected results regarding bending and pitting (contact) fatigue strength in a case study (Fig. 2).

Sector 1 is the reference part, with standard flank grinding as the finish condition. The tooth root is unground, and the shot blasting intensity has been deliberately increased to show its influence. The amount of retained austenite is slightly above the standard to show an SP effect.

Sector 2 followed a standard SP process (S330H/0.45 mmA/100% coverage) on the flank and root (Fig. 3).

Sector 3 follows a double SP process with modified intensity and coverage parameters. Afterward, a chemically accelerated superfinish process was applied to achieve an Rz flank value below 1 µm (Fig. 4).

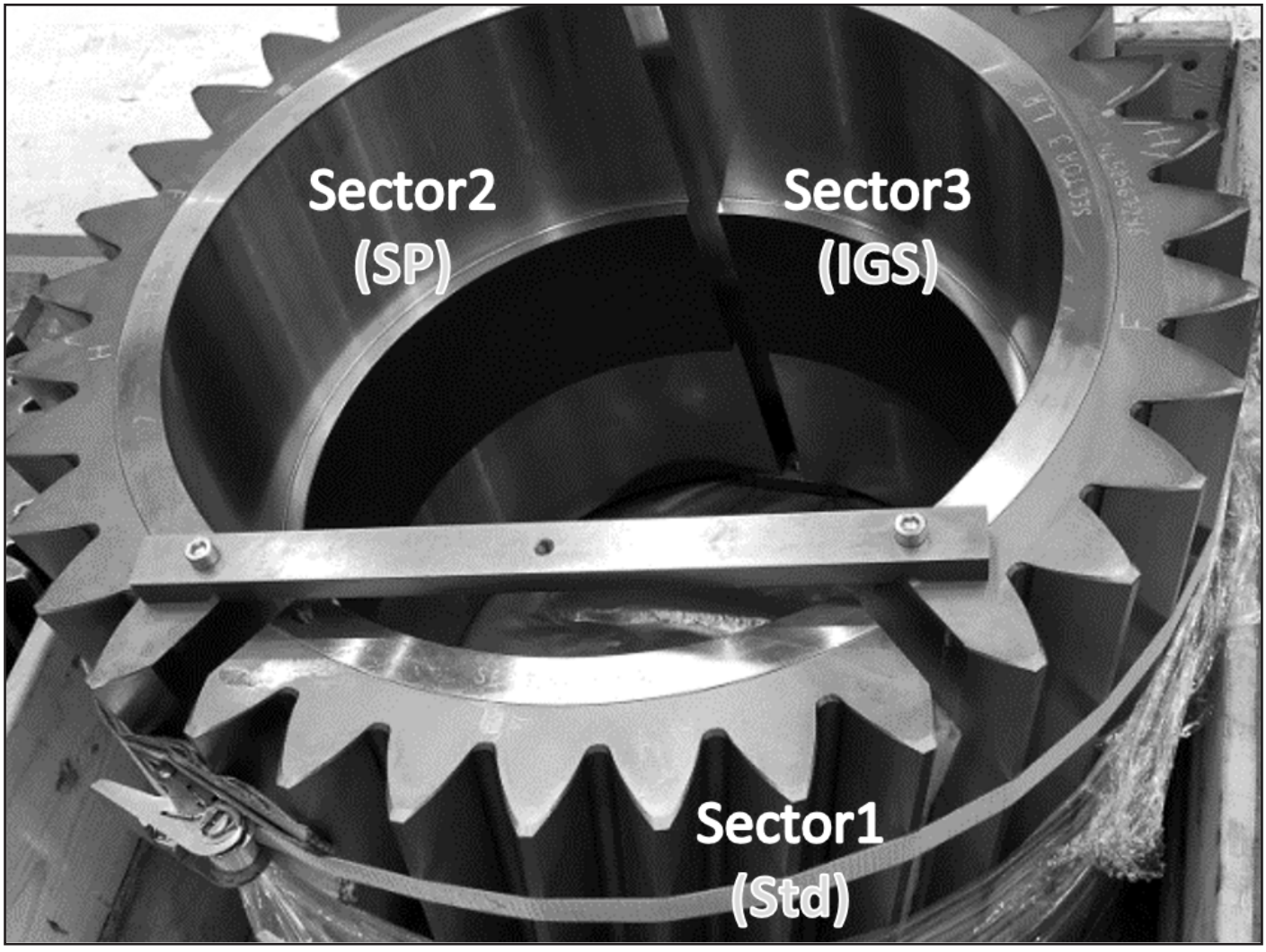


Figure 2 In the case study, a gear was divided in three sectors, and each sector received a different surface finishing process.

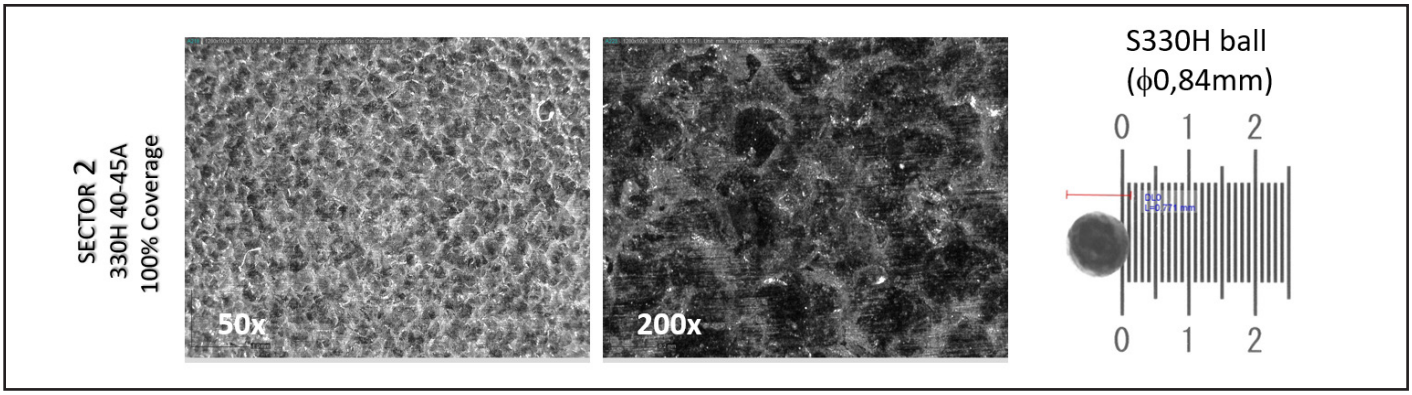


Figure 3 Almen strip Sector 2.

Figure 4 Chemically accelerated process applied on Sector 3.

Roughness was measured in three sectors, according to ISO-4288 (Ref. 6) over the three parts in the root and flank areas using three different profilometers (173 measurements).

To better understand the surface topography, an optical calibrated profiler based on confocal and interferometry techniques was also used over gear replicas (Fig. 6). A good correlation between both techniques was obtained, aligned with other reported experiences (Ref. 34).

This optical technique is an easy way to contrast root roughness measurements in areas and directions where standard profilometers cannot reach.

Optical measurements (Figs. 7, 8) clearly show that SP effectively changes topography and removes grinding marks, as observed in other papers (Ref. 31). The SF process in Sector 3 creates an isotropic surface condition.

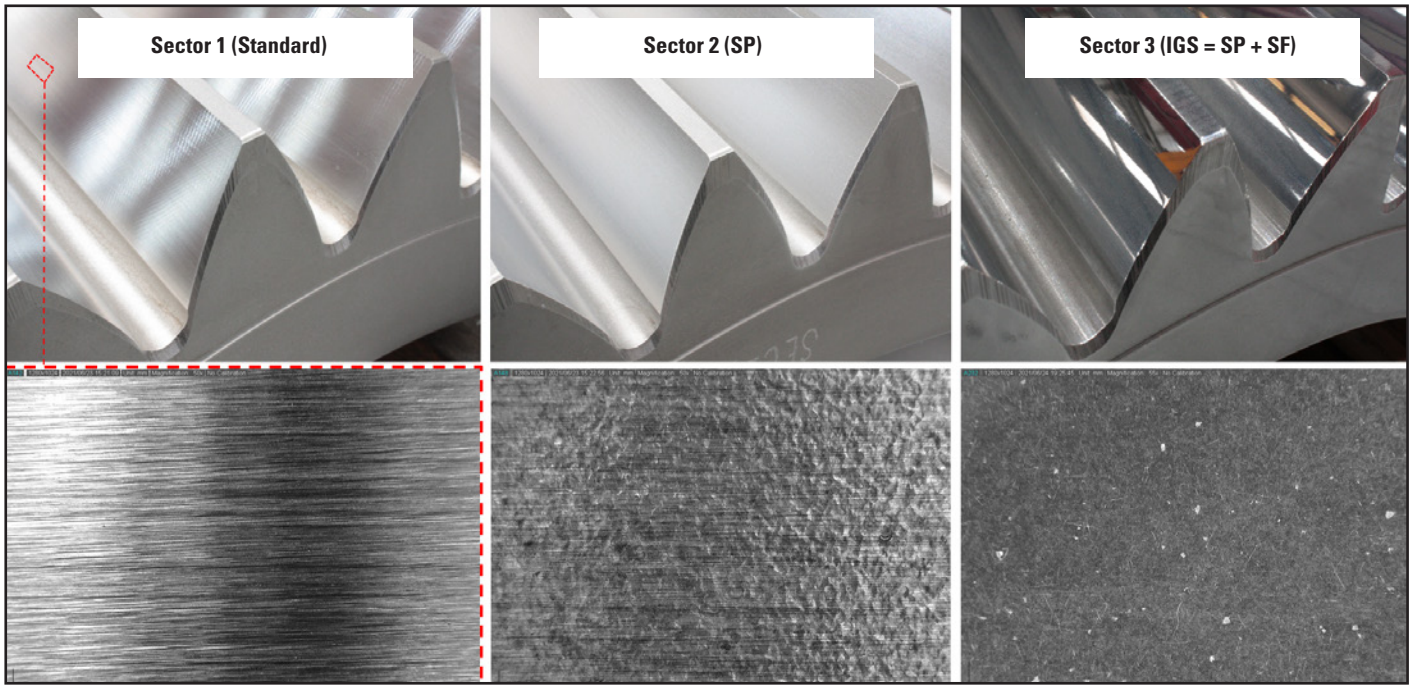


Figure 5 Microscope 50X flank surface images comparison, Sectors 1–3.

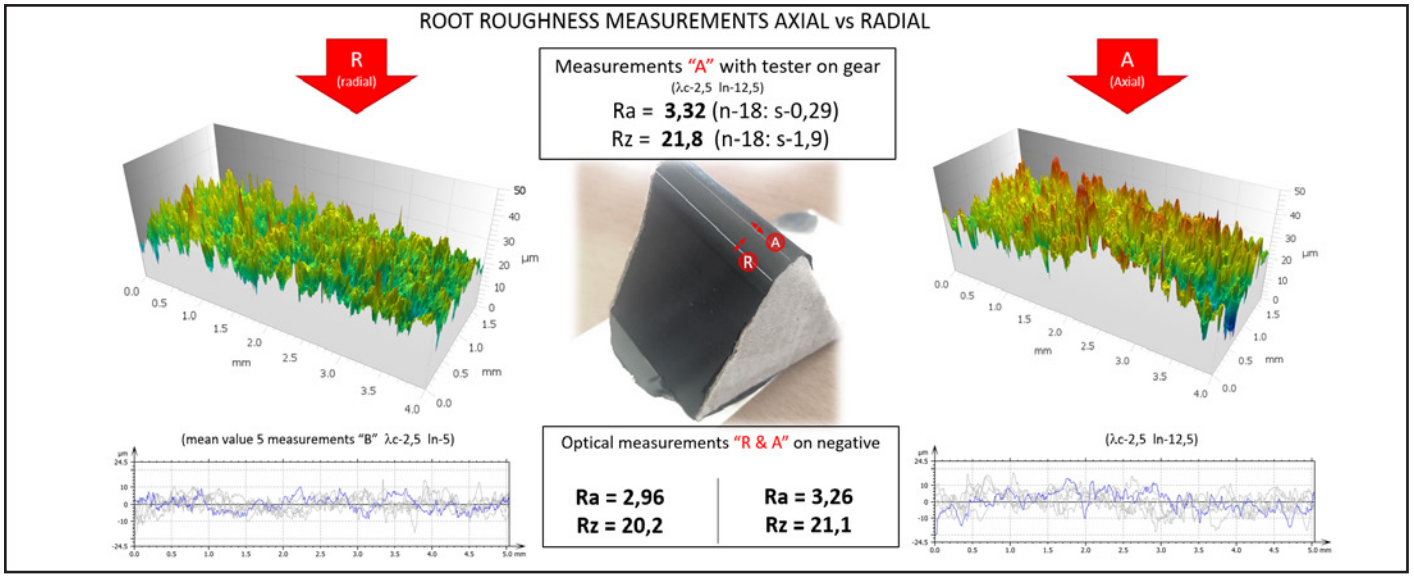


Figure 6 Gear replicas for optical roughness measurements.

