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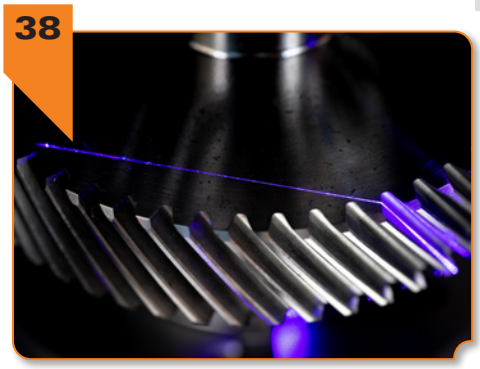

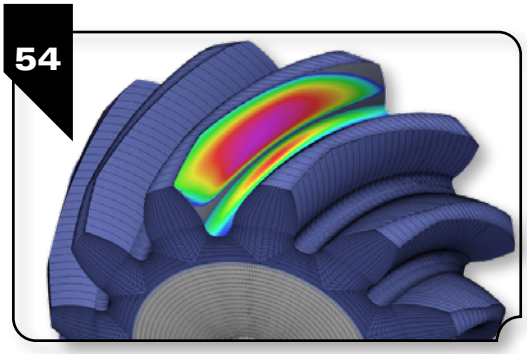

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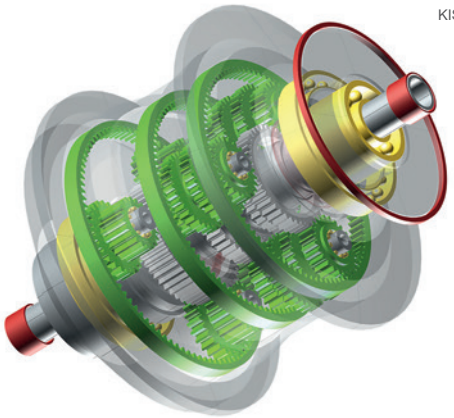

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GT Videos

DVS Technology Group and WMZ Offer V300 for Splined Shaft Machining

The modular system of the V300 allows configurations for multi-technology complete machining of splined shafts from the smallest to very large quantities. DVS Technology Group and WMZ offer unique solutions for metal machining.

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Spiral Bevel Gears with Chiron

The Chiron FZ16 5-axis machine offers speed and precision for spiral bevel production. It is designed to meet particular requirements for accuracy in 5-axis machining and for demanding machining applications such as aerospace.

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GT Revolutions

State of the Gear Industry Perspectives: Liebherr

State of the Gear Industry Perspectives takes an in-depth look at the challenges and opportunities in gear manufacturing today and in the future. Our third installment online is an interview with Peter Wiedemann, managing director, Liebherr-Verzahntechnik GmbH and Scott Yoders, vice president sales, Liebherr Gear Technology, Inc.

geartechnology.com/blogs/4-revolutions/post/30192-state-of-the-gear-industry-perspectives-liebherr

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Publisher & Editor-in-Chief
Randy Stott

You're Not Alone

I'm a fan of The History Channel's survival competition TV series *Alone,* where contestants are left in the wilderness to fend for themselves with limited resources in extremely harsh conditions. They have to build their own shelters, find food and survive. The last one to tap out wins.

One of the show's regular themes is the calorie equation. Contestants constantly have to make decisions about whether they should expend energy for a given task, because their calorie intake is extremely limited. High-energy tasks like building a sturdy shelter or actively hunting big game might have a high energy cost but also provide the best chance for staying in the game long-term. It's a risk-reward gamble with extremely high stakes.

To make matters worse, the competition is usually set as the season shifts from fall to winter, which means that the resources that are here today won't necessarily be here tomorrow.

Sometimes the winners are just lucky in finding the right resources at the right time: a good fishing spot or access to game trails can make all the difference. But the calorie equation almost always comes into play. You have a limited number of calories, and you have to decide where to spend them.

Surviving in the wild is a little bit like surviving in the world of manufacturing: Limited resources, challenging environment and constant decisions about the best way to sustain your existence long-term.

And unfortunately, it looks like manufacturers are starting to play the starvation game. By most measures, the manufacturing economy is struggling.

Just like the contestants on *Alone,* you're constantly deciding how to survive, and there just aren't enough resources to go around. You know you need to invest in automation and technology, but that choice is hard when you know you're facing increased costs across the board. Inflation has ensured that the pressures to increase wages and benefits will continue. It costs more to buy supplies, to move goods and keep the lights on.

How do you make the decisions about where to invest your resources? Unfortunately, I don't have a crystal ball, and besides, the answers will depend on your situation anyway.

> ***But I can tell you this:*** **the more information you have, the better-informed your decisions will be, and the better your chances of making the right ones.**

One of the best resources for information for the gear industry (aside from this magazine, of course!) is the upcoming Motion+Power Technology Expo (*motionpowerexpo.com*). The founder of our magazine, Michael Goldstein, often used to say that this show is the single greatest collection of gear knowledge, all gathered under one roof at the same time. And he was right. Every phase in the life of a gear is represented there, and the suppliers who exhibit run the gamut from the software to design gears to the machines and tooling to manufacture them, not to mention the many gear manufacturing exhibitors themselves, as well as the fact that the show runs concurrently with ASM's Heat Treat 2023 and AGMA's Fall Technical Meeting. That's a lot of gear knowledge.

So if you're looking for the best information to make your decisions about surviving in the manufacturing wild, you can't go wrong by attending MPT Expo. I hope to see you there.

Randy Stott

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An Intimate Tradeshow with Endless Opportunities

Steve Janke, President, Brelie Gear, AGMA Tradeshow Committee Chairperson

As the chairperson for the American Gear Manufacturers Association (AGMA) Tradeshow Committee, I can tell you that we have not stopped working to make Motion + Power Technology Expo (MPT Expo) the type of show that delivers quality leads and a platform for showcasing your latest innovations in mechanical, electric and fluid power.

It was decided three shows ago to rename Gear Expo to MPT Expo to represent the full supply chain of motion power. Gears make the world move, but because we are such a niche and hidden solution, it was time to incorporate all the facets of the industry together under one roof.

These last few shows have faced an economic downturn, a pandemic, acquisitions, major international trade changes and a lot of barriers that influence the success rate for an event this size. Fortunately, AGMA and the industry have shown up biennially to meet customers and subject matter experts in person to do business in real time. This has allowed the committee and leadership to develop robust programming for all exhibitors and attendees.

As a seasoned exhibitor myself, I experience the immediate ROI of MPT Expo. The booth investment is minimal compared to other shows, and my employees have the chance to showcase products and learn even more as a way of professional development. I get to check in with existing customers to save time on travel and meet new leads to help further my bottom line—and this is just being seen on the show floor. Let's talk about all of upcoming offerings for 2023.

1. **Groundbreaking Town Hall for Standardization in EV**
   Led by Amir Aboutaleb, AGMA's Vice President of the Technical Division, members, industry professionals and experts will gather to talk about where the EV sector is with regard to the process of application standards. This town hall is open and free to all. If you are currently or hoping to be joining the giant EV game, make sure to sign up today with your registration.
2. **First-Ever Global Gear Association Conference**
   AGMA is honored to host the first International Power Transmission Summit that will gather gear manufacturing associations from around the world with high-level executives from manufacturers in the gear industry. The purpose of the summit is to gather the leaders in power transmission to discuss, on a global scale, important issues businesses are facing, such as supply chain, workforce and leadership in an ever-changing environment.
3. **One-On-One Personal Introductions to Exhibitors & Decision Makers**
   One of the largest benefits to being part of AGMA is the fact that they connect you directly to the person you need to talk with. MPT Expo will be offering curated tours to groups who don't want to "find" their solutions but instead, would like a personalized road map taking them directly to vendors that specialize in emerging technologies such as robotics and automation, automotive, aerospace, defense, agriculture and more.
4. **Come for the Show, Stay for the Education**
   World-class education will be offered on topics ranging from basics of gearing all the way to reverse engineering that will help your employees learn on site. Many of these classes will include a guided tour that will demonstrate immediate examples of what students learned in the course. And for the true Gear Geeks, the tried and true Fall Technical Meeting will be happening on site. This is the perfect forum to stay up to date on the latest R&D in gearing and materials.
5. **We Are Live!**
   For each of the three days of the show, there will be a new manufacturing podcast covering all parts of the event live from the show floor. Interviews will be conducted on site and exhibitors and attendees will be able to share their thoughts about the challenges and successes of the industry. Hosts will share the latest information on disruptions and technology while telling the radio community all about how incredible the show is.

Gone are the days where people meet their customers through just word of mouth. Handshakes are important, bringing your products directly to the buyers to touch and feel make the difference when getting leads.

Don't miss out on the show that stayed "open" when everything else closed down—we have always been there and we always will be. Join me and many others in Detroit, MI, October 17–19.

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Steve Janke
President, Brelie Gear, AGMA
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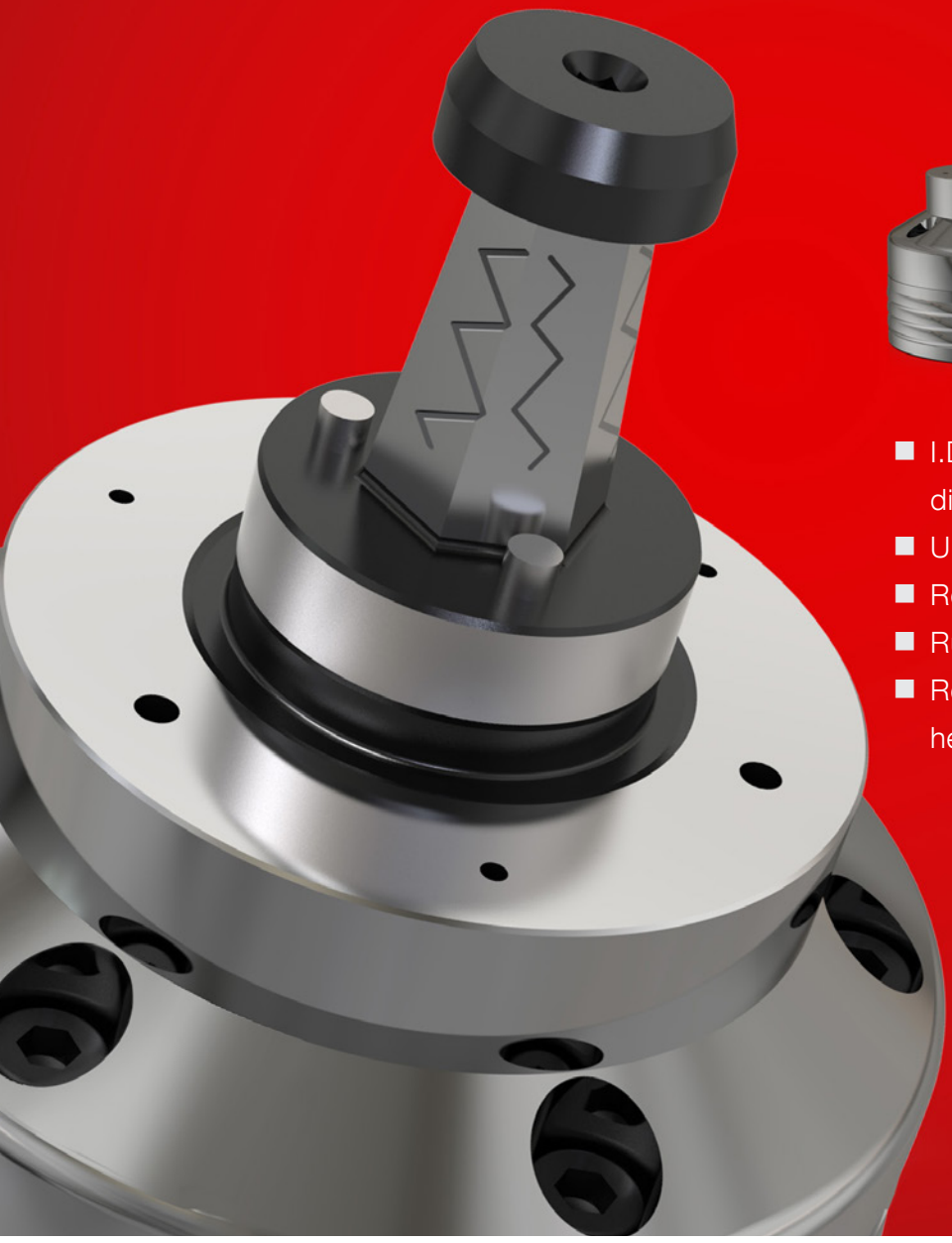

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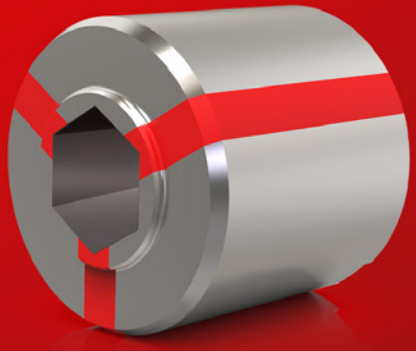

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EMAG SU

DEMONSTRATES ADVANCES IN TOOTH FLANK GRINDING

Gear grinding is currently attracting a lot of attention, especially in the production of components for electric drives. Production planners are demanding new solutions for a perfect surface that assures their necessarily smooth running at high speeds and heavy torque loads. To see how a high-tech niche machine builder implements these requirements, one need look no further than EMAG SU "tooth flank grinding" machines.