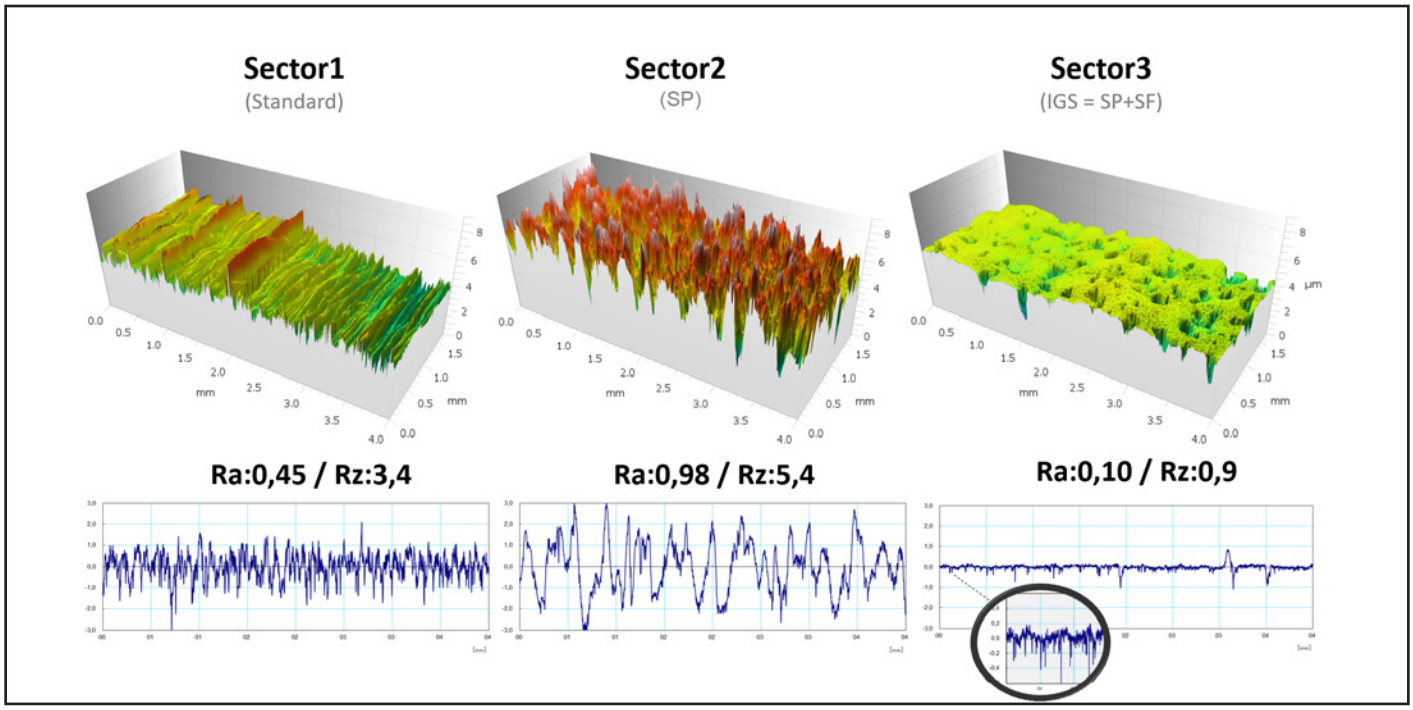


Figure 7 Gear flank roughness, Sectors 1–3.

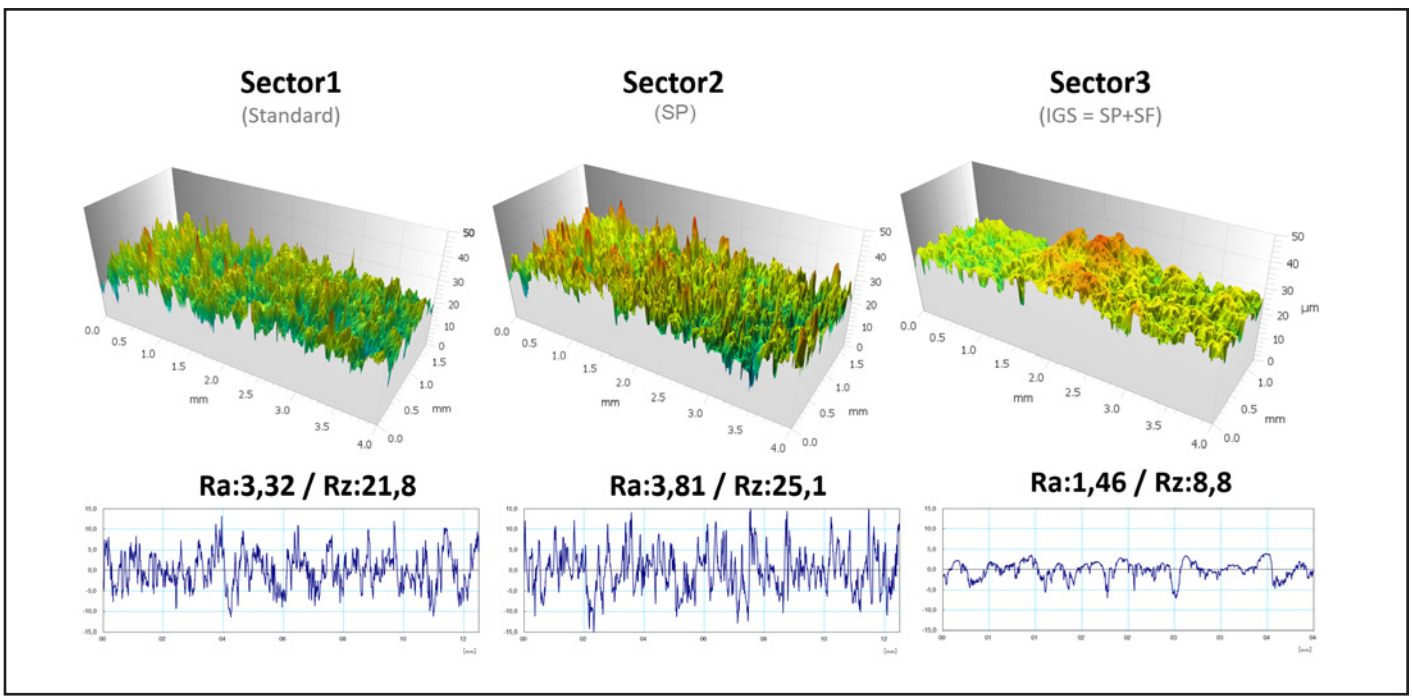


Figure 8 Gear root roughness, Sectors 1–3.

Mean results are summarized in Figure 9 and compared to part drawing specifications.

The Sector 1 flank is aligned with specification, while the root is rougher than the standard due to an intense shot blasting process.

Sector 2 is aligned with the SP expected flank influence, with an increase in Rz of 59% vs. Sector 1. Root roughness is almost not modified compared to Sector 1 due to the previously mentioned intense blasting.

Sector 3 superfinish corrects and improves the prior SP process, achieving Rz values at the flank surface less than 1 µm. SF reduces the peaks of this rough condition in Sector 3 root, but only in a limited way.

Residual stress measurements, retained austenite quantification and hardness measurements were also performed over the three sectors. The results are summarized in Figure 10.

Retained austenite evaluation was performed according to ASTM E 975-13 (Ref. 7). The X-ray energy-dispersive diffraction method was used, with a continuous spectrum of the tungsten anode, linked to elaborated software that rebuilt the theoretical diffraction patterns of any mixture. This technique allows 15 reflections of the ∝ phase (martensite) and 18 reflections of

Gear Root

	Rz	Ra
Sector1	21,8	3,32
Sector2	25,1	3,81
Sector3	8,8	1,46

Gear Flank

	Rz	Ra
Sector1	3,4	0,45
Sector2	5,4	0,98
Sector3	0,9	0,10

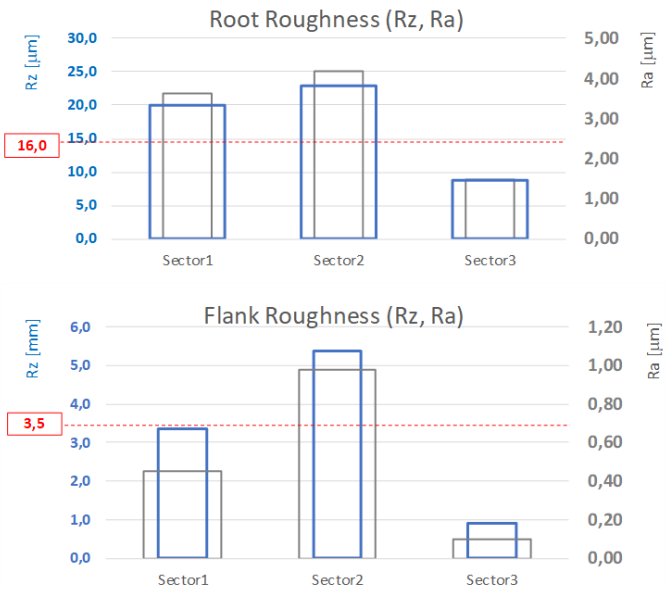


Figure 9 Roughness Ra and Rz results for Sectors.

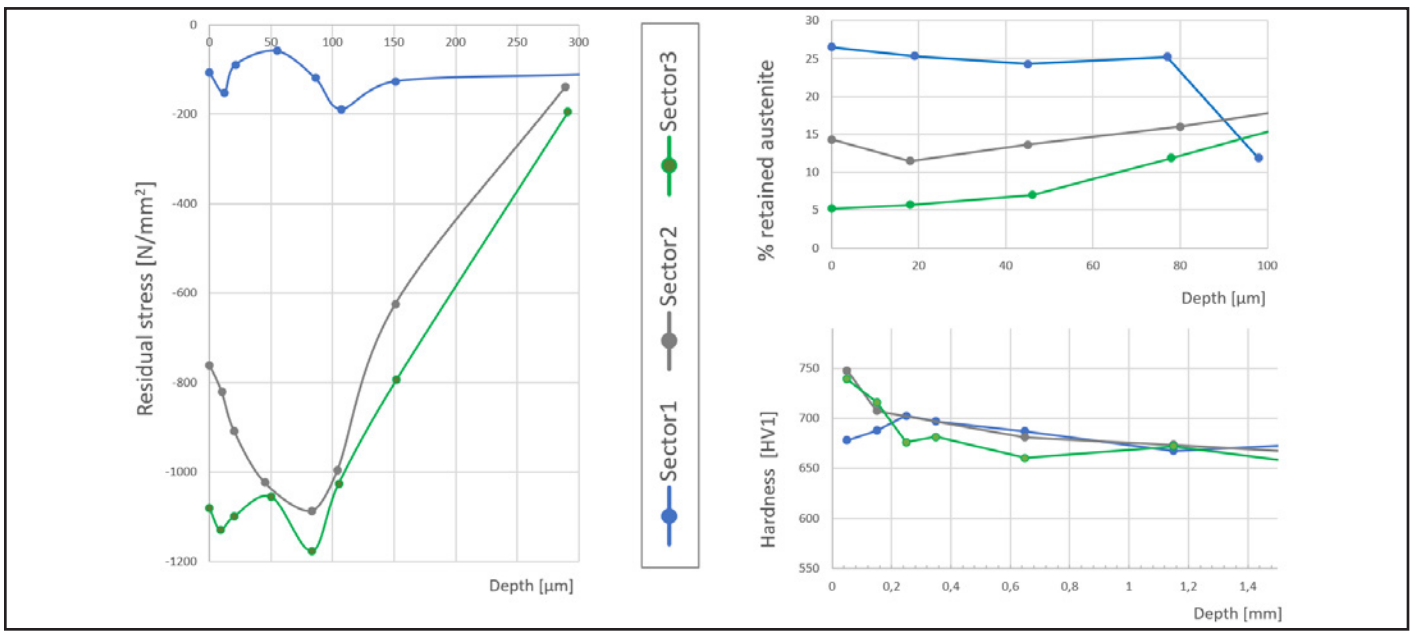


Figure 10 Residual stresses (axial direction), retained austenite and hardness [HV1] over gear sectors in the flank region.

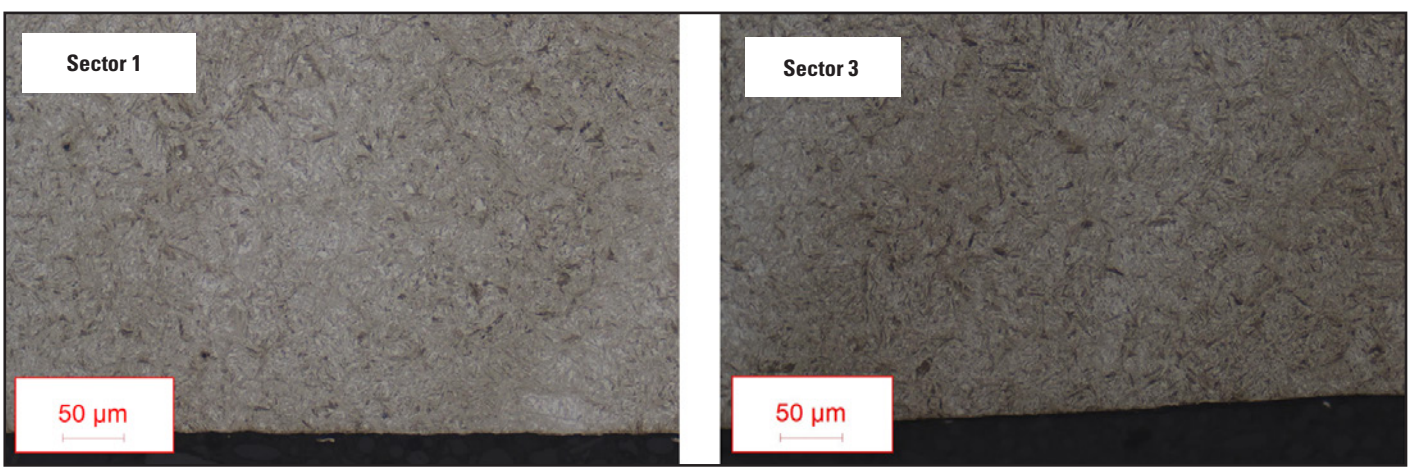


Figure 11 Micrograph comparison between Sector 1 and Sector 3 (same etching).

the γ phase (austenite) in the energetic field of 12 keV to 40 keV for an angular value fixed at θ=18.25°. Material removal was done by chemical attack.

Residual stress analysis was carried out by X-ray diffraction following the EN 15305 standard test method (Ref. 8). Metal removal was performed by electrochemical polishing, and the depth was controlled by a profilometer.

A hardness Vickers profile was carried out according to NF EN ISO 6507-1 (Ref. 9) on a cross-section of the tooth flank.

The results are aligned with expectations based on previously referred investigations.

The residual stress in Sector 1 is based on the heat treatment process and is affected by gear flank grinding and the high percentage of retained austenite in this part.

Sector 2 SP results are aligned with AGMA 938 (Ref. 2) and Stenico (Ref. 21) results for 18CrNiMo7-6 material, both in maximum value and penetration.

The Sector 3 results show an improvement in the maximum value and penetration depth compared with Sector 2 because of applying a double SP process with higher intensity and coverage in the first phase process, followed by a fine particle second process that increased the surface values.

Retained austenite is transformed into martensite due to SP in Sectors 2 and 3. The percentage of transformation is affected by SP intensity. A comparison of the micrographs of Sector 1 and Sector 3 (Fig. 11) clearly shows retained austenite transformation in Sector 3 near the surface due to SP.

Figure 12 shows bending and pitting fatigue safety margins of Sectors 1–3 compared to drawing specifications, calculated following ISO 6336 standard Method B (in blue).

An assessment of expected results is also done based on references ("Empirical" in Fig. 12).

According to ISO 6336, by applying IGS, an improvement of 1.14 and 1.11 in bending and pitting safety, respectively, should be expected compared to standard conditions (root fillet blasted, not ground; tooth flank ground).

Based on experimental investigations, additional improvement should be expected above 1.2 for pitting and bending fatigue.

Bending fatigue improvement has a potential scatter conditioned mainly on material cleanliness. Since wind power standards are quite exigent on this topic, a maximum value of 590 N/mm² for $\sigma_{F\ Lim}$ is considered feasible (Ref. 38). Additional bending improvement has been referred to using an optimized SP process, but the size effect and subsurface high cycle failures are recommended to be conservative. A closer approach to a real bending safety margin increase seems only possible following high cycle endurance tests on gears that are as close as possible to real size and cleanliness conditions.

Pitting improvement was calculated using Koenig et al. (Ref. 26) formulae to include the IGS effect.

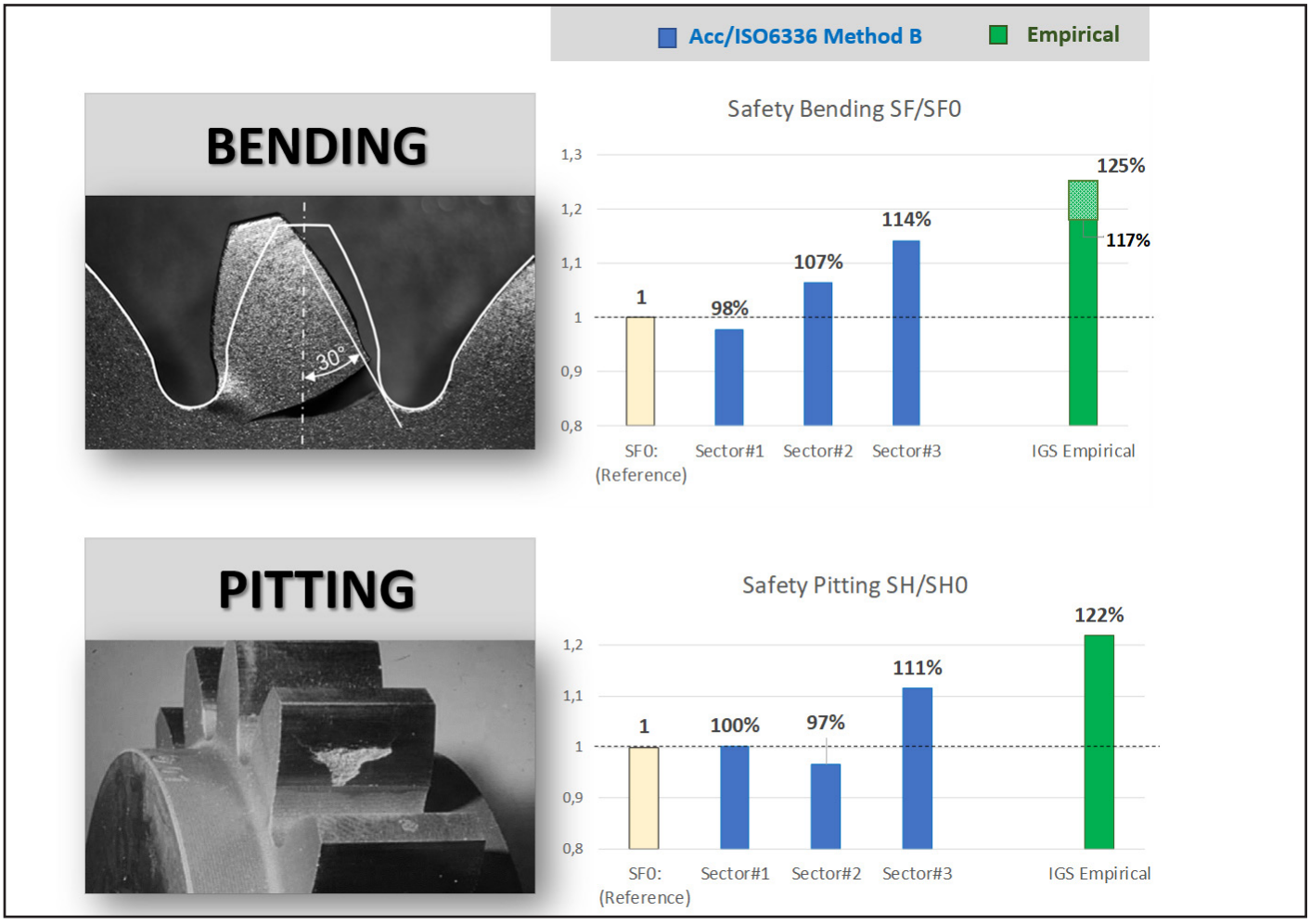


Figure 12 Bending and pitting fatigue safety margins compared to standard.

IGS benefits on micropitting, scuffing, wear and gearbox efficiency are not calculated here but should be considered as an additional benefit of this process.

Conclusions

The increased demand for wind power transmissions and mass reduction to improve LCOE leads to gear designs close to their load-carrying capacity limits. A good option to increase gear torque density is SP followed by SF.

To date, the calculation methods according to ISO 6336 Method B (Ref. 2) are based on investigations with conventionally ground gears and are mainly based on mn=5 mm studies. Gears with increased compressive residual stresses via SP and shallow surface roughness due to SF are not yet considered, or adequately considered, in the standard.

A case study for a wind gearbox planet wheel m_n=20.5 mm is analyzed. The measured results are aligned with other experimental studies, and based on those references, potential increases of safety margins above 1.2 both for pitting and bending strength have been assessed.

The bending strength numbers of ISO 6336 are conservative but valid due to subsurface high cycle fatigue failures and should only be increased if experimental investigations preclude such subsurface failures.

High cycle fatigue testing of gear samples that are as close as possible to wind gear parts, following Method B (Ref. 1), would be needed to confirm and certify such predictions.

Other IGS benefits, such as micropitting, scuffing and wear risk reduction, and gearbox efficiency, should also be considered and confirmed by testing on gear parts as close as possible to wind gear modules.

References:

1. ISO 6336, International Standard: *Calculation of Load Capacity of Spur and Helical Gears*. Part 2: 2019, Part 3: 2006 and Part 5: 2016.
2. AGMA 938-A05, American Gear Manufacturers Association Information Sheet: *Shot Peening of Gears*, 2005.
3. SAE AMS 2430U, *Shot Peening*, 2018.
4. SAE AMS 2432D, *Shot Peening, Computer Monitored*, 2013.
5. J2441_201506, *Shot Peening*, 2015.
6. ISO 4288, *Geometrical Product Specifications (GPS) – Surface Texture*, 1996.
7. ASTM E 975-13, *Standard Practice for X-Ray Determination of Retained Austenite in Steel with Near Random Crystallographic Orientation*, 2013.
8. EN 15305, *Test method for residual stress analysis by X-ray diffraction*, 2009.
9. ISO 6507-1, *Metallic materials — Vickers hardness test —Part 1*: Test method, 2018.
10. Inoue, Katsumi, T. Maehara, M. Yamanaka, M. Kato. "Effect of Shot Peening on the Bending Strength of Carburized Gear Teeth" (1989). *JSME International Journal*. DOI: 10.1299/JSMEC1988.32.449.
11. Lawerenz, M. and I. Ekis. "Guidelines for Establishing an Optimum Shot Peening Specification for Gearing" (1989). *SAE Technical Papers*. DOI: 10.4271/891934.
12. Townsend, Dennis P. "Improvement in Surface Fatigue Life of Hardened Gears by High-Intensity Shot Peening" (1992). American Society of Mechanical Engineers, Design Engineering Division.
13. Krantz, T.L., M.P. Alanou, H.P. Evans and R.W. Snidle. "Surface Fatigue Lives of Case-Carburized Gears with an Improved Surface Finish" (2001). *Journal of Tribology*. DOI: 10.1115/1.1387037.
14. Winkelmann, L., M. Michaud, G. Sroka, and A.A. Swiglo. "Impact of Isotropic Superfinishing on Contact and Bending Fatigue of Carburized Steel" (2002). *SAE Technical Papers*. DOI: 10.4271/2002-01-1392.
15. Winkelmann, L., E.-S. Omer and M. Bell. "The Effect of Superfinishing on Gear Micropitting, Part II" (2008). American Gear Manufacturers Association Fall Technical Meeting 2008.
16. Benedetti, M., V. Fontanari, V., B.-R. Höhn, P. Oster, T. Tobie. "Influence of Shot Peening on Bending Tooth Fatigue Limit of Case-Hardened Gears" (2002). *International Journal of Fatigue*. DOI: 10.1016/S0142-1123(02)00034-9.
17. Abudaia, F.B., J.T. Evans, and B.A. Shaw. "Characterization of Retained Austenite in Case Carburized Gears and its Influence on Fatigue Performance" (2003). *Gear Technology*, May/June 2003.
18. Shaw, B.A., C. Aylott, P. O'Hara, K. Brimble, K. "The Role of Residual Stress on the Fatigue Strength of High Performance Gearing" (2003). *International Journal of Fatigue*. DOI: 10.1016/j.ijfatigue.2003.08.015.
19. Herring, D.H. "A Discussion of Retained Austenite" (2005). *Industrial Heating*, March 2005.
20. Saoki Masumura, Naoji Hamasaka. "High Strength and Compactness of Gears by WHSP (Double Hard Shot Peening) Technology" (2006). Technical Paper, Komatsu Technical report.
21. Stenico, A. "Werkstoffmechanische Untersuchungen zur Zahnfußtragfähigkeit einsatzgehärteter Zahnräder" [Eng.: "Material-mechanical investigations of the tooth root load carrying capacity of case-hardened gears"] (2007). Dissertation, Technical University of Munich.
22. Masatoshi Yoshizaki. "Improvement in Tooth Surface Strength of Carburized Transmission Gears by Fine Particle Bombarding Process" (2007). *Transactions of the Japan Society of Mechanical Engineers*, Series C 73. DOI: 10.1299/kikaic.73.1924.
23. Koller, P. Optimierung Flankentragfähigkeit, Forschungsvorhaben (2010). Project Nr. 521 I (IGF-Nr. 14908 N). *FVA-magazine* Nr. 957, Frankfurt am Main.
24. Bretl, N., S. Schurer, T. Tobie, K. Stahl, B.-R. Höhn. "Investigations on Tooth Root Bending Strength of Case-Hardened Gears in the Range of High Cycle Fatigue" (2013). American Gear Manufacturers Association Fall Technical Meeting 2013.
25. Rao, S., A. Isaacson, G. Sroka, L. Winkelmann. "The Impact of Surface Condition and Lubricant on Gear Tooth Friction" (2014). American Gear Manufacturers Association Fall Technical Meeting 2014.
26. Koenig, J., P. Koller, T. Tobie, K. Stahl. "Correlation of Relevant Case Properties and the Flank Load Carrying Capacity of Case-Hardened Gears" (2015). *Proceedings of the ASME Design Engineering Technical Conference*. DOI: 10.1115/DETC201546300.
27. Güntner, C., T. Tobie, K. Stahl. "Influences of the Residual Condition on the Load Carrying Capacity of Case Hardened Gears" (2017). American Gear Manufacturers Association Fall Technical Meeting 2017.
28. Koenig, J., P. Koller, T. Tobie, K. Stah. "Influence of Additional Surface Finishing to the Material Properties and the Flank Load Carrying Capacity of Case-Hardened Gears with Grinding Burn" (2017). *Journal of Advanced Mechanical Design, Systems and Manufacturing*. DOI: 10.1299/jamdsm.2017jamdsm0075.
29. König, J., T. Tobie and K. Stahl. "Optimized Flank Load Carrying Capacity II, Load Capacity of Shot Peened and Superfinished Gear Flanks Under Considerations of the Case Properties and the Lubrication Condition" (2017, in German). Project Nr. 521 II (AiF-Nr. 17145), *FVA-magazine* Nr. 1245, Frankfurt am Main.
30. Güntner, C., T. Tobie, K. Stahl. "Alternative Microstructures and Their Influence on Mechanical Properties of Case-Hardened Gears" (2017). *Forschung im Ingenieurwesen/Engineering Research*. DOI: 10.1007/s10010-017-0222-5.
31. Nordin, E., B. Alfredsson. "Experimental Investigation of Shot Peening on Case Hardened SS2506 Gear Steel" (2017). *Experimental Techniques*, 41 (4). DOI: 10.1007/s40799-017-0183-5.
32. Meis, J.-A. "Flank Fracture Assessment Under Consideration of Material Quality" (2017). *VDI Berichte*, 2017 (2294), pp. 1294-1307.
33. Ghribi, D., C. Peyrac, M. Octrue. "Shot Peening of Gear Tooth Flanks: Search for an Optimal Surface Topography Against the Micropitting" (2017). *VDI Berichte*, 2017 (2294), pp. 1530-1539.
34. Wagner, M., A. Isaacson, M. Michaud, M. Bell. "A Comparison of Surface Roughness Measurement Methods for Gear Tooth Working Surfaces" (2019). AGMA Fall Technical Meeting 2019.
35. Fuchs, D., S. Schurer, T. Tobie, K. Stahl. "Investigations into Non-Metallic Inclusion Crack Area Characteristics Relevant for Tooth Root Fracture Damages of Case Carburised and Shot-Peened High Strength Gears of Different Sizes Made of High-Quality Steels" ["Untersuchungen zu Rissflächencharakteristiken nicht-metallischer Einschlüsse maßgeblich für Zahnfußbrüche von einsatzgehärteten und kugelgestrahlten hochtragfähigen Zahnrädern unterschiedlicher Größe aus hochreinen Stählen"] (2019). *Forschung im Ingenieurwesen/Engineering Research*. DOI: 10.1007/s10010-019-00324-x.
36. Winkler, K.J., C. Güntner, T. Tobie, K. Stahl, S. Schurer. "Material Properties and Tooth Root Bending Strength of Shot Blasted, Case Carburized Gears with Alternative Microstructures" (2019). American Gear Manufacturers Association Fall Technical Meeting 2019.