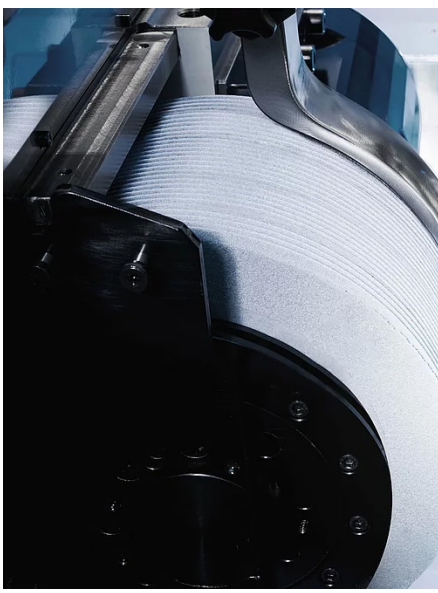
The gear grinding machine specialist, based near Bologna Italy, developed the G 160 model, for example, which features a special "virtual" axis concept for microscopically near-perfect surfaces. At the same time, the integrated material handling technology keeps the cycle times down to a minimum.

Electromobility is booming and the competition to have the best solution is accelerating. Almost all automotive manufacturers launched new EV models in 2022. What does this mean for the production planning by OEMs and suppliers?

"On the one hand, they have to effectively deal with growing production quantities, yet, still have to guarantee an ever-increasing level of quality, because the high torque load of an EV electric motor results in special requirements for tight tolerance dimensions and surface finish," said Alexander Morhard, technical gear support specialist with EMAG SU. "This development is particularly noticeable in the machining of tooth flanks on shafts and gears. Here it is important to achieve dimensionally accurate results in the micron (µm) range, because even minimal ripple in the surface finishing of the components can cause interference noise in the drive performance."

G 160: Minimal Chip-to-Chip Times

With a wide range of technological innovations, EMAG SU demonstrates how quality can be improved in this extremely precise application. The company offers a large range of machine tools that cover the entire gear tooth cutting process. Tooth flank grinding, with the alternative cornerstone procedures of generating grinding and profile grinding is a key area of application. With generating grinding, for example, the gear geometry is continuously generated by a combination of multi-axes, high performance machine motions and well-maintained grinding wheels. EMAG SU's G 160 model is a fast machine for components up to module 3 with a maximum outside diameter of 160 mm. The G 160 speed is made possible by an innovative slide axis concept with two parallel workpiece tables that take turns moving at high speed (with the help of durable, high performance linear motors) to the grinding wheel. During the time that one component is being machined, the loading robot inserts a blank into the other spindle, after first unloading the completed part, as needed. Self-centering alignment, or "meshing," of the grinding wheel to the rough-cut gear component takes place directly on the workpiece spindle, at load position, in parallel with the main machining operation. This results in a chip-to-chip time between the grinding processes of only 1.6 seconds (a very small value compared to grinding machines with turntables, where in some cases up to five seconds pass for the same process). Here it is important to note that the actual grinding time needed for a typical component, such as a planetary gear wheel, is only about 10 seconds. The difference between the chip-to-chip times between grinding is therefore a real game changer. The floor-to-floor time is significantly reduced, by about three seconds (more than 20 percent), and the output quantity is massively increased. This is a decisive factor in the planning of high-volume manufacturing in the growing electromobility market.



G 250: Short Cycle Times—Maximum Flexibility

Another interesting machine concept can be found in the G 250 machine of EMAG SU, which is suitable for components up to module 7, with an outside diameter of 250 mm. Axle drive gears, gear wheels or shafts with a maximum length of 550 mm can be produced with this solution, using generating grinding or profile grinding, with short cycle times. To this end, the machine is equipped with two table spindles to minimize idle time during the manufacturing process. "Additionally, the flexibility of the machine was very important to us," said Morhard. "For example, the G 250 can also be equipped with very small grinding wheels and worms." The G 250 HS variant also has a high-speed grinding head, which makes 20,000 rotations per minute possible, if a small grinding worm is used.

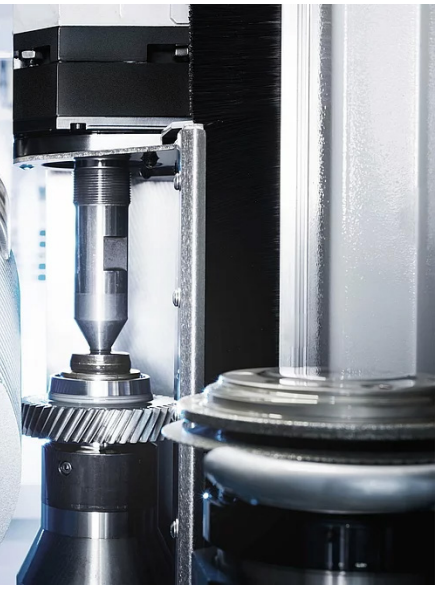
For large components in trucks or in general gear manufacturing, the cost-efficient G 400 rounds off the upper end of EMAG SU's product range for generating grinding. It is equipped with a tool table for components with a max. diameter of 400 mm and a shaft length of up to 750 mm. A feature that is important to many users: The machine can also be loaded from above, because the housing has an over-the-corner door.

Increasingly Strengthening the Market by Contributing Strengths

Short chip-to-chip times, intelligent axis concepts, thermal and mechanical stability, as well as high "user-friendliness," including self-explanatory, parametric input windows. With these quality characteristics, EMAG SU boosts the performance of tooth flank grinding procedures. To accommodate various grinding wheel sizes and types, a variety of spindles with the corresponding power and performance is available. Additionally, the technology can easily be combined with different automation technologies (Learn more here: *https://www.emag.com/products-services/automation-solutions/robot-automation-cells/*).

"We consider ourselves ideally equipped to supply machines for the grinding tasks needed in the field of electric mobility, as shown by a well-known French automotive manufacturer currently successfully using several EMAG SU grinding machines to generate gears," said Morhard. "In the coming years, we want to continuously improve our contribution to the global requirement for precision gear grinding machines for the ever-increasing quality demands for electric vehicles."

emag.com



PTG Holroyd

OFFERS TWO-IN-ONE CNC PRECISION GRIND FOR WORMS AND GEARS

Manufacturing high-accuracy worm gears and screws alongside precision spur and helical gears has traditionally required the use of two quite different CNC grinding machines. Thanks to PTG Holroyd's newly launched HG350-WG worm and gear grinding center, however, just one machine can now complete both tasks.

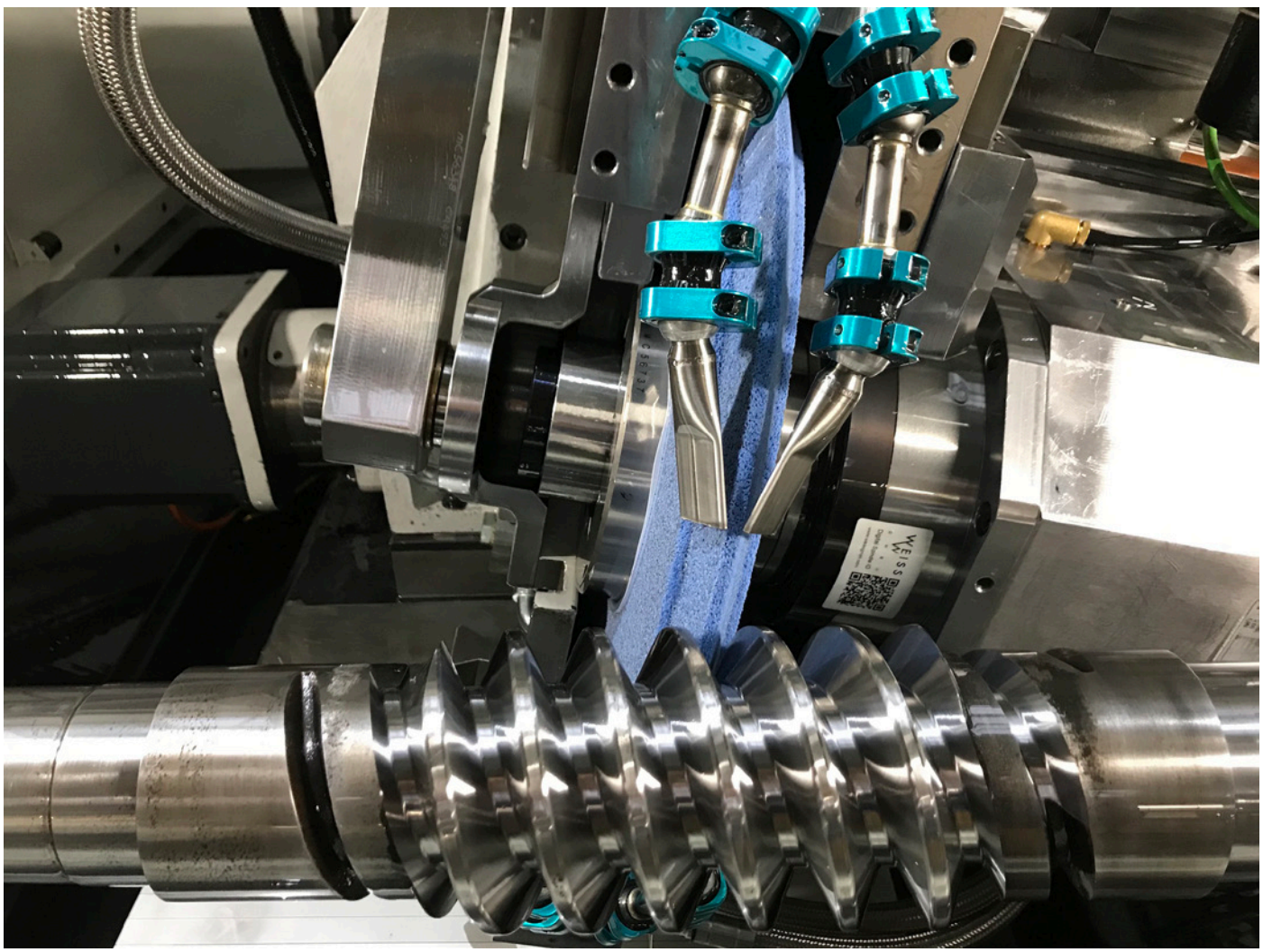
"Since the launch of our HG350-G [gear-only] grinding center in 2021, we've been investigating ways of bringing manufacturers of worms or gears, or both, greater levels of flexibility and efficiency in their manufacturing processes," comments Mark Curran, sales director of UK-based PTG Holroyd.

"The result of a £multimillion machine tool development program," he continues, "our new HG350-WG worm and gear grinding center does just that. Taking the concept behind the PTG Holroyd HG350 range a stage further, the dual-capability 'WG' model has been designed not only for the one-off and batch grinding of high-accuracy worms and screws but also for precision grinding spur and helical gears of up to 350 mm in diameter. Primarily, that means significantly improved versatility for manufacturers who need to quickly switch between grinding processes. Many other businesses will now only need to invest in one type of helical grinding machine tool while, for others, selecting an HG350-WG model will mean being able to expand their manufacturing capability to either worms or gears."

Designed from the ground up to bring greater levels of efficiency and accuracy to the production of specialized gears and tooth forms, this latest member of the PTG Holroyd HG350 family features an advanced version of the company's *HPMS (Holroyd Profile Management System)* for rapid programming and seamless background calculations of both worms and gears. In fact, operators will only need to input the profile shape and size they wish to achieve for a precise dressing path to be created.