37. Kratzer, D., F. Dobler, T. Tobie, T. Hoja, M. Steinbacher, K. Stahl. "Effects of Low-Temperature Treatments on Surface Hardness, Retained Austenite Content, Residual Stress Condition and the Resulting Tooth Root Bending Strength of Case-Hardened 18CrNiMo7-6 Gears" (2019). *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*. DOI: 10.1177/0954406219846160.
38. Winkler, K.J., S. Schurer, T. Tobie, K. Stahl. "Investigations on the Tooth Root Bending Strength and the Fatigue Fracture Characteristics of Case-Carburized and Shot-Peened Gears of Different Sizes" (2019). *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*. DOI: 10.1177/0954406219841650.
39. J. Hoffmeister, J. Hermes. "Optimized Tooth Root Strength by Controlled Shot Peening" (2019). International Conference on Gears 2019. DOI: 10.51202/9783181023556-138.
40. Kratzer, D., J. Konig, T. Tobie, K. Stahl. "Effects of Different Shot Peening Treatments in Combination with a Superfinishing Process on the Surface Durability of Case-Hardened Gears" (2020). American Gear Manufacturers Association Fall Technical Meeting 2020.
41. Meis, Jean-Andre. "A Finite Element Based Assessment Concept for the Tooth Root Strength of Gears in Wind Turbines" (2021). CWD 2021.
42. ISO 4287:1997, *Geometrical Product Specification (GPS) – Surface Texture* (1997).

For Related Articles Search
superfinishing
at www.geartechnology.com

Ing. Ruben Carranza Fernandez is developer and head of wind gearbox refurbishment business at Gamesa. He has worked in the quality, manufacturing and engineering departments of the gearbox unit over the last 20 years. Since 2008 he has also been manager of the Siemens Gamesa wind gearbox repair center in Spain.

Dr.-Ing. Thomas Tobie is head of the department "Load Carrying Capacity of Cylindrical Gears" at the Gear Research Center (FZG), Technical University of Munich. He is specialized in the fields of gear materials, heat treatment, gear lubricants, gear strength and gear testing with focus on all relevant gear failure modes like tooth root fracture, pitting, micro-pitting, scuffing and wear as well as subsurface initiated fatigue failures. Dr. Tobie is an active member of several national and international working groups of DIN, ISO, IEC and CEC and author of numerous papers in scientific journals and at conferences.

Investigation of Gear Surface Topography and Deviations in Gear Skiving Through Advanced CAD Modeling–Based Simulation

Nikolaos Tapoglou

Introduction

Manufacturing high-precision gears has been a key requirement in the automotive, aerospace and wind turbine industries. The volume of gears manufactured is ever-increasing and is expected to reach new limits owing to the drive towards electrification and sustainability. In the aerospace industry, a series of target key performance indicators (KPIs) need to be reached if industry is to meet its sustainability goals (Refs. 1–2). Based on goals set down by the Aerospace Technology Institute that includes the reduction of noise and emissions levels by up to 65% and 90% respectively. The use of high-efficiency gearboxes is crucial for reaching these targets. Looking at the manufacturing processes involved in machining such gears, gear hobbing and gear skiving are the prime candidates for achieving both the throughput and the quality required for such applications. Gear skiving in particular has been in the spotlight of research in this sector owing to the reduced cycle time and the capability to process internal and external gears. The history of the process is well documented and starts in the 18th century (Ref. 3) and is followed by a considerable hiatus during which the advances in machine tool manufacturing made the realization of the process on an industrial scale possible. In recent years, industrial and academic research programs have been focusing on gear skiving processes, including modeling, theoretical and experimental approaches in the study and optimization of this manufacturing process. The research presented in this paper extends the work done on CAD-based simulation approaches with an investigation of the surface topography of gears produced through gear skiving and the investigation of the cutting tool characteristics on the geometry of the produced gear. The study is complemented with the investigation of the cutting forces required in the machining process.

State of the Art

Traditionally, the understanding and optimization of manufacturing processes have been realized with extensive experimental campaigns which result in high operational costs and downtime of manufacturing equipment. Recently, simulation models and digital twins of manufacturing processes are used to increase the understanding of the cutting process and support the decision-making and the selection of the optimal process parameters. Simulation models increase the understanding of a machining process without the cost associated with machining trials. Models can be categorized based on the scale (macro, meso, and micro level) and the method used in the simulation of the process. Finite element, analytical and numerical models have been presented by researchers to investigate the cutting forces, surface quality, and microstructure of the simulated manufacturing process (Refs. 4–8). A review of the dominant simulation approaches used in this domain has been presented by Altintas et al. (Ref. 4) outlining the advantages of each method.

Like more traditional processes, in gear manufacturing a series of models have been developed in order to optimize the cutting processes and predict the developed cutting forces and the gear topography (Refs. 9–15). Since most the gear manufacturing processes have a complex kinematic chain, the simulation models can be a crucial tool in the optimization of the cutting processes in a cost-effective fashion as the results of the cutting process are influenced by a series of parameters. Looking in gear skiving, analytical, experimental, and CAD-based models have been developed to understand the development of cutting forces, the chip geometry and to a lesser extent the quality of the final gear (Refs. 16–17).

The research group of Guo et al. (Refs. 18–21) investigated the cutting mechanism of gear skiving using mathematical modelling with an emphasis on the effect of pose errors on the final gear quality and the design of the tool geometry. The design of cutting tools profiles for machining gears through gear skiving and the design of the machining method on six axis machine tools was the focus of Tsai (Refs. 22–23).

The development of dexel-based models is another contemporary research theme, where researchers have modeled the process using double or triple dexel-based models to predict the gear geometry and the cutting forces of the process (Refs. 24–25). The use of mathematically based models embedded in software has been also presented by Kang et al. (Ref. 26) who presented such a model and embedded the kinematics in Vericut to extract information on the gear characteristics. The work of Jansen (Ref. 27) focused on increasing performance and improving the accuracy of internal gears manufactured through gear skiving. Part of the work he performed also looked at the calculation and measurement of cutting forces.

The remainder of the paper is organized as follows: "Gear Skiving" presents the kinematics of the gear skiving process. The simulative approach developed is presented in "Simulation Model," along with details of the cutting force calculation algorithm. "Simulation Validation" describes the results obtained by the model and the validation of the results with experimental ones. "Investigation of Gear Profile Surface Topography" presents the investigation of the topography characteristics of a skived gear. Finally, "Conclusions" contains summary and ending remarks.

Gear Skiving

The complex kinematics of gear skiving allows for the increased processing speed that it can offer due to the continuous generating nature of the process. The main process of kinematics is presented in Figure 1. The tool is traditionally positioned at an inclined position with respect to the axis of the gear, this inclination provides the cutter with the required cutting speed to machine the gear gap. In the case of external gear, the rotation of the cutting tool is opposite to the one of the work gear whereas for internal gears the rotation of the tool is in the same direction as the one of the work gear. Figure 2 presents the cutting velocities involved in the process, visible in the figure is also the side rake angle which plays a crucial role in the chip formation process. The two rolling velocities of the two gears must be precisely tuned for the cutting tool and the work gear to be in mesh. Due to the inclination angle mentioned above, an additional velocity v_c exists which is the cutting velocity of the process.

The kinematics of the process can be influenced by a series of parameters that in turn affect the geometry of the final work gear, the geometry of the chip, and the final gear quality characteristics. Table 1 summarizes the parameters that can be altered during the process. Taking as an example the side rake angle (τ), an increased side rake angle leads to a different approach of the cutting edge on the machined gear gap and allows for the cutting forces to be directed across the axis of the gear thus promoting the stability of the process. Although the increase of the side rake angle does not alter the chip geometry to a great degree, the approach of the tool leads to a change in the cross-sectional area of the chip.

Simulation Model

An accurate model is a key development that would enable an increased understanding of the cutting process, the cutting forces and the final gear topography and gear quality. The development of a simulation model must take advantage of the latest technology in computational geometries and CAD platforms. As such the developed simulation package, presented in this research, was based on a state-of-the-art CAD package that allows the exploitation of the most up-to-date computer modeling platform. The model developed, named *Skive3D*, is embedded in a CAD environment directing

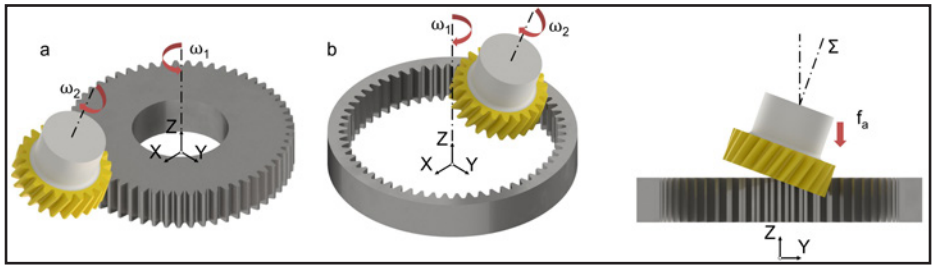


Figure 1 Gear skiving process kinematics for internal (b) and external gears (a).

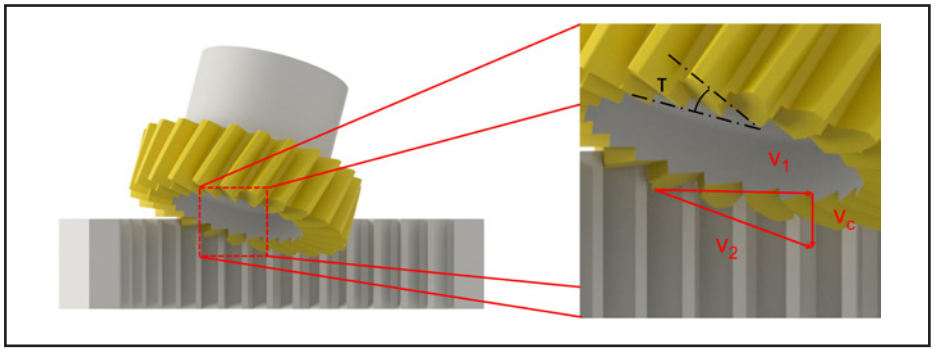


Figure 2 Cutting velocities during gear skiving (v_1 rotation of the work gear, v_2 rotation of the tool, v_c resulting cutting speed).

Table 1 Gear skiving parameters

Cutting Tool	Process Parameters	Work Gear
Helix angle (h_{at})	Cutting speed (v_c)	Helix angle (h_{ag})
Primary rake angle (γ)	Axial feed (f_a)	Pressure angle (α_n)
Side rake angle (τ)	Depth of cut (a_p)	Module (m_n)
Number of teeth (z_t)		Number of teeth (z_g)

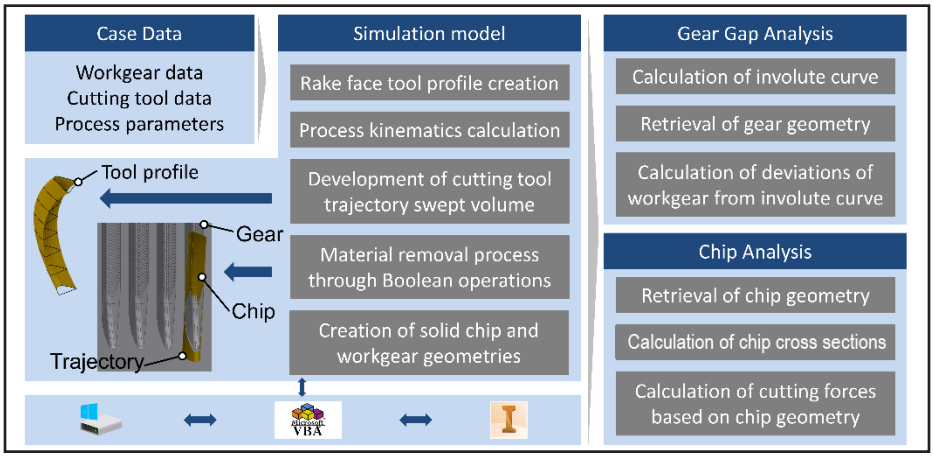


Figure 3 Skive3D flowchart.

commands on the kernel of the software for an increased simulation speed. Figure 3 presents a flow diagram of the information flow of the *Skive3D* model.

As is presented in the figure the initiating step is the input of the simulation data in the simulation model. The data is interpreted by the algorithm which in turn initiates a series of design functions responsible for the creation of the cutting tool profile and the development of a solid model that represents the tool profile trajectory during the cutting motion. Only revolving positions that contribute to the cutting action are created to achieve a lean approach and increase the density of data where they are required. By introducing a series of tool profiles throughout the tooth trajectory, thus ensuring the posture and the shape of the tool, the algorithm can generate high accuracy results. The results of the model are generated through the calculation of the intersection of the toolpath with the respective gear geometry and are stored as 3D solid parts. The results can be further analyzed to extract key data on the cutting process. Analysis of the chip geometry will produce an estimation of the cutting forces during the cutting process whereas the analysis of the flank geometries can provide key data on the resulting gear quality.

In more detail, the cutting force algorithm uses the Kienzle Victor (Ref. 28) equations to estimate the cutting forces from the nondeformed chip geometry characteristics. During the calculations, the ideal tool geometry is considered and any tool wear or defects in the tool geometry are not taken into consideration. As presented in Figure 4, the algorithm of the *Skive3D* model automatically extracts the chip cross-section in all the successive rake face positions. These positions are named revolving positions and are numbered sequentially along the cutting direction. In the top right side of Figure 4, a small subset of these revolving positions is presented. For each one of the cross-sections, it segments the chip geometry in elementary areas in which the Kienzle Victor model can be applied. The resulting forces are subsequently added up and transformed into the relevant coordinate system. For illustration purposes, the cutting force in the Z direction is presented in Figure 4.

The analysis of the flanks is based on the solid geometry of the gear after all the simulation code has been executed. The solid gear geometry includes the machining mark and any form errors due to the cutting tool profile. Systematic misalignment that affects the tool profile, such as run out, tool angle errors or tool wear, can also be included in the model. The algorithm of *Skive3D* can calculate lead and profile deviations. The first step is the creation of the designed involute curve based on the geometrical characteristics of the gear. This curve is used to find the deviations between the ideal and

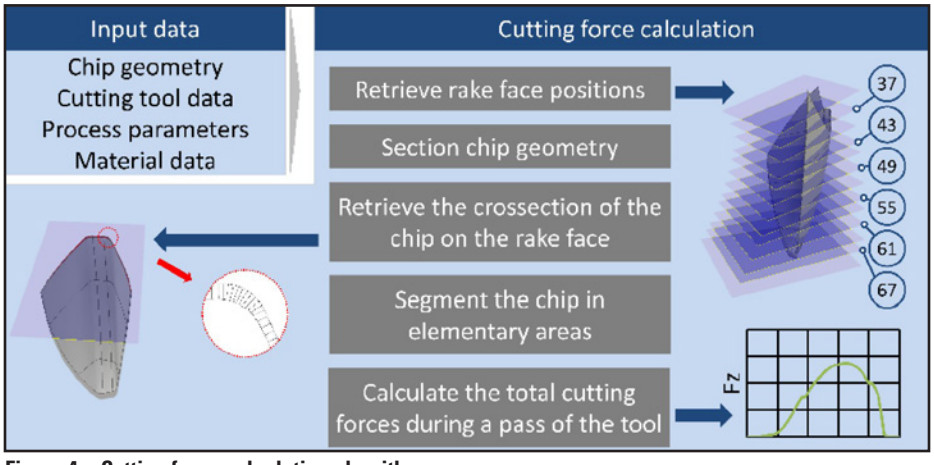


Figure 4 Cutting force calculation algorithm.

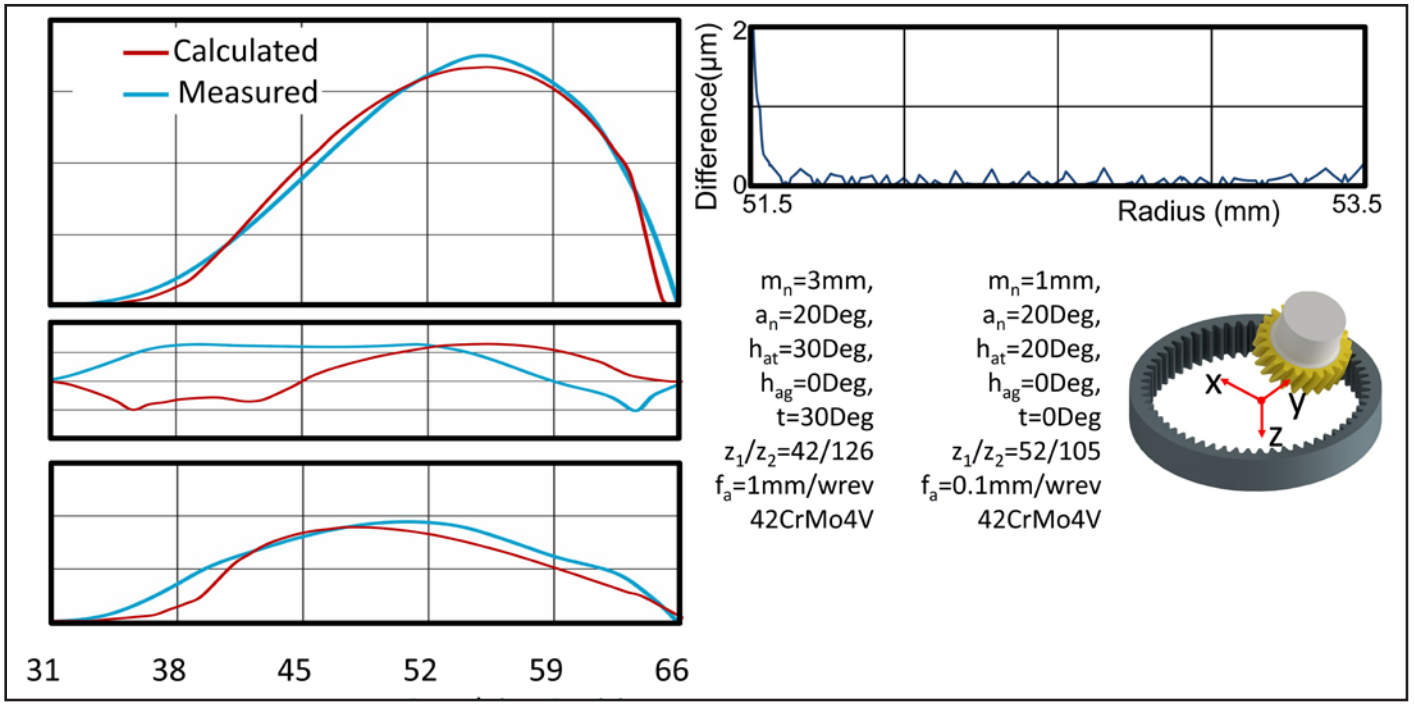


Figure 5 Cutting force (left) and surface topography validation (right).

machined geometry. The curve is also used to calculate the plane on which lead deviations can be measured. The algorithm can extract point cloud data that can be further analyzed to understand the spatial variation of the deviations in a gear.

Simulation Validation

A model validation is a critical step in the development of any simulation algorithm. *Skive3D* has been therefore validated with experimental data through literature for the cutting forces and through analytical relations governing the involute curve in terms of the flank geometries. Figure 5 presents the validation of the simulation results. As can be seen on the left side of the figure the simulation results on the cutting force magnitude closely match the experimental results of Jansen (Ref. 27). The predicted cutting forces show good agreement with the relevant experimental values especially in the Z and Y direction in terms of magnitude and form. In the X direction, there is good agreement in terms of magnitude. As the simulation model is based on the nondeformed chip geometry dynamic phenomena in the cutting process like collisions between chips coming from different flanks, chatter, etc., are not considered in the calculation. The X direction is more prone to such phenomena due to the nature of the cutting process. On the right side of the figure, the simulated flank geometry is compared against the involute curve profile. In the case of the gear profile validation the ideal flank profile, based on the involute curve equations, is generated as a 3D curve and the difference between the curve and the solid geometry produced through *Skive3D* is measured based on the radial direction.

Investigation of Gear Profile Surface Topography

Sections of the gear flank like the one present in Figure 5 provide an understanding of the quality of the gear, however, the spatial variation of that section is not clearly understood. A novel algorithm was introduced in the *Skive3D* model that is responsible for the extraction of data across the length of the gear, therefore giving a spatial image of all the deviations in the resulting gear geometry.

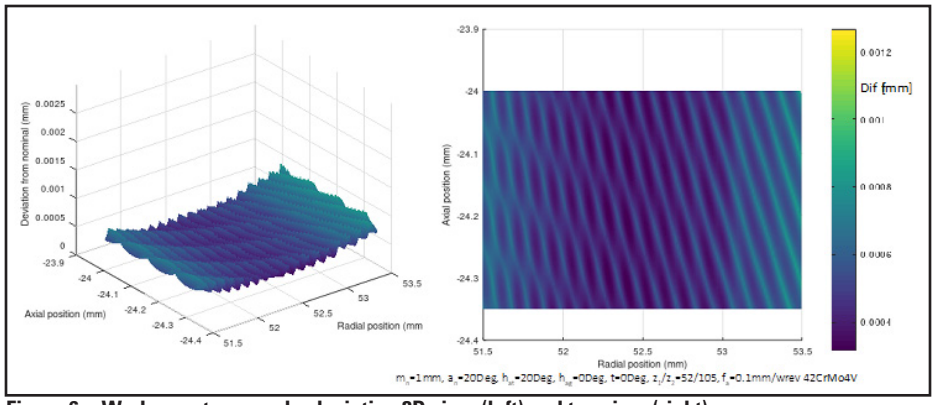


Figure 6 Work gear topography deviation 3D view (left) and top view (right).

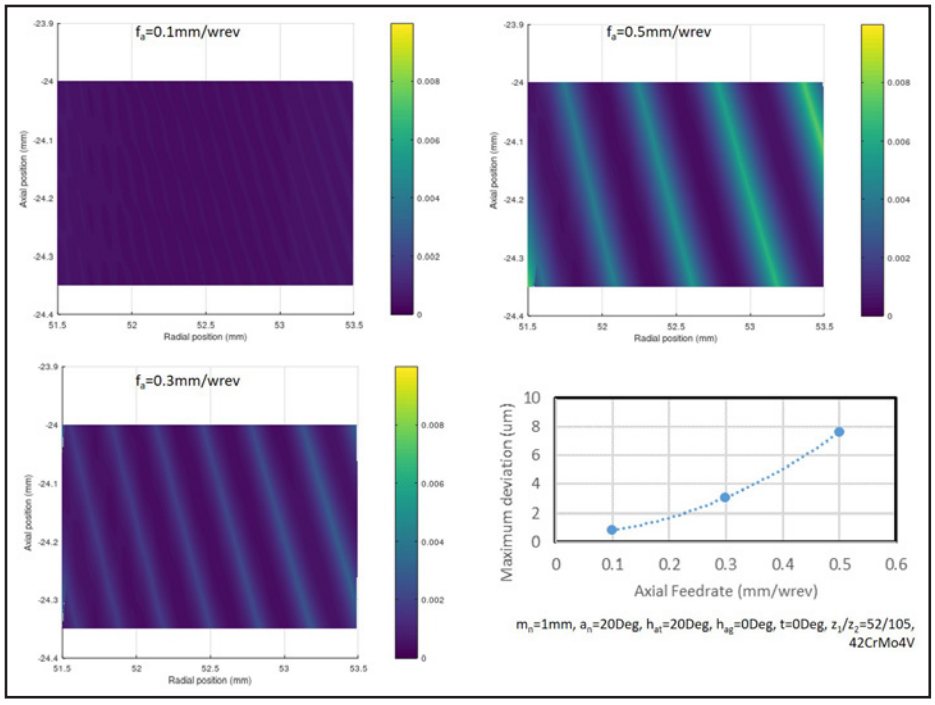


Figure 7 Influence of feed rate (f_a) on the gear topography.

Figure 6 presents the deviation map that is produced from the algorithm. On the left-hand side of the figure, the 3D view of the surface is presented whereas the right side of the figure presents a top view of the deviations of the flank when compared with the ideal involute curve. As it can be easily noticed the simulated surface appears to have a series of feed marks in a periodic fashion that are inclined with respect to the axis of the gear and match the axial feed. The total overall deviation is sub 1 µm which is expected due to the relatively small axial feed rate and module of the gear.

As it can be seen the simulation model is able to predict the feed marks that are generated from the cutting process and can be used to verify the feed rate used in the process. These maps were used to understand the influence of key parameters in the deviations in the topography of the gear. As part of the investigation, two key parameters were investigated, namely the cutting feed rate and the tool inclination angle.

Influence of Feed Rate on Gear Topography

Cutting feed is a deciding factor in terms of the quality of the produced gear and the production time of components. Like other processes, in gear skiving, the increase in feed rate leads to an increase in the maximum deviation of the flank geometries. Figure 7 presents the effect the cutting feed has on the resulting gear topography. As it can be seen the maximum deviation is increased with the increase of feed rate

in a nonlinear manner as fewer tool teeth are passing through the gear gap. It can also be observed that the angle of the feed marks is constant for all three feed rates examined.

Influence of the Inclination Angle on Gear Topography

Another crucial factor in the cutting process is the inclination angle of the tool. As the tool inclination angle is increased, the tool-workpiece contact is extended. Figure 8 presents the effect the inclination angle has on the resulting gear topography. As it can be observed, the result of the increased contact between the tool and the workpiece at higher inclination angles leads to an improvement in the quality of the produced gear. At a higher inclination angle, the feed marks also appear at a steeper angle when compared to lower inclination angles.