Uses Renishaw Sprint 3D scanning probe alongside Sinumerik ONE CNC

Just like all PTG Holroyd HG350-G gear grinding machines, the new HG350-WG worm and gear variant is controlled by Siemens' highly intuitive Sinumerik ONE which has integral safety and failsafe features, enhanced reporting of machine health and performance data, and uncompromising levels of industrial security.



"Using the Sinumerik ONE CNC has also allowed us to equip HG350-WG models with Siemens' 'Create my virtual machine' and 'Run my virtual machine' software capabilities," adds Curran. "When used in tandem with our own internal machine design packages, these features have enabled our teams to build virtual 'digital twin' HG350-WG worm and gear grinding centers on the desktop, then grind virtual gears and threads—all while observing entire manufacturing cycles, and testing safety and failsafe capabilities. The software also makes acceptance testing exceptionally straightforward, as our customers are able to sign off on their new machine before it has even been built. Then, following installation, they too can benefit from carrying out 'virtual' gear and worm grinding to ensure right-first-time results."

The new HG350-WG uses Renishaw's Sprint 3D scanning probe, alongside Siemens' Sinumerik ONE CNC, for rapid precision scanning for infinitesimal profile corrections. "We have worked in close association with Renishaw and Siemens to use orthogonal data from the grinding machine's X, Z [linear] and C [turning axis] to create a virtual Y-axis for use by the Sprint probe," says Curran.

About the HG350-WG worm gear and gear grinding center

PTG Holroyd's HG350-WG machines feature the high power required for deep grinding operations. A specially developed extended machine bed allows screws and worm shafts of up to one meter in length to be accommodated. Dedicated software compensates for helical twist, and full topological capability comes as standard. Embracing the Sinumerik ONE CNC's Profinet capabilities, IO-Link communication technology will be offered with all new HG350-WG machines – as will RFID scanning, an option that will be particularly suitable for machines destined for production cells, by helping ensure that virtually any component or tooling item that needs to be switched between manufacturing cycles, is correctly changed for each gear grinding operation.

Simplifying the most complex processes

Continuing the PTG Holroyd tradition of building machines that simplify even highly complex manufacturing processes, the HG350-WG combines extreme rigidity with high power for both CBN and conventional deep grinding operations. On-board features include automatic coordinate adjustment, in-cycle wheel dressing, integrated profile management, and coordinate measurement. Grinding cycles are included for: spur gears; helical gears; crowned helical and spur gears with root or tip relief; worm gears of the form ZK, ZI, ZN, and ZA; dual lead (duplex) worm gears; and splines.

Incorporating the brands of PTG Holroyd, PTG Powerstir Friction Stir Welding, and Holroyd Precision Rotors, PTG is optimized for high-precision machine tool design, build, and supply for specialized applications. The range includes advanced machine tools for the production of complex helical components

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such as compressor rotors, pump screws, and high-accuracy gears, and Powerstir machine tools for friction stir welding advanced alloys used in transport applications. With production facilities in the UK, United States, and China, Holroyd Precision Rotors manufactures the special purpose, ultra-precision helical components used in a wide range of industries, including refrigeration, air-conditioning, gas and vacuum pumping, industrial air handling, aerospace, medical equipment, motion control, power transmission, power generation, oil and gas, fluid transfer and high-end automotive. PTG also provides advanced technical consulting services.

holroyd.com

Mazak

SHOWCASES EZ AFFORDABLE PRODUCTIVITY AT WMTS 2023

The Kentucky-built Mazak Ez Series was recently featured at the Western Manufacturing Technology Show (WMTS) in Edmonton from May 30th until June 1st, 2023.

For multitasking part processing, the QT-Ez 12MY features milling and Y-axis off-centerline capability, and for further increased productivity and unmanned operations, the machine seamlessly integrates with a range of automation solutions. These include simple bar feeders and parts catchers as well as full cooperative robot installations such as Mazak Automation Systems' Cobot Cell System.

While the machine comes standard with a 12-in. chuck, Mazak offers a smaller 10" option. Available bed lengths are 20 in. and 40 in., and machine turrets include 2-axis drum style with a bolt-on or BMT55 turret for rotary tool applications. Tailstocks are offered with either manual positioning via hydraulic quill or servo positioning capability.

All QT-Ez models feature powerful and reliable integral motor headstocks, Hybrid MX roller guideways, and pretensioned ball screws supported at both ends for reliable, thermally stable and precise machine axis movement. An innovative bed casting design provides outstanding rigidity as well as streamlined chip flow that helps to eliminate chip accumulation.

Also, an automation-ready machine, the Mazak VT-Ez 20's rugged 40-taper spindle and space-saving design offer unprecedented affordability with a full range of spindle, auto tool changer, and chip/coolant management options. The affordable, highly configurable machine meets many production needs with a compact, space-saving design.

Enhanced operator ergonomics and a generous work area ease the loading and unloading of workpieces and tools, while an extremely fast traverse rate of 1,654 ipm (42 m/min) in the X, Y and Z axes enables higher throughput. A 25 hp (18.64 kW) 12,000 rpm (standard) or versatile 29.5 hp (22 kW) 15,000 rpm (optional) spindle offers 81.13 ft-lb (110 Nm) of torque for additional production versatility.

All VC-Ez Series machines sport C-frame designs with X and Y axis motion via moving the table and saddle. For rigidity and repeatable part precision, guideway systems use Mazak's MX linear roller guide systems, and dual lagged pre-tensioned ball screws ensure precise axis movement. For increased maintenance free operation, the auger-type chip removal systems provide an economical solution, or for increased chip volume the addition of an

affordable hinge-type chip conveyor that ships affixed to the machine to eliminate the cost of a second shipping pallet.

To ensure ease of use and programming success, Mazak equips all its Ez Series machines with its Mazatrol SmoothEz CNC that provides dual 800 MHz processors, 512 MB of RAM and a vibrant 15 in. capacitive touch screen that includes a full keyboard and displays up to 60 lines of code. Within the control, G-code and Mazatrol Conversational programming languages support a full range of programming options directly on the machine, while the Mazatrol Twins function enables use of Solid Mazatrol, Virtual Machining and Cutting Adviser through Smooth Cam Ai and centralized storage and file management through Smooth Project Manager.

mazakusa.com

VBN Components'

NEW MACHINE SHORTENS DELIVERY TIME AND IMPROVES MATERIAL PROPERTIES

VBN Components AB in Sweden manufactures extremely wear-resistant materials and is known for "the world's hardest steel," Vibenite 290, and "the world's first 3D-printed cemented carbide,"

Vibenite 480. Since its inception in 2008, the company has focused on hard, additively manufactured alloys with unique properties. Additive manufacturing is often associated with faster lead times for both development and production, and now VBN has shortened the production chain even further.

VBN's new heat treatment machine, a so-called URQ-HIP (Uniform Rapid Quenching-Hot Isostatic Pressing), was recently inaugurated at the company. It offers "HIP:ing." heat treatment and rapid quenching. In this way, pore-free materials are guaranteed, but above all, VBN will be able to develop the alloys further, for instance through even higher hardness and toughness. VBN has continuously invested in developing alloys with better properties than traditional ones, which they have demonstrably succeeded in doing.

Now VBN's materials can both be further improved and delivered faster to the growing customer base. Another important aspect is sustainability. In

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addition to the direct minimisation of unnecessary heating, as well as reduced transport, the machine has been equipped with a recycling system for the process gas, which further reduces the environmental impact.

"We have long planned for a URQ-HIP at the company, so it means a great deal that it is now in place! Above all, we are happy to have integrated another part of the production chain, so that we can significantly shorten our delivery times," says Magnus Bergman, CEO of VBN Components.

vbncomponents.com

Machine Tool Builders

INTRODUCES RECONTROL/ RETROFIT PACKAGE FOR LARGER FORM GEAR GRINDING MACHINES

Machine Tool Builders Inc. has introduced a comprehensive new recontrol/retrofit package for larger-capacity profile grinding gear machines with outdated controls that add highly desirable performance at a fraction of the cost for new machinery.

The package is built on state-of-the-art Fanuc or Siemens CNC platforms and includes MTB's *Human Machine Interface (HMI) with Profile and Worm Conversational Software* designed to simplify the operator's programming, setup, and operational tasks, and help reduce costly nonproductive time as well as the risk of operator error.

In addition, the MTB package includes provisions for advanced, fast, and flexible onboard wheel dressing, as well as optional on-board inspection featuring the latest Marposs or Renishaw 3D scanning probe technology (depending upon the machine, control choice, and application). The package includes all required mechanical and electrical components—standardized, up-to-date, and easily replaceable to help avoid early obsolescence.

"With the rate of today's controls obsolescence increasing and the longevity of the physical machine tools today, upgrading your controls platform becomes important to remain competitive," says MTB's Ken Flowers. "This new recontrol/retrofit program is the best way for companies to extend the productive life of their older machines for years to come, take their performance to levels expected today, and at the same time save tremendously versus the cost of new equipment."

The MTB recontrols/retrofit program is available for all major gear grinding machine makes and models, in size ranges 400 mm and above, and can be performed at the customer's facility or at MTB, depending on the customer's location, requirements, and machine size.

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CTI USA Symposium 2023 Recap

Range anxiety, infrastructure debates, raw material shortages and unanswered questions shake up automotive's move toward electrification—the journey won't be easy, but the industry will push technology until it finds a way.

Matthew Jaster, Senior Editor

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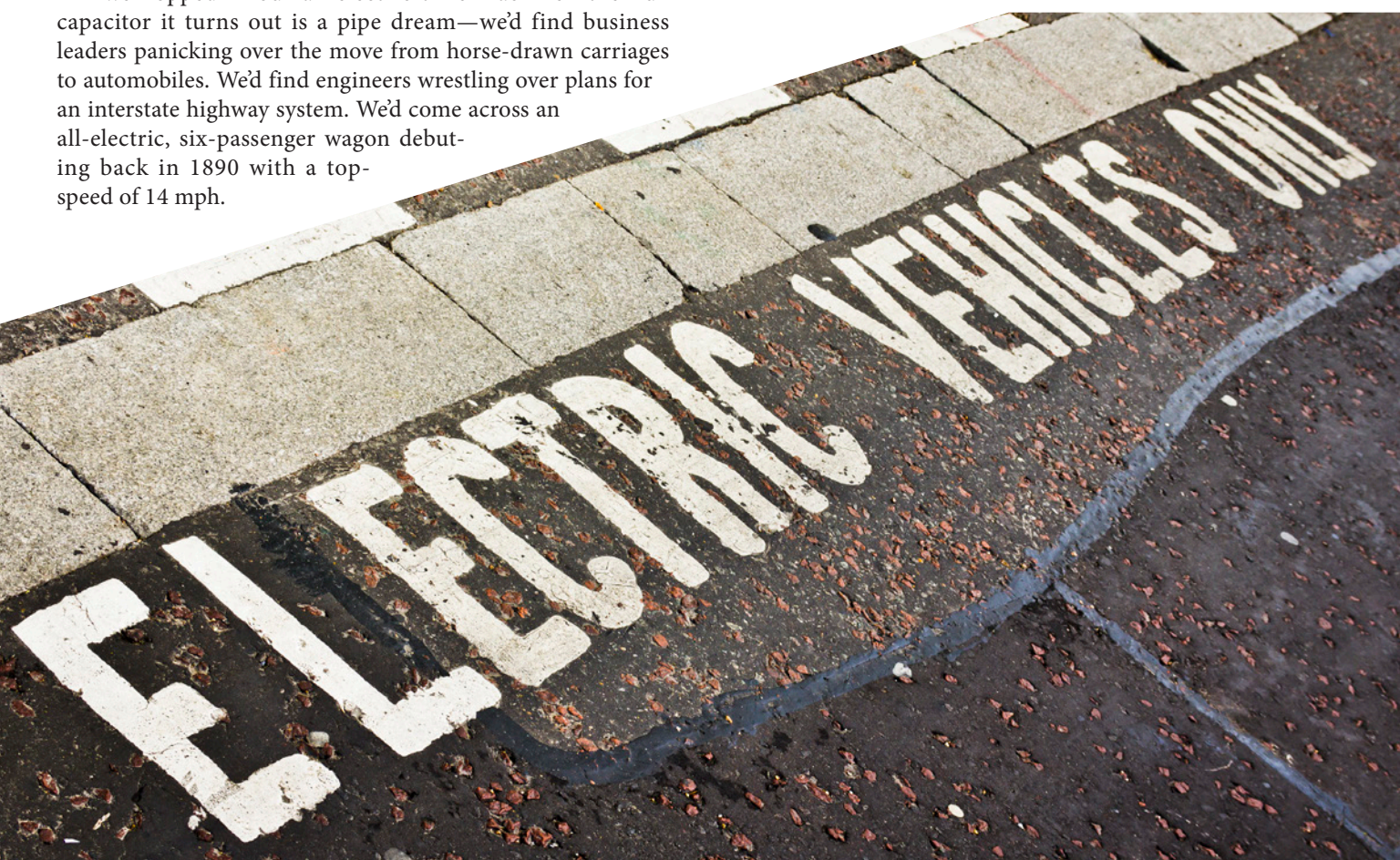
Our global push towards electrification continues to produce skepticism, pessimism, and doubt despite the many obstacles the automotive industry has overcome. There are good ideas, bad ideas, and the occasional terrible idea still on the table, but hearing all the debates, challenges and future considerations at the latest CTI USA Symposium in Novi, MI, reminds us EVs weren't built in a day—and batteries, charging stations and all-electric heavy-duty trucks weren't either. What we should appreciate—despite all the noise and uncertainty—is the men and women rolling up their sleeves and trying to solve the many challenges occurring in the e-mobility and electrification space.