Using *Skive3D* a broader investigation of the influence of all the factors that affect the cutting process can be performed. Other parameters of the cutting process including the cutter profile, the number of the teeth of the gear and the tool micro geometry can be investigated to achieve an optimal work gear profile for each application. The direction and magnitude of feed marks can be used to understand their impact on the transmission quality, vibrations, and acoustic emissions during operation.

Conclusions

The research presented in this paper focuses on the study of deviations in gear topography in the gear skiving process. The study was based on the development of surface deviation graphs through a novel simulation software that was developed as part of this research. The CAD-based simulation model was developed using the programming interface of the CAD software and can accurately simulate the cutting process through a solid modeling approach. The results of the model were validated through analytical and experimental data from the literature. The results of the model show that both the feed rate and the inclination angle influence to a large degree the quality of the final surface with the feed rate having a nonlinear effect and influencing the gear quality in a larger effect compared to the inclination angle. The use of simulation models, like the one presented, has the potential to reduce overall costs in the development of manufacturing methods for complex gear forms and lead toward optimized manufacturing processes. The optimization of the cutting process could lead to gears with improved quality characteristics that have lower noise emissions during operation. The research presented extends current research efforts in the modeling of the gear skiving process through accurate CAD-based models. Further expansion of the experimental data to assist with

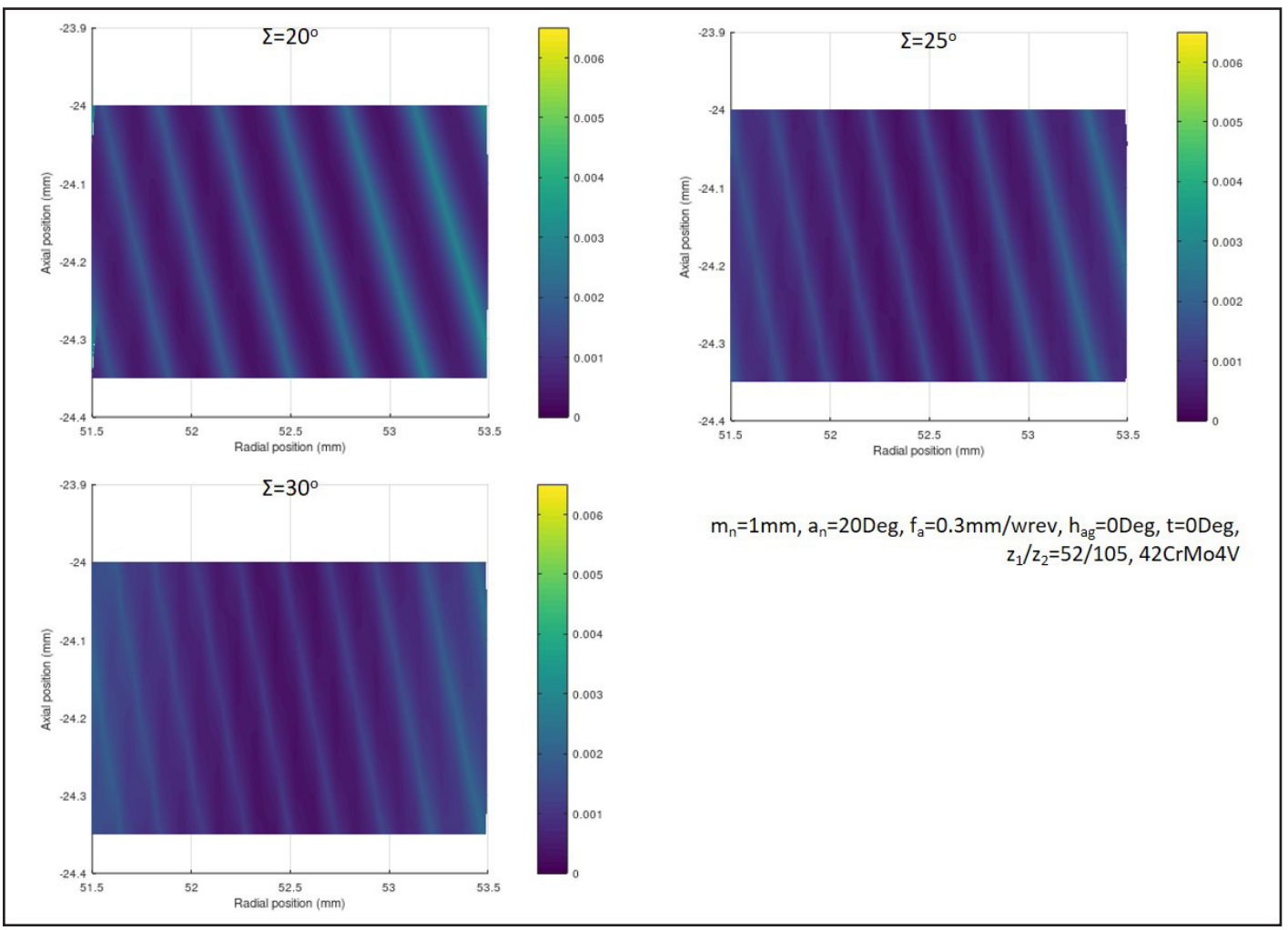


Figure 8 Influence of inclination angle on the gear topography.

further validation of the program, as well as the development of an optimization backbone, are the next steps in the development of the simulation platform. The study of the effect of the tool micro- and mesogeometry on the resulting gear is also a considerable research strand that the work will be expanded on.

References

1. Karpuschewski, B.; Knoche, H.-J.; Hipke, M. Gear finishing by abrasive processes. CIRP Ann. Manuf. Technol. 2008, 57, 621–640.
2. Global Gear Technology Market by Technology by Geographic Scope And Forecast. Verified Market Research, Delaware, USA 2021.
3. Pittler von, W. Verfahren zum Schneiden von Zahnrädern mittels eines zahnradartigen, an den Stirnflächen der Zähne mit Schneidkanten versehenen Schneidwerkzeugs. Patent Application DE243514C, Germany, 16/02/1912.
4. Altintas, Y.; Kersting, P.; Biermann, D.; Budak, E.; Denkena, B.; Lazoglu, I. Virtual process systems for part machining operations. Ann. CIRP 2014, 63, 585–605.
5. Meijer, A.; Bergmann, J.A.; Krebs, E.; Biermann, D.; Wiederkehr, P. Analytical and Simulation-Based Prediction of Surface Roughness for Micromilling Hardened HSS. J. Manuf. Mater. Process. 2019, 3, 70, doi:10.3390/jmmp3030070.
6. Tapoglou, N.; Antoniadis, A. 3-Dimenstional Kinematics Simulation of Face Milling. Measurement 2012, 45, 1396–1405.
7. Kyratsis, P.; Tzotzis, A.; Markopoulos, A.; Tapoglou, N. CAD-Based 3D-FE Modelling of AISI-D3 Turning with Ceramic Tooling. Machines 2021, 9, 4, doi:10.3390/machines9010004.
8. Chang, Z.; Chen, Z.; Mo, R.; Zhang, D.; Deng, Q. An accurate and efficient approach to geometric modeling of undeformed chips in five-axis CNC milling. Comput. Aided Des. 2017, 88, 42–59.
9. Bouzakis, K.D.; Lili, E.; Michailidis, N.; Friderikos, O. Manufacturing of cylindrical gears by generating cutting processes: A critical synthesis of analysis methods. CIRP Ann. Manuf. Technol. 2008, 57, 676–696.
10. Tapoglou, N.; Antoniadis, A. CAD-Based Calculation of Cutting Force Components in Gear Hobbing. J. Manuf. Sci. Eng. 2012, 134, 031009—1–8.
11. Sabkhi, N.; Nouari, M.; Moufki, A. Mechanistic approach applied to the gear hobbing process. Adv. Mater. Process. Technol. 2017, 3, 45–51.
12. Erkorkmaz, K.; Katz, A.; Hosseinkhani, Y.; Plakhotnik, D.; Stautner, M.; Ismail, F. Chip geometry and cutting forces in gear shaping. CIRP Ann. Manuf. Technol. 2016, 65, 133–136.
13. Klocke, F.; Kobialka, C. Possibilities for Reducing Production Costs in Cylindrical Gear Hobbing and Shaping. In Proceedings of the 4th World Congress on Gearing and Power Transmission, Paris, France, 16–18 March 1999; pp. 1609–1620.
14. Koenig, W.; Bouzakis, K.-D.; Chip Formation in Gear-Shaping. Ann. CIRP 1977, 25, 17–20.
15. Bouzakis, K.-D.; Friderikos, O.; Tsiafis, I. FEM-supported Simulation of Chip Formation and Flow in Gear Hobbing of Spur and Helical Gears. CIRP J. Manuf. Sci. Technol. 2008, 1, 18–26.
16. Stadtfeld, H. J. Power skiving of cylindrical gears on different machine platforms. *Gear Technology*. 2014, 31, 52–62.
17. Tapoglou, N. Calculation of chip and gear geometry in power skiving using a CAD based simulation. Int. J. Adv. Manuf. Technol. 2019, 100, 1779–1785.
18. Guo, E.; Hong, R.; Huang, X.; Fang, C. Research on the cutting mechanism of cylindrical gear power skiving. Int. J. Adv. Manuf. Technol. 2015, 79, 541–550.
19. Guo, E.; Hong, R.; Huang, X.; Fang, C. A novel power skiving method using the common shaper cutter. Int. J. Adv. Manuf. Technol. 2016, 83, 157–165.
20. Guo, E.; Hong, R.; Huang, X.; Fang, C. Research on the design of skiving tool for machining involute gears. J. Mech. Sci. Technol. 2014, 28, 5107–5115.
21. Guo, E.; Ren, N.; Liu, Z.; Zheng, X. Influence of sensitive pose errors on tooth deviation of cylindrical gear in power skiving. Adv. Mech. Eng. 2019, 11, doi:10.1177/1687814019843759.
22. Tsai, C.Y. Mathematical model for design and analysis of power skiving tool for involute gear cutting. Mech. Mach. Theory 2016, 101, 195–208.
23. Tsai, C.Y.; Lin, P.D. Gear manufacturing using power-skiving method on six-axis CNC turn-mill machining center. Int. J. Adv. Manuf. Technol. 2018, 95, 609–623.
24. McCloskey, P.; Katz, A.; Berglind, L.; Erkorkmaz, K.; Ozturk, E.; Ismail, F. Chip geometry and cutting forces in gear power skiving. CIRP Ann. 2019, 68, 109–112.
25. Inui, M.; Huang, Y.; Onozuka, H.; Umezu, N. Geometric simulation of power skiving of internal gear using solid model with triple-dexel representation. Procedia Manuf. 2020, 48, 520–527.
26. Jia, K., Zheng, S., Guo, J. and Hong, J., A surface enveloping-assisted approach on cutting edge calculation and machining process simulation for skiving. J. Mech. Sci. Technol., 2019 100(5–8), 1635–1645.
27. Jansen, W. Leistungssteigerung und Verbesserung der Fertigungsgenauigkeit beim Wälzschälen von Innenverzahnungen, Ph. D. Thesis, RWTH Aachen, Aachen, Germany, 1980.
28. Kienzle, O.; Victor, H. Spezifische schnittkräfte bei der metallbearbeitung. Werkstattstech. Masch. 1957, 47, 224–225.

Asst. Prof. Dr. Eng. Nikolaos Tapoglou is assistant professor in the department of Industrial Engineering and Management department of the International Hellenic University, Greece. Prior to joining IHU, he led the emerging machining technology team in the Advanced Manufacturing Research Centre (AMRC) of The University of Sheffield as a Technical Fellow. He has developed substantial research in the field of simulation technologies for gear manufacturing processes. His current research focuses on the simulation of gear manufacturing processes, emerging machining technologies, sustainable lubri-cooling techniques for metalworking, additive manufacturing, optimization of advanced manufacturing processes, manufacturing simulation focusing on the calculation of in-process characteristics and manufacturing informatics. He is a member of several international organizations including the ASME, IMechE and the HEA. He has co-authored over 40 journal and conference publications and has worked on more than 20 research projects.

Gleason Corporation

ANNOUNCES THE PASSING OF JAMES S. GLEASON

It is with great sadness Gleason Corporation announces the passing of **James S. Gleason**, a Gleason board member and former chairman and CEO of the company who died on June 17th at the age of 88 years old. Jim, a great grandson of the company's founder William Gleason, contributed to the company in various roles, continuing to serve as a director on the board up until his death.

Jim Gleason started working in the company in 1959, holding various positions, ultimately becoming CEO in 1981. He was CEO of the company until 2002. During his time as CEO the company went through significant transformation, more than doubling in size both through organic growth and acquisition. During that time, the company recommitted to its strategy of global leadership in gear technology, broadening its range of products and further expanding its geographic manufacturing footprint. In 2000, the company also returned to private ownership (from a publicly traded company on the NYSE).

Beyond his accomplishments within Gleason Corporation, Jim Gleason held leadership positions in industry trade organizations along with board representation in various business, social, charitable, and educational organizations. He also held leadership positions within the Gleason Family Foundation (formerly Gleason Foundation) which for many years was one of the largest charitable donors within the Greater Rochester area and in recent years, supporting initiatives aimed at improving primary and secondary education on a national level.

"Jim will be remembered for his contributions to Gleason Corporation, our industry, and his philanthropic activities but most of all his fairness, sense of humor, intellect, thoughtfulness, and integrity," said John J. Perrotti, Gleason chairman and chief executive officer. "He helped shape and influence the values that exist in our company culture today which I believe will be his enduring legacy."

gleason.com

Hexagon Manufacturing Intelligence

ANNOUNCES TECH START-UP WINNERS

Hexagon's Manufacturing Intelligence division recently announced the winners of its first cohort of start-ups selected to help the manufacturing industry operate more sustainably and efficiently. The company launched its Sixth Sense open innovation platform in January 2022 to challenge how multinationals approach innovation and help nurture creative solutions to emerging manufacturing challenges by connecting with world-class companies to solve some of humanity's biggest challenges.

The two joint winners were chosen following an intense eight-week training program to hone their business model and approach, concluding with a final presentation to a panel of expert judges to pitch for the resources to globalize and gain access to Hexagon's extensive customer base.

The winners are:

RIIICO, a company that has designed a 'Sims-style' drag and drop virtual factory floor. Its AI solution creates a true-to-life simulation of a plant with a single 3D scan, empowering teams with the tools and flexibility to collaborate and improve on factory design from anywhere in the world. This has enormous productivity improvement potential, with around 80% of factory improvements currently getting stuck in the ideation phase. This can remove barriers to greener workflows by making the identification, installation, and optimization of them as painless and low-resource as possible. The young team of university friends from Germany launched the company last year and since joining the platform have already been backed by the likes of UC Berkeley's SkyDeck fund, multiple investors, and AI experts in the United States and Germany.

SmartParts, a company that has created an embedded digital barcode for 3D printing. It has developed a solution utilizing data-rich particles that can be embedded into the materials of 3D printed parts, which when scanned reveal the material and part full specifications and history. The solution will enable industries with specific technical requirements, like aerospace and defense, and those with strong ESG commitments such as governments, to have greater control over their supply chain and processes and encourage responsible business decision making. With modern supply chains under intense pressure, there is increasing need to monitor and verify the authenticity of products. For example, 520,000 counterfeit aerospace parts are installed in planes every year, and 8% of all medical devices on the market are estimated to be fake. SmartParts aims to combat this by directly connecting physical assets with digital records to ensure end-to-end traceability and trust in 3D printing. The small US-based team has direct experience with manufacturing in high requirement industries, having served as New York City's main contractor for 3D printed swabs during the height of the COVID pandemic in 2020.

From left to right: Paul Boris, president of runner-up Praemo; Milan Kocic, head of the Sixth Sense platform, Jan Büchsenschütz and Felix Fink, co-founders of RIIICO; Cody Burke and Robert Haleluk, co-founders of SmartParts.

Sixth Sense is a revolutionary approach to the traditional accelerator, designed as an exchange of value between Hexagon and the start-ups, providing more than just theoretical training. The cohort gains tailored instruction on how to hone their offering for greater commercial success using Hexagon's deep market insight, while Hexagon aims to apply learnings from the start-ups' agility and fresh approach to innovation.

Parth Joshi, chief product officer and chief technology officer of Hexagon's Manufacturing Intelligence division, said: "We expect all seven companies from this first cohort will go on to have a significant impact on the future of the manufacturing industry, and we will work with them all in some way; we were incredibly impressed with the strength and creativity of all solutions. As winners, SmartParts and RIIICO should be particularly proud of their achievements, and we look forward to working with them to help grow their businesses and relationship with Hexagon and our customers."

"Sixth Sense has broken the mold, and successfully so—everything from the initial demand to the final result has been eye-opening," said Paolo Guglielmini, president of Hexagon's Manufacturing Intelligence division. "At Hexagon, we are searching for smart, efficient solutions that will not only boost performance, but benefit people and the planet. We will be recruiting for the next cohort soon, and I would emphasize that we encourage applicants from diverse backgrounds to help foster creative answers to global challenges."

The runner-up to the two winners is Praemo, who developed Razor, a sophisticated manufacturing insights application that ingests data 'as-is' from automation, quality, historians, and maintenance systems to drive next level continuous improvement in areas like throughput, cost and productivity using advanced machine learning without the need for skilled data science teams. Hexagon would like to congratulate all the companies involved in this pioneering cohort, which included Eyeflow AI, IconPro, SmartPM and SmartUQ.

sixthsense.hexagon.com

Chiron

PRESENTS MACHINING INNOVATIONS FOR THE FUTURE

The Chiron Group Open House in Tuttlingen, Germany welcomed more than 1,200 expert visitors from around the world May 11–13, offering new ideas and to improve their manufacturing practice—in the Chiron spirit of "Performance meets Precision."

"We received much positive feedback from customers, partners and suppliers on the many new innovations and experiences at the Open House, indicating that the Chiron Group and the product portfolio has the right answers to current and future questions and demands," said Carsten Liske, CEO of the Chiron Group.

Visitors saw live demonstrations of combined friction stir welding (FSW) and machining processes; scalable manufacturing system for microtechnology; high-productivity twin-spindle machining—three new product innovations by the Chiron Group, focus on productivity, efficiency and sustainability.

High dynamics plus high stability plus large working chamber plus a twin-spindle machining center with a spindle distance of up to 1,200 mm: The 22, 25 and 28 Series machines from the Chiron Group set a new benchmark in terms of productivity and precision in this. As an example in practice, a DZ 25 P that has been in use for two years improved the manufacturing of automotive structural components. All in all, this turnkey solution has provided, according to the customer: "A stable and high-precision process with greatly increased output in comparison to the previous system."

"In addition to other double-spindle applications such as battery and e-motor housing manufacturing, these new series are also fully capable of massive machining applications starting with solid material," said a Chiron spokesperson. "The extremely stable portal design forms the basis for high precision, while an efficient work area and user ergonomics enable flexible integration of a wide range of automation solutions for ideal productivity and process reliability."

Scalable manufacturing system for microtechnology sector

The Chiron Group also demonstrated a manufacturing system for the microtechnology sector—a high-precision automated machining of workpieces with maximum dimensions of 50 x 50 x 50 mm. It is based on the Micro5 from the Chiron FACTORY5 brand—a high-speed milling center with the power consumption of a coffee machine and the size of a refrigerator.

As a stand-alone solution, it is ideal for manufacturing smaller batch sizes in the medical technology sector. With its six-pallet capacity, the Micro5 also supports production with minimal personnel.

"The combination of a Micro5 with a Feed5 handling system will form an ideal plug-and-play solution once it enters series production. "Feed5 offers increased autonomy for automated workpiece handling with a six-axis robot. Capacities for Micro5 and Feed5 projects are currently being expanded further," the spokesperson said.

Combining FSW and machining—new innovation for sustainable mobility

One process that may not be particularly well known is Friction Stir Welding (FSW), a reliable, efficient, and sustainable manufacturing technology for creating pressure-tight and media-tight connections between two materials.

FSW is fundamentally suitable for applications involving joining aluminum or unrelated materials. The target workpieces for FSW currently include, in particular, battery trays and inverter housings as well as all electronic components that require heat dissipation alongside high requirements for leak-tightness. Friction stir welding technology also enables car manufacturers to relocate electrical modules to the wet areas of vehicles.

"The Chiron Group boasts comprehensive expertise and practical user experience for machining these target workpieces," the spokesman said. "By combining FSW and machining, the Chiron Group is developing a forward-thinking innovation to provide benefits for users similar to those offered by other process combinations: Reduced space requirements, shorter cycle times and higher quality and productivity. The first projects using this combination are already underway at a technology partner company, resulting in the first turnkey machining centers such as the MILL 2000 machining center, offering combined FSW and milling technology."

chironamerica.us

GROB

LOOKS TO BUILD SKILLED WORKFORCE

GROB Systems, Inc. recently hosted a 2022 Apprenticeship Class orientation and signing day on June 4th, 2022. New apprentices and their families learned what to expect from the GROB Apprenticeship Program, and they celebrated each student choosing this path after high school by participating in a signing day photo opportunity. The 2022 apprenticeship class is made up of 41 individuals from 25 area high schools and 6 area career centers.

The roots of the GROB apprenticeship program date back to the very beginning of the company's foundation in Bluffton, OH in 1990. "Over the last 32 years, GROB has hired over 450 apprentices," said Michael Hutecker, GROB Systems CEO. "The continued growth of our apprenticeship program reflects our desire to develop highly skilled employees for GROB, critical as we navigate challenging technological changes as well as labor shortages." Thirty-two percent of GROB's current workforce in Bluffton is comprised of past or current apprentices.

The GROB apprenticeship program is a four-year journey comprised of job-specific training, while also building

a strong educational foundation. Apprentices get hands-on training and work alongside experienced workers in the manufacturing and assembly areas to further develop their technical skills. Through a partnership with Rhodes State College in Lima, OH apprentices will earn a company-paid associate degree in Engineering Technology. The combination of their GROB training and college coursework will prepare apprentices to become highly skilled mechanical and electrical technicians at GROB.

grobgroup.com/en/

EMCO

EXPANDS MACHINING CAPABILITIES

In September 2021, EMCO opened a new Technology Center in Belforte Monferrato.

EMCO caters to customers from industries which are as versatile as the company's range of products. Traditional small and medium-sized companies have been an integral part of EMCO's customer base for many years.

Thanks to technologically innovative solutions, high flexibility and customer orientation, EMCO has succeeded in recent years in winning the confidence of large international companies, too. Automation solutions and the digitization of processes have been, and continue to be, key topics in the decision processes.

Notwithstanding the difficult framework conditions, the opportunities and chances offered by these business areas allow EMCO to remain very optimistic about the further course of the anniversary year.

"We focus entirely on those aspects that we, as a team, can shape and influence in such a way that they will have a positive effect for our customers, regardless of whether this happens in the area of development, production or service. And, last but not least, it is the excellent order intake of the past months—which seems to be stabilisingthat gives us cause for optimism," said Dr. Ing. Stefan Hansch, managing director of EMCO.

In March 2022, it was possible to complete an investment that is essential for the development of the milling machine segment: The property adjacent to EMCO's CNC milling machine production site in Pordenone, one of EMCO's five European production plants, was acquired along with a hall for production expansion purposes.

Thus, EMCO has an additional 2,235 square meters of production space and 270 square meters of office space at its disposal for the upcoming expansion of the UMILL and MMV series.

Sustainability-related investments are already being implemented at the headquarters in Hallein: a complete roof refurbishment and the installation of a 7,900-square-meter photovoltaic system with an output of 400 kWp.

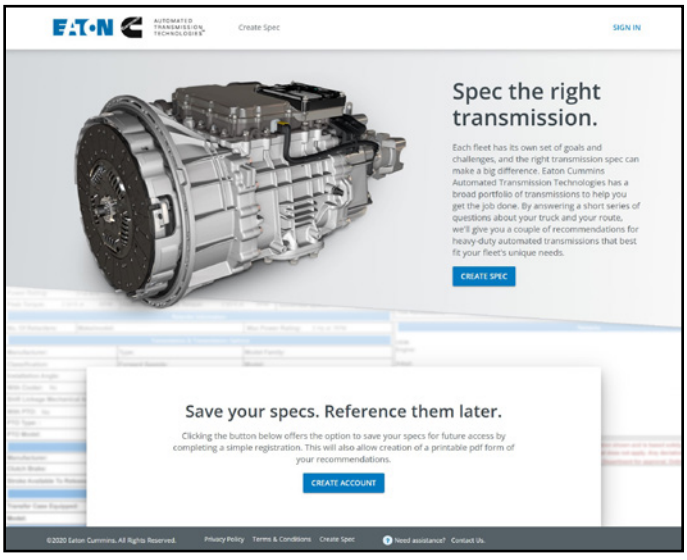
emco-world.com

Eaton Cummins

LAUNCHES ONLINE TRANSMISSION SELECTOR

Eaton Cummins Automated Transmission Technologies recently announced a new online selector tool, which helps users choose the optimal transmission from its portfolio.

"Small to midsize fleets and dealership salespeople will benefit from the online selector," said Michael Garrison, lead applications engineer, Eaton's Vehicle Group. "The tool eliminates much of the guess work when it comes to selecting the ideal transmission that best fits the user's needs based on their particular requirements."



To guide customers to the ideal transmission choice, the online selector asks a series of questions, such as how the vehicle is used, its maximum gross weight rating, the type of terrain on which it will operate, and whether it will be used with a Power Takeoff (PTO) unit.

Based on the responses, the tool provides two transmission recommendations and a suggested axle ratio range.

Users can register for an account, which allows them to save their specifications, and generate a downloadable PDF file for reference and/or dealership consultation. Help is always available via a link on the tool homepage if the user requires assistance with definitions or examples. If the user has questions on transmission specifications, they are directed to a Roadranger representative.

Eaton Cummins Automated Transmission Technologies' portfolio includes the new Endurant XD and Endurant XD Pro, Endurant HD, Fuller Advantage series, and the UltraShift PLUS series (MXP, VXP, MHP, VMS, VCS).

eatoncummins.com

Velo3D

OPENS NEW EUROPEAN TECHNICAL CENTER IN AUGSBURG, GERMANY

Velo3D, Inc. has announced the opening of its European Technology Center in Augsburg, Germany to manage the company's operations in Europe, host customers for trainings, and conduct meetings with customers and partners. Velo3D's European customer success, sales, and support teams will reside in the technology center, which will act as the hub for the company's efforts in the region and showcase an end-to-end additive manufacturing solution from the company.

"Three years ago, we shipped our first Sapphire printer to our very first customer and since then, we've experienced tremendous growth across all of our key industries," said Benny Buller, Velo3D founder and CEO. "Our new Technology Center in Augsburg will support our efforts in expanding our presence in Europe in a similar manner and will feature an additive manufacturing solution capable of printing our customers' most ambitious designs."

The new technology center is more than 110 square meters (1,200 square feet) in size, with a lab area featuring a Velo3D Sapphire printer, a showcase of parts that were printed using the company's technology, offices, and conference rooms for hosting customers and events. The facility will be located at the Augsburg Innovations Park in Augsburg, Germany. Its opening was commemorated in a ribbon cutting ceremony with Velo3D executives, European customers, local government leaders, and other engineers in attendance.