If we hopped in our all-electric time machine—the flux capacitor it turns out is a pipe dream—we'd find business leaders panicking over the move from horse-drawn carriages to automobiles. We'd find engineers wrestling over plans for an interstate highway system. We'd come across an all-electric, six-passenger wagon debuting back in 1890 with a top-speed of 14 mph.

The point here is the electrification of the automotive industry has *so many* obstacles to consider before we meet our future vehicle requirements—but the transition is taking place no matter what side of the argument you land on. As a yearly attendee to the CTI Symposium, the dialogue and debate over the right technologies and infrastructure to meet our e-mobility goals is always in question—as it should be.

"We're right on the verge," said Jason Gies, vice president, product and channel management at ABB e-Mobility, USA. "I don't care if it's charging technology, battery technology or vehicle technology, we're still in an evolution period and though it may take a few more years, we're still heading in the right direction."



Patience is a priority even with strict 2030 climate and sustainability goals right around the corner.

"We need to give the technology a chance," said Don Hillebrand, deputy associate director, Argonne National Laboratory USA. "10 years ago, the average range of an electric vehicle was 63 miles, this last year the average range was 257 miles. Technology is moving behind the scenes at the same rate regarding new battery technology, infrastructure and charging initiatives."

Despite political undertones from both parties here in the United States, the truth is that most Americans want to drive a vehicle with performance, comfort, style, and technology benefits that won't hurt their bank account at the gas station. We're still a consumer-driven society, of course.

Many of the panelists at CTI urged attendees to consider EVs as a "second vehicle" while the technology continues to go through growing pains.

"Most people could have a BEV today as a second vehicle, this is the mindset we need to consider," said John Juriga, global head of energy management and vehicle performance, Stellantis USA. "Let's not worry about these huge batteries for larger vehicles, if we do this the right way, we can still reach our sustainability and energy goals. There are so many different options to consider in the market right now."

Tommy Doran, manager EV infrastructure charging experience at GM, summed up the state of the EV market like this, "Once a customer gets in and drives an EV many of the doubts start to go away. This anxiety will eventually disappear. We must focus on the pros instead of the cons."

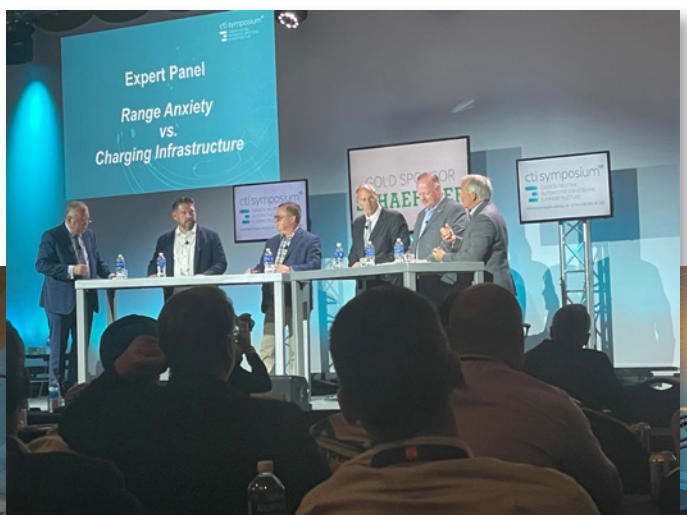
A platform like CTI—committed to discussing EV and e-mobility trends in North America, China and Europe on a yearly basis—helps bring all these engineers and manufacturers together to sort out the chaos.

"We have to all work together on a common carbon-neutral footprint," said Patrick Lindemann, chairman, CTI Symposium USA. "What can we do to increase efficiency and reliability, reduce cost and at the same time reduce the upstream of CO_2? CTI is actively demonstrating how to keep pace and stay ahead of customer, environmental, institutional, and economic demands."

Technology Talk at CTI

A couple of pages in the magazine can't examine two full days of presentations and panel discussions, but here are a few examples of new technology discussed at the symposium:

FEV believes BEV batteries will hold a major share of >90 percent of global cell production due to high-capacity demand through 2035. FEV together with the production specialist for aluminum hot sheet forming, Impression Technologies (ITL) recently presented a battery housing concept for electric vehicles. Utilizing a hot form quench technology, it makes optimum use of the space available for energy storage. For this purpose, the demanding structural requirements for this component are implemented in a novel way. By completely laying the structurally relevant components on the outside and at the



same time an integration of the battery housing into the overall vehicle, installation space for additional battery cells is created.

Dana is using its engineering experience in vehicle electrification. Everything from in-house gearboxes, low- to high-voltage motors, inverters, and controls to thermal and battery management in off-highway, light vehicle, and commercial vehicle markets. Dana's complete e-Propulsion and e-Power systems provide customers with a turnkey solution for the design, development, integration, and upfitting of electrified technologies to the vehicle chassis. This fully integrated electric vehicle solution leverages Dana's core technologies in electric vehicle architecture, vertically integrated systems engineering, and core product portfolio in integrated electric systems to accelerate the time to deliver vehicles to market.

The increased development of electric and hybrid drive systems has shown that manufacturers require testing capacities directly on site. Atesteo has reacted to the needs of the market by searching for a site for new headquarters in the United States. The German company plans to start operations at Atesteo North America, East Lansing, MI in 2023.

Atesteo plans to start with 10 test benches, gradually increasing capacity to 20. The company will serve current and future customers from the automotive industry and transmission development sectors in the United States directly in Michigan with a full range of drivetrain testing services supporting their drive system development efforts early on.

Automotive manufacturers and powertrain developers need NVH testing on electric powertrain components and on the overall system to optimize acoustics at the vehicle level. Because today, the quality of a vehicle is no longer determined only by performance, efficiency, and design. Factors such as noise and vibration are becoming increasingly important comfort aspects that influence NVH performance in electromobility. Therefore, Atesteo uses novel test capacities for the acoustic optimization of electric drives.

Eaton continues to expand and evolve its global e-mobility business design capabilities, technologies, and operations to support global electrified vehicle manufacturers. These upgrades will support Eaton's efforts in delivering electric vehicle solutions to passenger cars, commercial vehicles, and off-highway OEMs globally.

The Breaktor circuit protection technology from Eaton is an advanced circuit protection solution for electrified vehicles that combines the function of fuses, pyro switches and contactors into a single coordinated device. As EV power levels increase, Breaktor circuit protection technology solves the ever-increasing coordination challenge between fuses and contactors and provides protection for high-power battery and inverter systems.

In addition to Breaktor, Eaton has high-voltage, fast-acting fuses in numerous global electrified cars. Both Breaktor and fuses can be integrated into power distribution units (PDU) and battery disconnect units (BDU) to serve as complete power distribution and protection solutions for electrified vehicle manufacturers.

The prediction of gearbox reliability does not start from a clean sheet. Gearbox fatigue has been a subject of mathematical methods that have evolved over the years and implemented in standards (ISO 6336 for gears, ISO 16281 for bearings) that have become universally implemented. These have been the basis of the technical implementation of a project from Hexagon AB.

The Digital Twin has included many of the refinements that have been proven to be essential in the prediction of gear and bearing performance over recent decades. Housing stiffness has been shown to impact on gear and bearing misalignment and hence life, and this is included; likewise, gear micro-geometry is introduced to accommodate misalignment from system deflections, impacting gear stress and fatigue; finally, bearing internal load-sharing, pre-load and misalignment are also included.

All these influences are part of the commercial software package, *Romax ENDURO,* which has been marketed under various Romax names since its release in 1994 and which was acquired by Hexagon in 2020.

Both ISO 16281 and ISO 6336 output component fatigue damage. This does not predict failure. Rather, 100 percent damage for the L10 life of bearings indicates 10 percent failure, whereas 100 percent damage (a safety factor of 1.0) for gears indicates 1 percent failure.

Being a long-term user of Romax, an OEM customer had a confirmed model of the gearbox which could be used for a Digital Twin study. This model had been used in the design of the gearbox in question (some might call it a 'Design Twin'), and a 'Design Duty Cycle' had been established by the OEM with the intention of representing the usage pattern that the vehicles would see during an anticipated working life.

However, the OEM was aware of the potential for using data to learn more about their applications. In recent years, the OEM installed on its standard production vehicles the instrumentation that is necessary to transmit to the cloud significant quantities of CAN (Controlled Area Network) data. It is important to note that this set up was established to understand the vehicle as a whole, not just the gearbox—this gearbox Digital Twin worked with data that was already being downloaded.

Check back on the *Gear Technology* and *PTE* websites for further coverage on the EV and e-mobility markets.

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Efficient Turnkey Machining of Complex E-drive Components

Perfect E-Shaft with Integrated Production Solution

Kerstin Stumpf-Trautmann, Head of Marketing, DVS Technology Group

For the transmissions of electric vehicles to develop the desired high torque under all driving conditions, a very large gear ratio is needed, which requires high speeds. And to ensure sufficient momentum at all speeds and enable the driver to accelerate without shifting gears, the electric drive must achieve up to 15,000 rpm, which is about three times that of a typical combustion engine. This puts a lot of strain on the rotor shaft. The manufacturers of rotor shafts are thus facing new challenges, such as the significantly lower shape and position tolerances and the need for greater machining precision.

Figure 1—EV gearbox showing the components that can be manufactured with machines from the DVS Group.

Lower shape and position tolerances as well as fine surfaces also help to avoid vibrations from moving components and thus minimize the background noise of the drive system, i.e., optimize the NVH behavior. Since electric motors work virtually silently, the noise emissions are much more critical than with a petrol or diesel engine.

Figure 2—Illustration of an EV drive shaft. (Source DVS Technology Group)

Another challenge: the small installation space. In EVs, the batteries still take up most of the space. The so-called "E-axis," which comprises an electric motor, transmission, and power electronics, must therefore be very compact. For the drive shaft, this means that there is only an extremely small amount of tool run-out available for the manufacture of gears, for example.

Integrated Production Solution for E-Shafts

In order to meet these very stringent requirements, the DVS Technology Group (DVS), an association of experienced companies with core competencies in the field of machining technologies, has developed a forward-looking, integrated production solution for the turnkey machining of monoblock e-shafts from raw to finished parts. This means that these complex drive components can be manufactured up to 40 percent more economically.

Soft machining by skiving

First in the production chain is the Pittler V300, an innovative multi-technological production solution that combines fully automatic turning, milling, and drilling operations as well as gear cutting using the highly productive skiving process. This enables complete soft machining of the hollow shafts in just two setups on one machine. It reduces setup, transport, and idle times, which means that the total processing time is also shorter. In addition, processing on just one machine means lower investment costs and a shorter time-to-production.