Augsburg was selected for its central location to key regions in Europe, its proximity to Munich, and Velo3D's existing presence in the region.

velo3d.com

September 12–17—IMTS 2022

The International Manufacturing Technology Show (IMTS) is the largest manufacturing technology show in the Western Hemisphere. IMTS (Chicago,Ill.) brings the industry together to discuss new opportunities and network with the manufacturing community. Other highlights include the Smartforce Student Summit, Exhibitor Workshops, the Emerging Technology Center and IMTSTV. Pavilions include additive, gear generation, machining, tooling, quality, controls and more. IMTS is co-located with Hannover Messe USA where cobots, digital twins, and smart factory solutions come together under one roof. See the latest industrial automation, motion and drive technologies in the East Building.

imts.com

September 12–14—International Conference on Gear Production 2022

The requirements in gear manufacturing are increasing dramatically which delivers a dilemma between productivity (scale) and flexibility (scope) of today's technical solutions. Lead times need to be shortened in order to increase productivity while batch sizes are getting smaller and individual geometric features (topological modifications) push the need for intelligent support by manufacturing simulation and closed-loop approaches. The digitalization of the gear manufacturing processes promises high potential but also raises some challenges. In addition, new technologies evolve, that challenge the conventional manufacturing chain for gears. Topics in Garching, Germany, include manufacturing of internal gears, manufacturing processes, gear soft machining, new concepts for machine and manufacturing processes, advances in special gearings, modeling in gear production, measurement technology and gear hard machining.

vdiconference.com/event/gear-production/

October 17–19—AGMA Fall Technical Meeting 2022

The gear industry is faced with emerging trends and innovations challenging engineers to stay course with the latest design, quality, materials and analysis technology. It is imperative that researchers and gear engineers communicate ideas with fellow experts in the field. AGMA's annual Fall Technical Meeting (FTM) is the forum to share research and disperse knowledge for the benefit of the global gear industry. Each year, authors selected by AGMA write peer-reviewed technical papers on gear topics such as design and analysis; manufacturing and quality; materials, metallurgy, and heat treatment; operation, maintenance, and efficiency; and gear failure. The authors will present their work at the 2022 FTM in Rosemont, Ill. (outside of Chicago). All papers presented at FTM will be indexed in Scopus, the international database of peer-reviewed literature.

agma.org/events/fall-technical-meeting-ftm/

October 18–20—AGMA Gear Materials

Attendees will learn what is required for the design of an optimum gear set and the importance of the coordinated effort of the gear design engineer, the gear metallurgist, and the bearing system engineer. Investigate gear-related problems, failures and improved processing procedures. Class takes place at the Doubletree Hilton Chicago Midway Airport Hotel from 8:00 a.m.–5:00 p.m.

agma.org/education/advanced-courses/2022-gear-materials/

October 24–30—Bauma 2022

Bauma 2022 (Munich, Germany) will focus on five key topics including: Zero emissions, the digital construction site, tomorrow's construction techniques and materials, autonomous machines and mining—sustainable, efficient, reliable. The show examines the latest products and technology for construction machinery, building material machines, mining machines, construction vehicles and construction equipment. Bauma features more than 3,500 exhibitors and nearly 630,000 visitors. Product groups include components, systems, services, safety, security, handling machines, drilling, mining equipment and more.

powertransmission.com/events/903-bauma-2022

ad index

gear TECHNOLOGY

FREE SUBSCRIPTION

18GTPAGE

RESPONSE REQUIRED

☐ **YES** I want to receive/continue to receive ***Gear Technology***

☐ **NO** Thanks anyway, but I don't need the world's best publication on gear engineering and manufacturing.

Name _____ Job Title _____
(please print)

Signature _____ Date _____
(required)

How would you like to receive *Gear Technology*?

☐ PRINT version (Verify mailing info below)
☐ DIGITAL Version (E-mail required)
☐ BOTH Print AND Digital (E-mail required)

E-mail _____*

***Your PRIVACY is important to us. You get to CHOOSE how we use your personal information. The next e-mail we send you will have clear instructions.**

How are you involved with GEARS?

☐ My company MAKES GEARS (20)
☐ My company BUYS GEARS (22)
☐ I DESIGN gears (23)
☐ I am a SUPPLIER to the GEAR INDUSTRY (24)
☐ OTHER (Please describe) _____

What is your company's principal product or service? _____

_____

MAILING INFORMATION

NAME:
JOB TITLE:
COMPANY:
ADDRESS:
☐ Check if this is a home address

CITY:
STATE/Province:
ZIP/Postal Code:
PHONE:
FAX:

Put your business card here to make it easier!

Mail to:
1840 Jarvis Ave., Elk Grove Village, IL 60007 USA

or

FAX to 1-847-437-6618
SCAN to: subscribe@geartechnology.com

On the Loop

Supervising Automation in Manufacturing

Aaron Fagan, Senior Editor

The mere mention of artificial intelligence (AI) often conjures one dystopian vision or another—perhaps the prime example of all is the HAL 9000 going spectacularly awry in the film *2001: A Space Odyssey.* The prospect of the widespread adoption of AI is understandably alarming to people in a host of ways, but be that as it may, various forms of it are already a central part of how things are done—from finance to health care, from heavy machinery to retail—and the reason for this is simple: AI allows computers to do things people can't unassisted, and by pairing algorithmic accuracy with automation, this helps save valuable time and resources. However, as AI and other control mechanisms affecting systems grow increasingly sophisticated, the human link to these processes becomes critical.

We are familiar with closed-loop manufacturing, but as AI systems are being leveraged and scaled, what will meaningful human interaction "on the loop" look like. Originally an engineering term, requiring a human "in the loop" who could halt systems, the term "on the loop" aims to distance humans further from systems.

Having an operator in the loop means a person still has complete control over starting or stopping any action performed by an intelligent system after receiving a cue. Moving toward an on-the-loop standard pushes human control farther from the center of automated decision-making. It would still give humans oversight of an automated system, but the AI would function without the need for human pre-approval as it would with an in-the-loop design.

You cannot have "meaningful human interaction" with data or sensors, or actuators at the time of data collection and operation. "The loop" is the whole system—the sensors, the actuators, the data (mostly historical, often poor quality, almost always difficult to interrogate), the machine learning or AI, the pieces separately, and the interoperable whole. No single human has the capacity to understand and oversee all these parts, let alone to meaningfully intervene.

An operator cannot meaningfully interact with active AI code. AI is a different coding discipline from machining that requires an entirely different competency. In the case of the code being embedded in other systems, few people, if any, can parse these elements in real-time. It also bears mentioning people get quantifiably bored when working with autonomous systems. The situations where machines can be autonomous but require human supervision are often the most problematic. Humans tune out or get distracted—with costly effects. Research data shows that humans cannot actively supervise machines for long periods of time without risk increasing, particularly where the systems are largely autonomous. The reason is related to the concept of "magical thinking," meaning humans are prone to assume systems cannot fail, and yet they do.

The HAL 9000 from Stanley Kubrick's *2001: A Space Odyssey* was presumed to be "incapable of error."

The complexity, speed, and scale of many autonomous, and even automatic, systems do not allow for enough time to challenge them. The speed at which information is provided, and the time-sensitive decisions that need to be made, will often render potentially appropriate human intervention impossible. If meaningful human interaction on the loop is remote, there are even greater risks. Network delays—due to issues of bandwidth, lag time, human cognitive delays, and data poverty (i.e., not having all the information you need, some of which cannot be captured by automated or autonomous projects)—amplify existing risks. Lack of transparency prevents predictability. Even where low risks exist, the speed and scale of autonomy may expedite or expand the potential of serious errors.

Meaningful human interaction on the loop will mean something different in the context of each specific system. Having experts with diverse and interdisciplinary skills involved throughout the development and lifecycle of a system directed at solving a challenge will have a far greater impact than any human on the loop. After the system is active, just being on the loop will almost certainly not provide the capabilities for any human to pause, reflect, question, and stop the trajectory of the machine.

A strong link exists between the amount of information to be processed, the tempo, and the position of humans in the decision process. The faster automation goes, the more humans will be on the loop.

Inspection at Nano Level

The new GMS nano series combines latest inspection capabilities into a single, compact platform for the complete inspection of gears and shafts, fine pitch gears as small as .2 module. Measure sub-micron surface finish with a skidless probe, analyze waviness for profile, lead and pitch, execute noise analysis with sophisticated software tools.

gleason.com/nano

smart loop

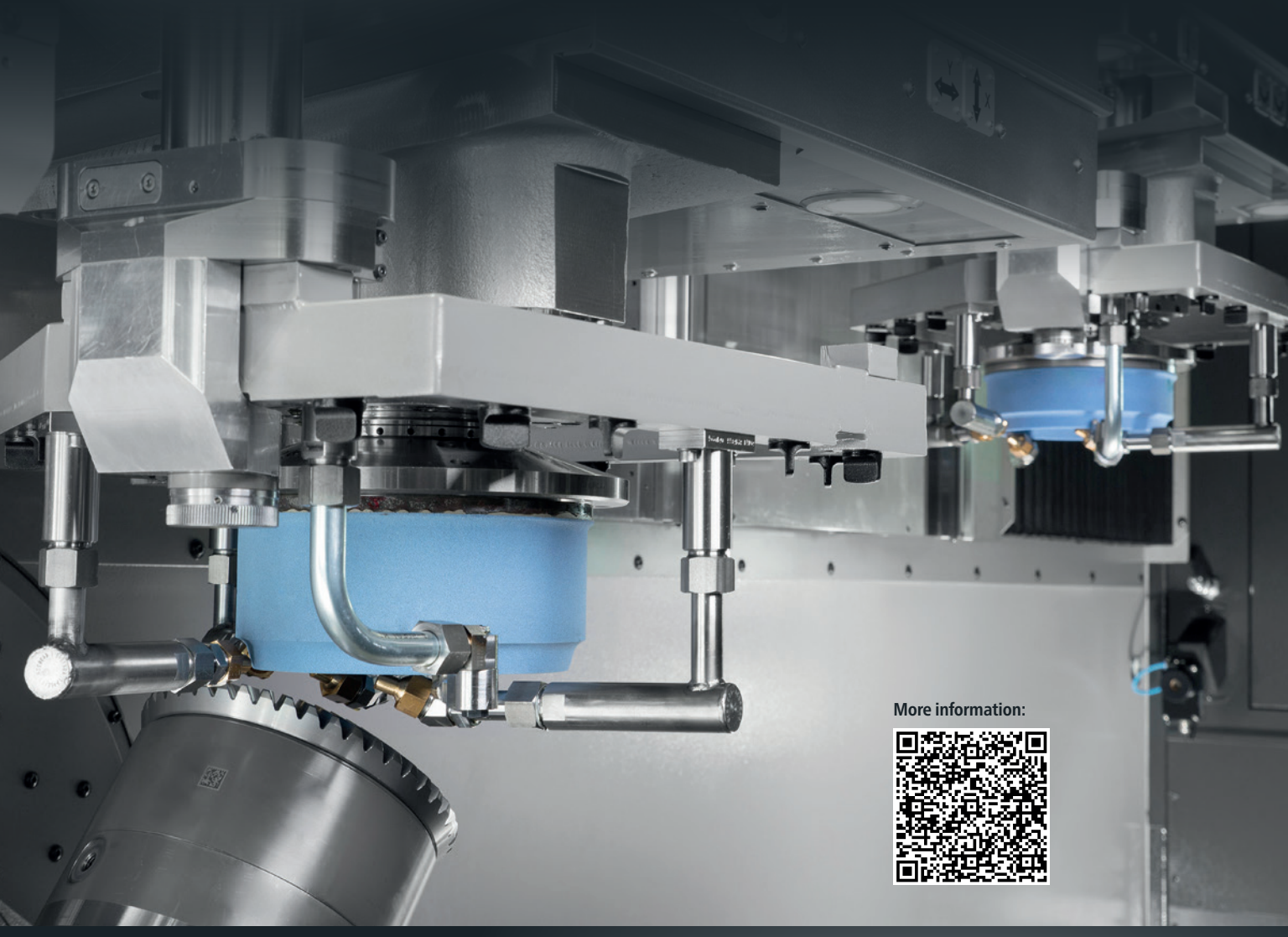
IMTS 2022

Total Gear Solutions Gleason

G 35

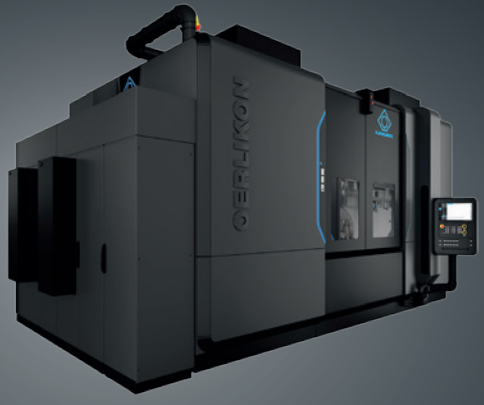
OPTIMAL FLEXIBILITY AND MAXIMUM PRODUCTIVITY IN THE AVIATION INDUSTRY

KLINGELNBERG



More information:

Ready for take-off – specifically tailored to the requirements of the aviation industry, the Oerlikon G 35 bevel gear grinding machine takes aviation gear manufacturing to a new level with its two vertical grinding spindles. Tried and tested concepts and components were used to ensure optimal functionality and the best possible availability of spare parts for this special-purpose machine.



Subject to changes

BEVEL GEAR TECHNOLOGY | CYLINDRICAL GEAR TECHNOLOGY | PRECISION MEASURING CENTERS | DRIVE TECHNOLOGY

WWW.KLINGELNBERG.COM