Skiving is used to produce gears in green machining. This is a metal-cutting

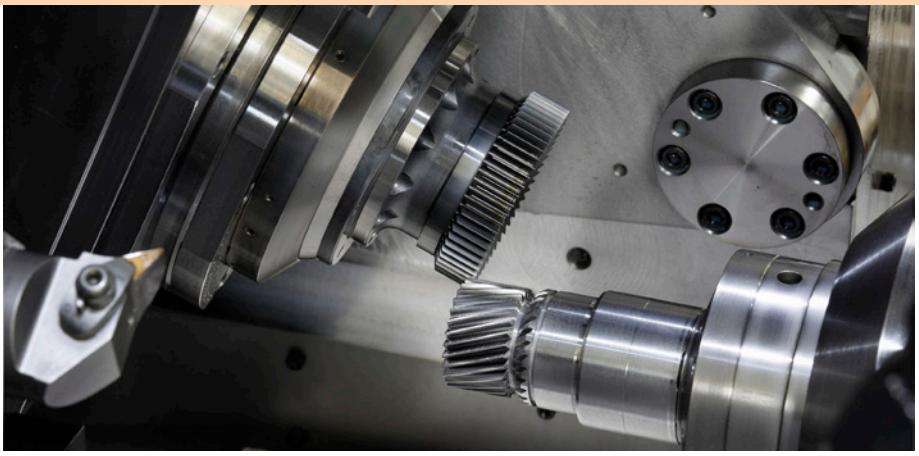
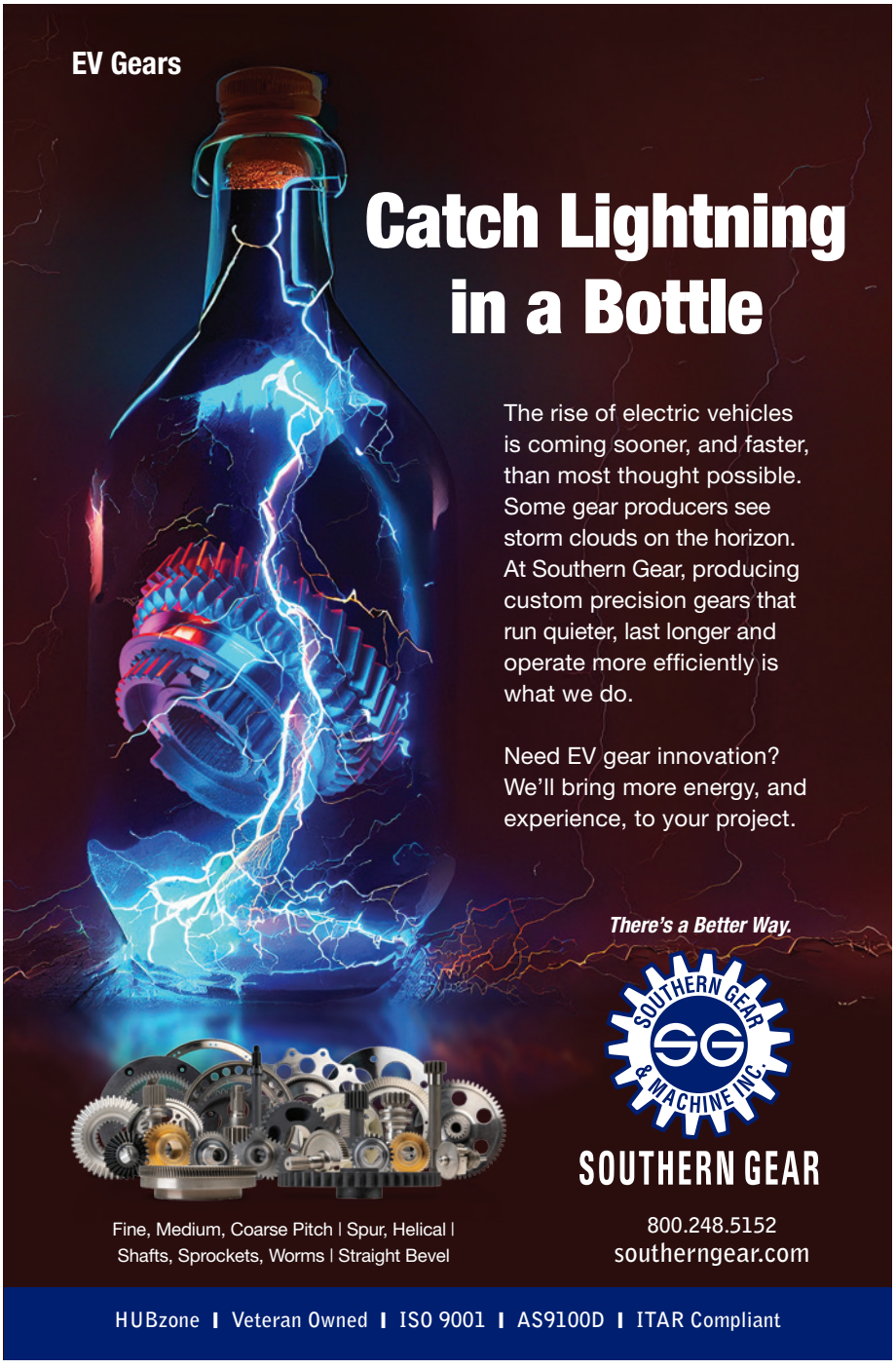


Figure 3—Skiving with running gear on an e-shaft. (Source: Pittler T&S)



process used in the production of gears which is based on a patent filed by Wilhelm von Pittler in 1910. Thanks to the latest developments in manufacturing technology, skiving has emerged as an efficient and flexible alternative over recent years for the gearing of components.

One of the characteristics of skiving is the oblique arrangement of the tool axis to the workpiece axis (Figure 3). This is called an axis intersection angle. This positioning of the tool, a defined axial feed, and the coupled speed of the tool and workpiece results in a relative movement. This relative movement "peels" the tooth gap out of the workpiece along the main cutting direction.

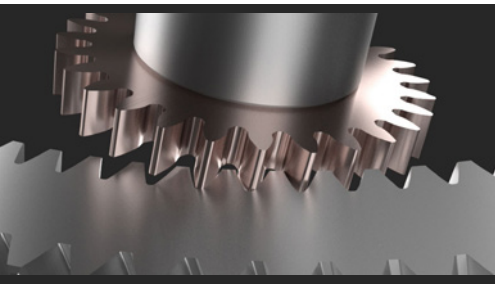


Figure 4—Animation of the skiving process. (Source: Pittler T&S)

The contact kinematics of skiving require a tapered tool when the cutting point is on the direct line connecting the tool and workpiece axis. To avoid this, the DVS Group has further developed the power-skiving process: The cutting position is shifted in the Y direction out of the direct line connecting the tool and workpiece axis. This optimization enables the use of cylindrical tools with a substantial increase in tool life through frequent regrinding of the tools. Accordingly, the cost of tools is reduced significantly.

The quickly changing cutting forces of the skiving process cause vibration in the machine and the control system. That is why skiving requires extremely rigid machine structures, tool and workpiece carriers as well as highly optimized control circuits. This is precisely what the Power Skiving machine concepts from DVS were designed for.

Skiving Technology Comparison

Compared to other processes, skiving stands out due to a number of processing characteristics:

Figure 6—Skiving technology comparison. (Source: Pittler T&S)

Skiving

Advantages
- Short primary processing time
- High metal removal rate
- Moderate tool costs
- Can be combined with other machining methods
- Production of internal and external gears in one clamping

Disadvantages
- New technology

Shaping

Advantages
- Flexible
- Simple technology

Disadvantages
- Long primary processing times due to idle stroke (about three to eight times longer)
- Higher workpiece costs
- Can not be combined with other processes

Figure 8—Shaping technology comparison. (Source: Pittler T&S)

Hobbing

Advantages
- High metal removal rate
- Short primary processing time
- Low tool costs
- Proven technology

Disadvantage
- Suitable only for external gears
- Requires larger run-out compared to skiving

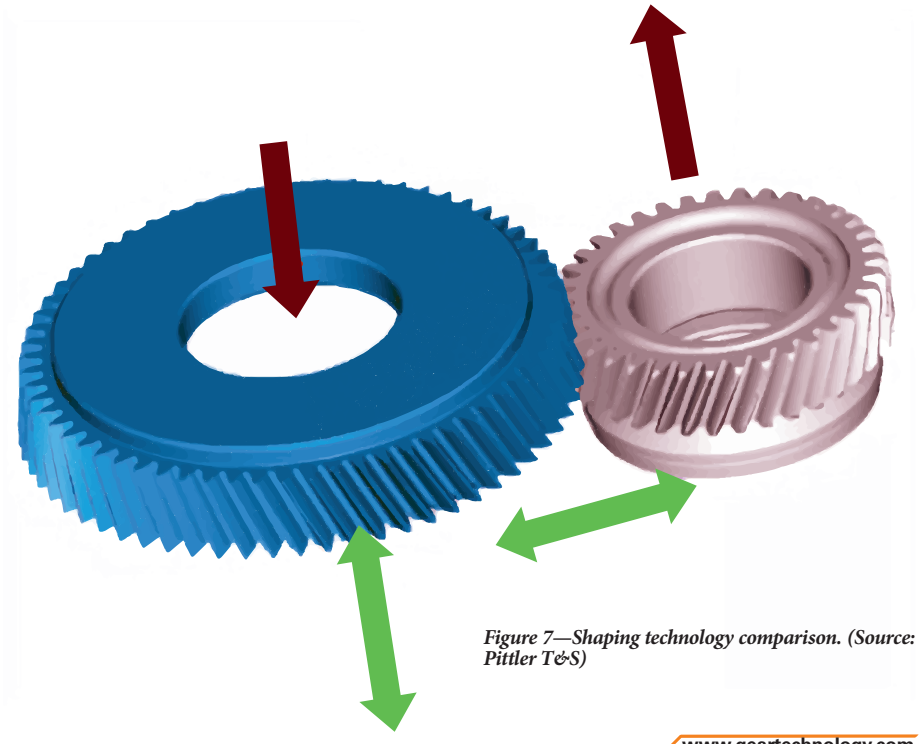


Figure 7—Shaping technology comparison. (Source: Pittler T&S)

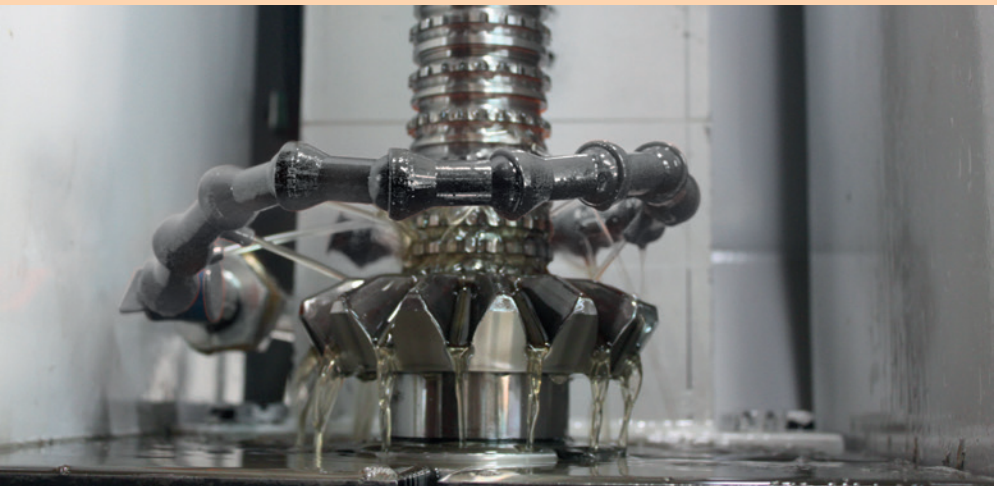


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Figure 9—Broaching technology comparison. (Source: Pittler T&S)

Broaching

Advantages
- High throughput with large quantities
- Very short primary processing times

Disadvantages
- Suitable only for external gears
- Requires larger run-out compared to skiving

Comparison Summary

Using skiving for the production of gears with green machining has a number of advantages. Two of the unique selling points are the possibility of manufacturing internal and external gears in one clamping as well as the possibility of machining all-in-one or combine it with other machining.

Grinding and Hard Turning on the Buderus 235VH/M

The heat treatment of the shaft is followed by the first hard-fine machining step. Most rotor shafts have a similar design due to the required properties. A typical monobloc e-shaft consists of a running gear or spline, two bearing seats, two sealing surfaces, and a rotor seat. Depending on how the laminated core is fixed, the rotor seat is additionally provided with notches or spanner flats.

Figure 10—Machined rotor shaft with running gear, bearing seat, sealing surface, and rotor seat. (Source: DVS Technology Group)

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The bearing seats and sealing surfaces are machined by plunge grinding (Figure 11) and the rotor seat by peel grinding or plunge grinding (Figure 12). End-faces and cut-ins are usually machined by hard turning during the same clamping, as a rotary turret can be integrated into the Buderus 235VH/M if required.

Tolerances in the micrometer range should be achieved on the bearing seats, sealing surfaces, and rotor seats. Experience has shown that typical tolerance requirements range between 0.004–0.03mm for cylindricity, 0.002–0.025 mm for roundness, 0.005–0.08 mm for coaxiality, and 0.008–0.1mm for concentricity. For sealing surfaces and rotor seats, it is also necessary to obtain a peak-to-valley height of up to 1 µm.

This accuracy is possible by grinding with the Buderus 235VH/M in a single clamping.

The 235VH machine concept stands for the highest quality, low unit costs, and maximum adaptability. The innovative machine platform is specially designed for the machining of rotationally symmetrical shaft components with a diameter of up to 300 mm and a length of up to 1,000 mm.

The machines enable both combined and simultaneous machining processes. The flexible configuration options enable a wide variety of machining technologies from grinding, hard turning, and honing to the use of powered tools.

Buderus is also a specialist on the use of center drive technology. The latest development is the 235VM center drive machine with an advanced drive head. This head achieves a working speed of up to 2,500 rpm and thus also enables the hard turning of components. The main advantage of the center drive technology is the fact that inner and outer geometries can be machined in just one clamping, which results in greater precision as well as significantly higher efficiency.

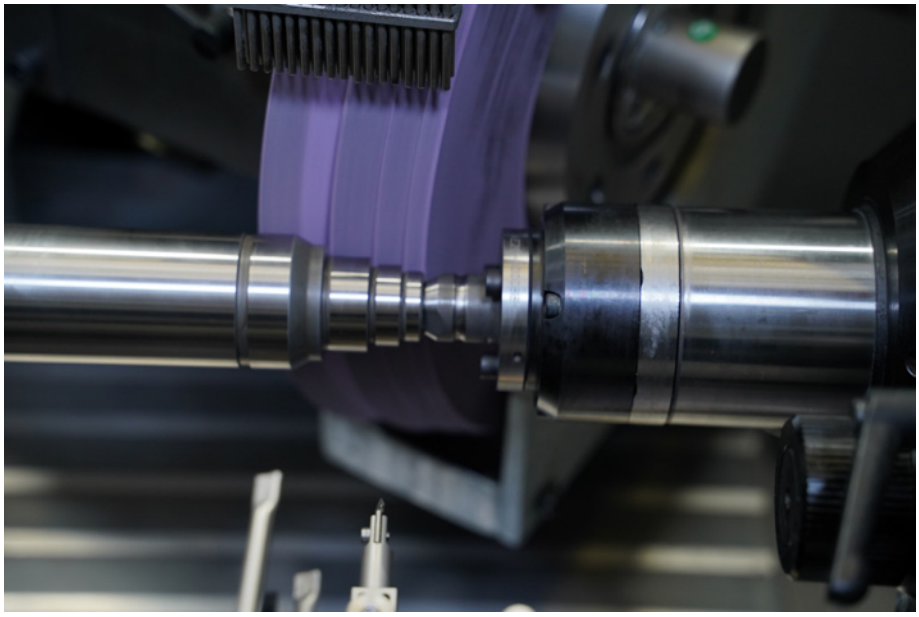


Figure 11—Grinding in single clamping. (Source: BUDERUS Schleiftechnik)

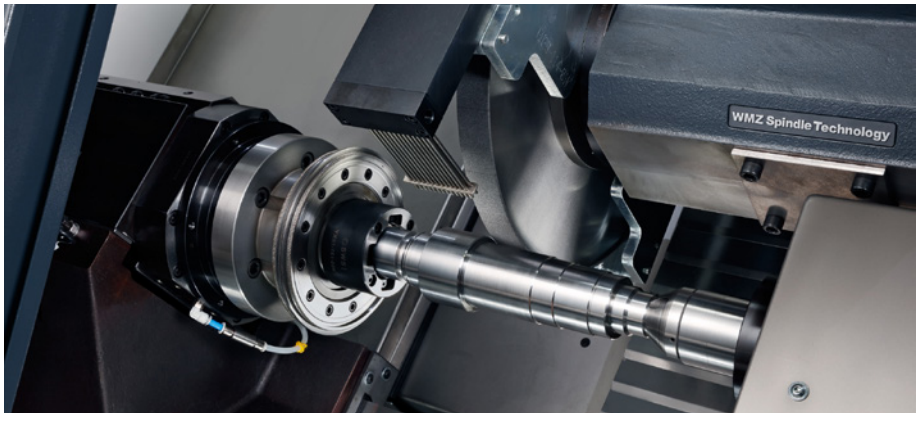


Figure 12—Grinding in single clamping with WMZ Spindle Technology. (Source: BUDERUS Schleiftechnik)

Gear Honing—Advantages of Honing for Generating Grinding

The last step in the DVS process chain before the hollow shaft is ready for installation is gear honing. In recent years, the DVS subsidiary Präwema has further developed a technology that enables lower friction losses when the gears roll off. This so-called "power honing" process is now standard in much of the international vehicle industry. The honed gear surfaces are critical for the reduction of noise levels and to lower energy consumption in electric vehicles.

High workpiece qualities are achieved through some unique processing properties of honing. For example, as the cutting speeds do not exceed 12 m/min there is no grinding burn, which is usually an almost invisible byproduct of grinding due to too high cutting speeds. A high-induced surface tension can also increase the service life of the gearing and reduce the risk of pitting. Moreover, the entire toothing width is machined simultaneously using the plunge method, and the surface structure runs diagonally across the flank to improve quiet running.

In addition, short cycle times, low tool costs, and the possibility of processing closely adjacent gears that cannot be processed by a worm grinding wheel make honing extremely economical.

The extremely productive process enables ultra-precise machining in gearing qualities IT below 6 and super-fine surfaces with an Rz under 1. For optimal NVH behavior, specific micro-geometries (e.g., profile angle and profile shape deviations) can be used for the running gears. Test results are available upon request.

Tool Solutions for Gear Honing

Another important factor for gear honing are the tools and their geometry and material. The tool solutions tailored to the respective process ensure the highest level of quality when it comes to the surface and profile of toothed components. The product range of DVS Tooling

covers the entire scope of gear-honing tools. The main products include the Präwema Original honing (Figure 12) and the vario speed dresser (VSD) dressing tool (Figure 14).

The forces applied during gear honing for highly precise machining results are enormous. These forces in combination with component-specific influences can lead to undesirable vibrations during machining, which must be absorbed to prevent inaccuracies. This is why Präwema Original honing rings have two zones: The geared processing zone enclosed by a second zone, the so-called damping zone. This second zone dampens the vibrations that occur during machining, preventing their transfer onto the honing head and the machine.

Pre-cut Präwema Original honing rings feature quality that comes much closer to the required series quality than comparable honing rings on the market, which is usually only achieved after dressing during the process. We make this possible with vario speed profiling (VSP), which yields extremely high pitch accuracy and profile shape quality through profiling during rolling, while at the same ensuring that the entire honing ring gearing remains at a constantly high quality.

Figure 13—Honing ring for Präwema.

The latest generation of Präwema SynchroFine gear honing machines uses VSD technology for dressing the honing tools. VSD is a dressing process with a geometrically defined cutting edge in which only the leading cutter of the dressing tool enters the honing ring. Compared to conventional dressing with diamond dressing gears, VSD dressing tools achieves previously unattainable profile shapes and accuracies. The achievable roughness improves from 2.0 µm to 1.3–1.4 µm. Using our proprietary DVS LaserCut finishing technology on the VSD, the surface quality and profile quality of toothed components can be increased even further. During a special vibration process, the achievable roughness can be increased from 1.3–1.4 µm to 0.8 µm using a refined VSD and a honing ring with special grain. The downside is that the honing time increases by three to five seconds.

Economy with Maximum Precision

By precisely coordinating all process steps, the integrated manufacturing solution developed by the DVS Technology Group enables the production of high-quality rotor shafts that meet all the requirements of EV transmissions. With this process, the DVS Group also enables highly efficient production while at the same time significantly reducing the cost per unit. In some cases, the costs are up to 40 percent less compared to conventional production.

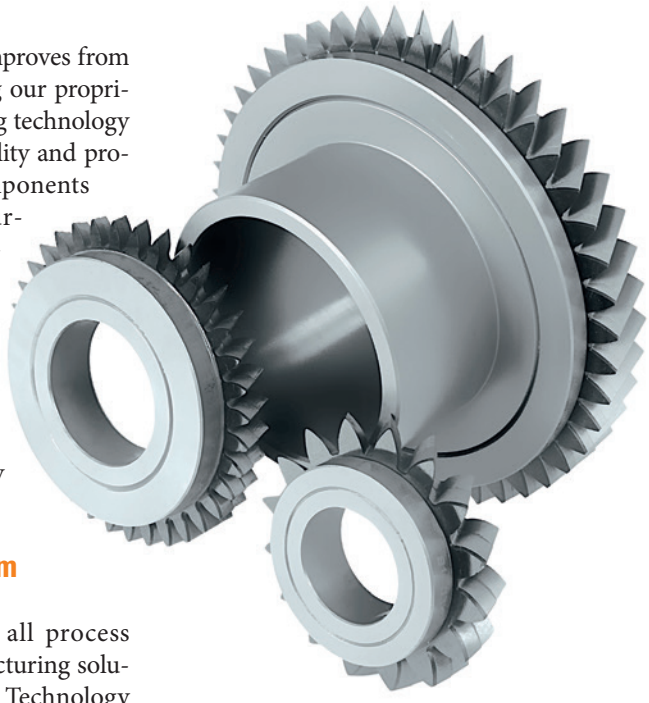


Figure 14—Vario speed dresser (VSD) group. (Source: Präwema Antriebstechnik)

dvs-technology.com

ABB's collaborative robots are made for a huge range of tasks, in operations of every size. They're easy to set up, program, operate, and scale. Courtesy ABB.

The Inside Track on Automation, Robotics and Motion Control

Eight takeaways from Automate 2023 that gear manufacturers should consider

Matthew Jaster, Senior Editor

Automate 2023 in Detroit featured 757+ exhibits with 30,000+ registrants. The success of the 2022 and 2023 events prompted A3 to continue the show as an annual event moving forward. Historically, the show was biennial until the pandemic changed scheduling.

"Over the past several show cycles, Automate has grown substantially," said Jeff Burnstein, president of A3. "What's more, the pace of change in automation is staggering—attendees and exhibitors alike asked that we increase our frequency to an annual show to help keep them ahead of the curve."

1. Companies are (Really) Investing in Education

The manufacturing sector has always invested in training and education, but something feels different in 2023. ABB has invested more than $22 million in robotics and will continue to prioritize education in the future.

"Businesses in the future will need employees with experience in applying automation to perform a variety of processes," said John Bubnikovich, US Country Lead Robotics & Discrete Automation, ABB Robotics. "As robots become more prevalent in factories, warehouses and other environments, there will be an increase in partnerships between robot OEMs, system integrators, manufacturers, and educators to provide people the necessary skills for an automated future. There are already more than 150 examples of ABB partnerships with educators in the United States, where our robots, RobotStudio simulation and programming software, and augmented reality and virtual reality tools are used to teach students of all ages the skills needed to program and use robotic automation."

ABB has transformed Autonomous Mobile Robots (AMRs) with the addition of Visual Simultaneous Localization and Mapping (Viusal SLAM) technology, in collaboration with Swiss-based AI specialist, Sevensense.

Automation, robotics, and Industry 4.0 are expanding their educational reach. The School of Mechatronic Systems Engineering at Simon Fraser University in Canada is offering the Siemens Mechatronic Systems Certification Program (SMSCP) to help students prepare for the high-tech job market. SMSCP is a comprehensive industry skills certification program offered in collaboration with Siemens focusing on system understanding, troubleshooting, and problem-solving skills which has been used in training Siemens' own employees.

Schaeffler is also looking into expanding mechatronic education and training to develop the individual and grow the business.

"MIT, Stanford have offered these programs for decades. It still seems to be a coastal thing, however," said Mike Paschke, industrial automation national sales manager at Schaeffler. "You have plenty of mechatronic and robotics classes in Boston, New York, and Silicon Valley. This is where you'll find the lion's share of the big players in robotics."

"I am, however, seeing a difference in the kids coming out of school today," said Craig Hooker, director research and development, industrial and mechatronics at Schaeffler. "Even if they don't have a mechatronics background, they'll typically have a mechanical engineering degree with an interest or passion in robotics. They have a good fundamental understanding that they can build on once they start their careers."

2. Addressing Lead Times

Steve Alexander, vice president of WI Operations and Standard Products at Acieta, agrees that price per part is important in manufacturing today, however, customers will pay a premium for beating lead times.

"If you can be quicker than your competitor, you will win that business. You're also going to open more capacity for more work. These are the things that should be considered when integrating robotic automation into your manufacturing process," Alexander said.

Automation, according to Alexander, can address labor shortages, bolster lead times, increase capacity and position a manufacturer for immediate growth.

In a report from the Institute for Supply Management lead times are finally coming down post-COVID, but a larger rebound and recovery period is going to need more new orders to really take off. Is it time to consider new automation and robotic investments for your shop floor?

3. Cobots are Moving in New Directions

Advancements in machine vision and machine learning software are opening new market opportunities for collaborative robots. In the coming years, logistics, education, medicine, and retail will see upticks in the use of cobots to replace personnel in quality/inspection, packaging, picking and placing, and loading/unloading applications. Prices for some of these tools will also come down allowing small to mid-size job shops the ability to incorporate these technologies on their shop floors.

These cobots offer several advantages over traditional automated systems in terms of safety, quality control, accuracy, reduced labor requirements, shorter lead times and more.

The Cobot Feeder from PBC Linear provides a platform for storing, staging, and safely delivering parts.

4. Automation and the Skilled Workers Gap

The skilled worker shortage seemed to take an even bigger blow during the pandemic. Shop floors that need to run three full shifts to keep up with production demands can't find the personnel necessary to do the job. They may not need to worry about this in the future thanks to automation and mobile data communication.

When these robots are working in factories during second and third shifts, shop floor personnel will be on call via a smartphone, tablet, or desktop computer, but will not have to be onsite unless an issue occurs. Fundamentally, this is where automation and robotics can be the most helpful according to companies such as PBC Linear, Festo and SEW Eurodrive. Lights out manufacturing will continue to gain momentum in the coming years as job shops find more affordable technologies that mirror larger OEMs smart factory strategies.

"We've consistently had more than 800,000 open manufacturing roles nationally for quite some time. And it's going to be really difficult, even with perfect recruiting efforts, to close the gap. So, I think the biggest opportunities with automation are this: it's going to enable the same size workforce to do more. And in this moment, I call it "glocalization," where we have supply chains that are regrowing U.S. manufacturing more is certainly needed. We need more scale, more speed, more sustainability, and now we have all the tools we need to deliver those," said Barbara Humpton, president and CEO, Siemens Corporation USA in a Q&A with the Automate Team.

5. ChatGPT isn't Taking Over…Yet

AI is on everybody's minds except the robots! Seems like every presentation at Automate had a question or two regarding the fear and trepidation of artificial intelligence in 2023. Even James Cameron is waiting to see how AI innovations "shake out" before tackling another Terminator film.

Is there real cause for concern? Robert Huschka, vice president at A3, moderated two fascinating panels including "What ChatGPT, Large Language Models and Other AI Advances Mean for Industrial Automation." Panelists included employees from GM, NVIDIA, GE Research, and Microsoft. The second, "Executive Roundtable: The Future of Robotics & Automation in North America," included panelists from Siemens, ABB, Fanuc, and FedEx.

Panelists discuss "What ChatGPT, Large Language Models and Other AI Advances Mean for Industrial Automation."

Huschka asked both panels how soon the manufacturing floor would mirror the Tony Stark, Iron Man, robotic assembly process where he's talking to the AI system that is manufacturing his latest suit of armor. Both panels agreed that while we're not quite there yet, there are areas where AI can improve production processes.

Examples of AI products at GE Research include reduced downtime on assets through AI-driven proactive intervention (for e.g., airline delays and cancellation), increased throughput (for e.g., optimal control of wind turbine settings to maximize farm output), or reduced costs (for e.g., optimal power plant operation to minimize fuel costs).

"I think there's a lot of opportunity for AI to be incorporated into current and existing applications," said Bubnikovich at ABB Robotics. "We're just on the cusp of new AI applications. Five years ago, we started to see picking and vision advancements, but in terms of generative AI there must be a need where it provides value."

"Robots are only going to do what we program them to do," added Mike Cicco, president and CEO, Fanuc America Corporation. "In the case of ChatGPT, it just has a very big brain and can see all these other documents, but when you ask it a question it just pulls from every other document it's using."

Johan Reiman, principal scientist, AI and machine learning at GE Research, summed it up by suggesting to the audience to be skeptical about ChatGPT. We should always ask questions, try out the technology ourselves and be mindful of its advantages as well as its limitations.

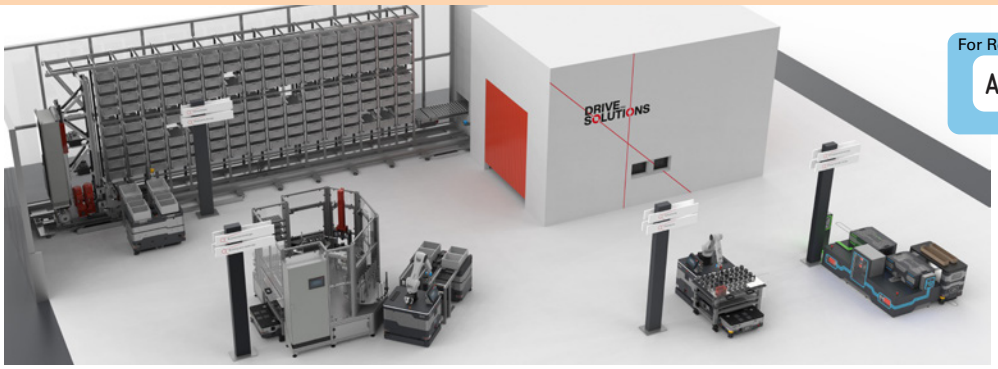
6. Consider Every Automation Format

Articulated robotic arms are typically the showcased technology in manufacturing automation, but the field is growing and changing at a rapid pace. Modern linear transport systems, for example, move parts and products and can assist with adapting production machines for rapidly changing production lots.

Jeff Johnson, mechatronics product manager at Beckhoff Automation, discussed how mechatronic transport systems can offer advantages over traditional robotic automation. This includes the ability to create a mobile handling system, heat or cool products during transport or integrate data communication for condition monitoring and predictive maintenance.

The Maxolution process modules from SEW-Eurodrive offer insight into what tomorrow's world of adaptable production could look like. Performance benefits can be achieved with the aid of supporting automation and future-proof material flow and logistics concepts.

The story of the production process starts at the small parts warehouse. The solutions for the storage/retrieval systems come from the MOVI C modular automation system. From drive technology, control technology, and safety technology to software and visualization, SEW-Eurodrive offers everything from a single source and to suit the relevant application.



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An automation model suggests what the factory of the future might look like from SEW-Eurodrive.

7. Robot Demand is Increasing

The Congressional Budget Office recently forecast that the size of the US labor force will grow by just 0.2 percent annually from 2024 to 2031, and by 2030, it is predicted that more than 2.1 million U.S. manufacturing jobs will be unfilled. This will hamper economic growth and present companies with the need to find new ways to plug gaps in the workforce.

Demand for robots will be particularly strong in countries where companies are planning to re- or near-shore their operations to help improve their supply chain stability in the face of global uncertainty.

In a survey of 1,610 companies carried out by ABB Robotics in 2022, 70 percent of US businesses said they are planning to re- or near-shore their operations, with 62 percent indicating they would be investing in robotic automation in the next three years.

"While much of the mainstream attention has focused on the impact of automation taking jobs, robots will increasingly perform the physically stressful tasks that people are reluctant to perform, helping to moderate industrial and commercial labor shortages," said Bubnikovich. "The continuing advancements in ease of use and flexible performance of robots, including the development of collaborative models with larger payloads such as ABB's GoFa and SWIFTI cobots, mean companies can address skills gaps and make better use of their existing workforces.

8. Stay the Course

Conviction. Conviction. Conviction. If the universe throws a pandemic your way, a skills shortage, a raw material treasure hunt or six months just doesn't go by the books, the lesson here is simple: Keep on keeping on!

If Gregory Robinson, former director, NASA, James Webb Space Telescope, can overcome an exorbitant number of obstacles and challenges—including COVID—to successfully spearhead an astronomy project that was way over budget and years behind schedule, it's possible to get to the finish line of any venture.

"I didn't even want the job at first," Robinson said during a keynote address at Automate. "I was enjoying my job as deputy associate administrator for programs at NASA. They had to twist my arm a little."

With the heavy burden of getting the James Webb Space Telescope program back on track, Robinson celebrated the men and women on the team by prioritizing relationship-building, creativity, knowledge-sharing and understanding the importance of successful collaboration.

Listening to his address at a show full of robotics, automation, and motion control, it was ironic how important the human element still is to achieve any manufacturing and engineering goal despite being surrounded by cobots, AMRs and drones.

Automate 2024 will take place May 6–9, 2024, at McCormick Place in Chicago.

automateshow.com

Gregory Robinson, former director, NASA, James Webb Space Telescope, addresses the crowd during his keynote presentation at Automate 2023.

Figure 6—The desired batch sizes in a given period of time are taken into account in the development of the robot solution.

Custom-Fit Robot Solutions Ensure Fast Parts Flow in Production

EMAG develops integrated automation solutions

Oliver Hagenlocher, Head of Marketing, EMAG

Production solutions with robotic automation are on the rise: With their help, a fast and low-manpower flow of parts can be established within a site—thus reducing unit production costs and increasing production reliability and quality. In this example, EMAG links pick-up machine technology with highly individual robot solutions designed within the requirements of the workpiece and the production process. What are the important details?

According to the "World Robotics 2022" report of the International Federation of Robotics (IFR), there are now around 3.5 million robots in use in industrial production worldwide. The USA is one of the three largest robot markets in the world. Current examples from EMAG show why this is so: The specialists combine their high-performance machines with completely different robot cells—and thus not only ensure highly efficient processes for loading and unloading the machines but also

integrate additional stations for quality assurance, labeling, cleaning, and much more. What is the overarching objective at EMAG when robots are used? "The focus is always on the requirements of the workpiece and the associated production process," explains Jochen Arnold, CEO EMAG L.L.C. "Decisive questions here are, for example, what batch sizes are to be produced in a given period of time and how autonomously the solution should operate. In any case, we are very flexible and adapt in many ways to the existing production environment or space conditions."

With Conveyors, Palletizers, or Drawers

A look at the details shows just how different EMAG's robotic solutions are: Parts can be fed, for example, using infeed and outfeed belts, palletizers, drawers, or bin picking. With the help of these systems, the robot "operates" itself when it picks up or finishes placing new components. Each solution has different strengths and basic conditions. For example, belt or hinge conveyors are an ideal option when the flow of parts needs to be smooth from an upstream production solution to the EMAG machine. The robot can then simply pick up the components from the belt and deposit them again later, with the belts arranged in different ways—depending on the space situation or the desired flow of parts. Pneumatic stoppers ensure that the components are separated. It is also possible to detect the workpiece alignment on the belt using a camera. A highly flexible alternative to this is the so-called "bin-picking systems" ("reach into the box"). Here, the workpieces are in a chaotic position, with the robot arm not only picking the components with the aid of a 3D sensor system but also correctly recognizing and aligning them and feeding them to the next processing step. The system can be used flexibly and configured for many applications.

In contrast, the use of palletizers presupposes an "orderly" start. In this case, the system is loaded and unloaded via a blister cart, for example. It contains boxes stacked on top of each other with corresponding mold nests containing the components—i.e., a relatively large quantity per cart, which an operator simply pushes into a defined position from which the robot can access. The cart with finished parts is in a different position. "One of the things that matter in this kind of solution is that you relate the cycle time of the EMAG machine and the desired man-hours at the machine. So, if the machining cycle within the machine is only a few seconds and at the same time you are aiming for minimum operator effort at the machine, this solution may not be suitable because the carriages would then have to be replaced too frequently. But these are precisely the

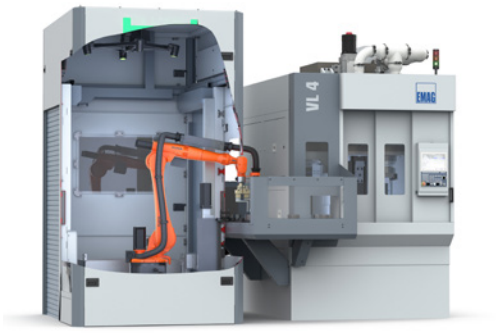

Figure 1—The equipment options of the individual robotic cell (here next to a VL 4) are large—from statistical process control (SPC) to deburring systems.

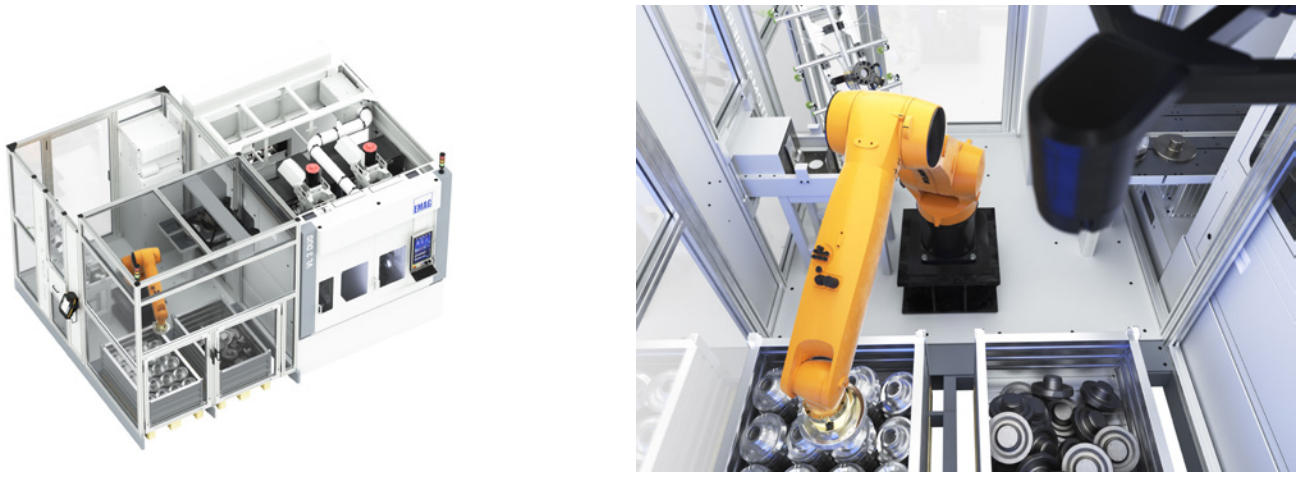

Figure 2—In bin picking systems ("reach into the box"), the workpieces are in a chaotic position. With the help of a 3D sensor system, the robot not only picks the components but also correctly recognizes and aligns them and feeds them to the next processing step.

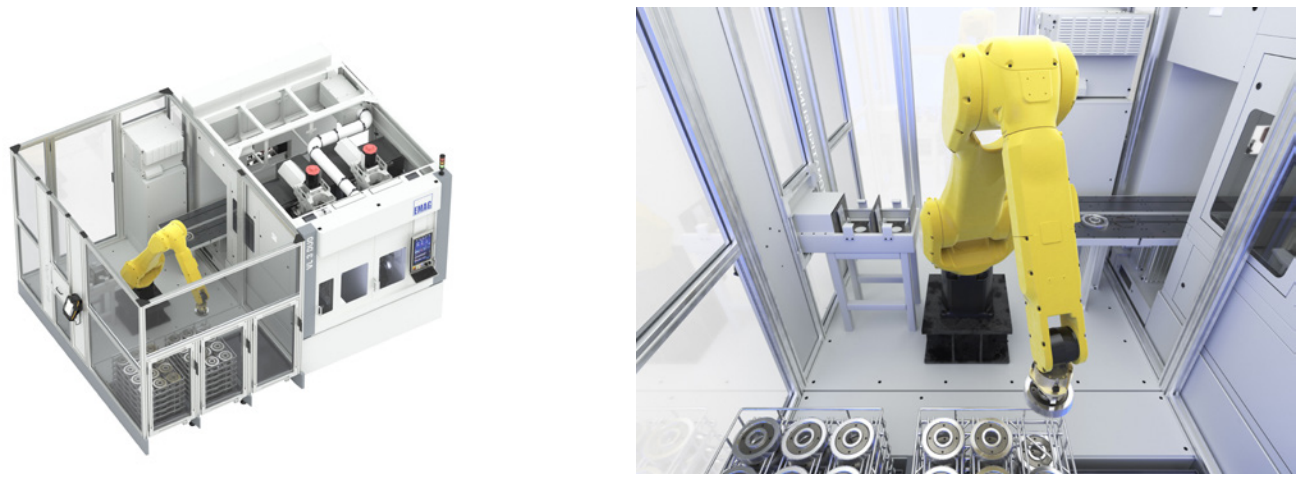

Figure 3—In automation cells with basket stacks, the system is loaded and unloaded by baskets from which the robot picks up or deposits the oriented workpieces. The empty baskets are transferred to the stack by the robot.

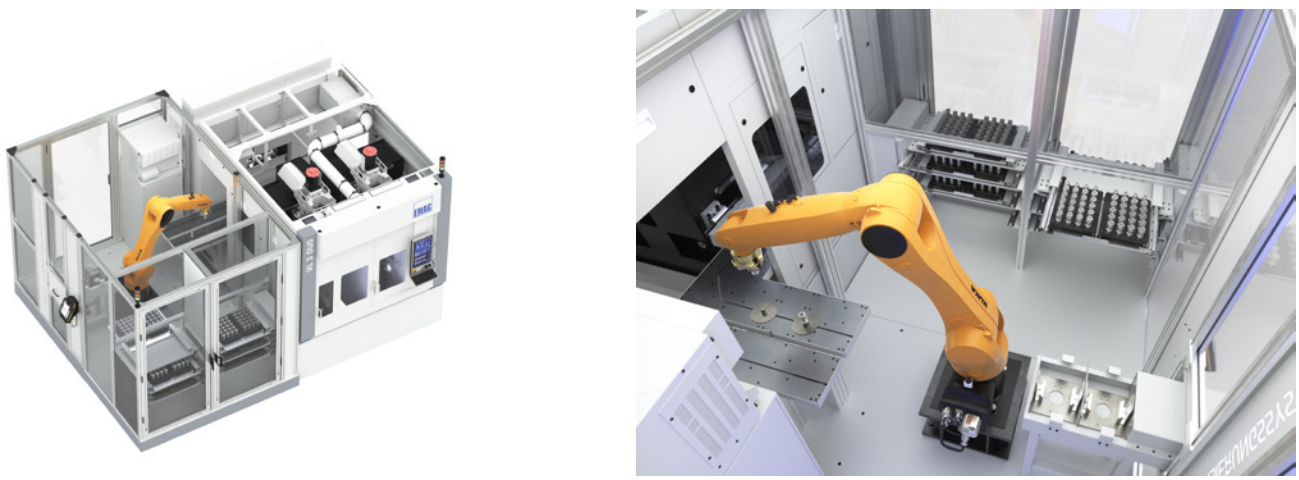

Figure 4—With the drawer system, the workpieces are provided to the robot on different levels. While the drawers are being loaded, the robot in the cell supplies the machine with workpieces.

calculations that we carry out for every robot solution and advise the customer accordingly," explains Arnold.

A drawer system is a conceivable third variant. The workpieces are located in pneumatically movable drawers, which are quickly loaded by blister systems. In this case, three of these drawers are arranged one above the other in a cabinet, allowing a larger number of pieces to be stacked and processed (without intermediate operator intervention) in a small (possible) footprint. Incidentally, loading and unloading of the drawers takes place without interrupting the process—the robot simply continues to work on a compartmentalized drawer.

Number of Robot Solutions from EMAG Increases

The following applies to all these solutions: The equipment options for the individual robotic cell are extensive. For example, it is conceivable to integrate a statistical process control (SPC) including a measuring station. Here, individual components are regularly ejected, measured, and reintroduced for quality assurance. It is also possible to place optical control systems with cameras, a gripper station for processing a wide range of workpieces, small washing and cleaning stations, deburring systems, or laser or engraving stations within the robot cell. The respective solution is then also controlled by the robot. The result is a continuous flow of parts across different technologies. For sustainable success with all customers, EMAG relies on computer-based simulations when planning automation cells. Our experts thus check many factors such as cycle time, accessibility of the robot, material flow in large production lines and much more. Virtual commissioning - that is, testing planning data on a virtual machine - is similarly important. In this way, unforeseen errors can be detected and eliminated at an early stage of development. What's more, "real" commissioning is much faster later on.

"Overall, it is safe to say that more and more robotic solutions are being used on our machines, although this is also obvious," summarizes Jochen Arnold. "After all, we have a large number of machines that already have internal automation based on pick-up technology. Consequently, we can integrate these solutions via robots into integrated production systems relatively easily and establish a smooth flow of parts at a single location. The components, therefore, get from A to B with little effort. This is our approach, which is winning over more and more customers."

emag.com

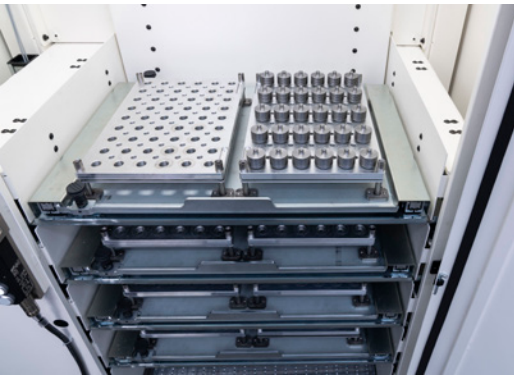

Figure 5—EMAG solutions with robots are very flexible and are adapted in many ways to the existing production environment or space conditions.

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Improving In-Process Gear Manufacturing Quality to Meet New E-Drive Demands

The use of noncontact technology for gear quality control

Marco Curina, Marposs, International Industry Manager of Automotive Transmissions

A combination of international regulations and consumer expectations is driving the demand for reduced noise on all drivetrain components. Further demand is driven by the growing trend towards EVs and HEVs, where noise from ICE is intermittent or no longer present, and the contribution of transmission noise to overall vehicle noise becomes dominant.

Electrified transmissions are subject to several challenges and requirements. What is true is that the number of gear wheels is significantly reduced in electric vehicles due to the use of one or two-speed reducers instead of the classic manual or twin-clutch gearboxes. In return, these are loaded with torque and rpm not previously found in high-volume production.

The other big shift in the automotive industry, the one towards automated driving, is not setting off any alarm bells for gear manufacturers, either. The idea of self-driving cars is currently capturing the industry's attention and, while it is a fascinating trend to follow, having a computer behind the wheel instead of a person is not likely to affect the gear side of the industry too deeply.

To meet the new torque and rpm requirements, the gears for electric drives need to be designed with tighter manufacturing tolerances, especially those dealing with profile and lead features, turning out to become a great challenge for gear manufacturers.

Figure 1—Gears for electric drives need to be designed with tighter manufacturing tolerances, especially around profile and lead features.

While representing a demanding task for manufacturers, it also opens up the opportunity for quality control partners to work more closely with gear producers in order to improve processes and routines. This greater required precision, in fact, results in the need for highly accurate production control.

In this regard, the combination of long-term expertise and the application of newer technologies are key to supporting gear manufacturers who have accepted the challenge of entering the electromobility arena.

The control of the process is paramount and more effective when applied along the entire production chain of a gear. This starts with machine monitoring solutions that detect early breakages on the hob tool through in-process gauging during the grinding operations until the end-of-line measurement and inspection of the finished gear. It is not an insignificant fact that the use of systems for tool analysis to determine optimal edge rounding and surface coating can lead, on average, to a 60 percent increase of the hob utilization. However, what is even more interesting is the adoption and integration of new technologies that quality control companies are ready to develop, embracing innovation and elevating their business tasks.

Earlier, we mentioned the importance of reduced noise on all drivetrain components. Until recently, a noise analysis—better defined as NVH (Noise Vibration Harshness) study—was performed on the assembled gearbox as a functional end-of-line test. However, now that ensuring a silent gearbox has become of paramount importance, the detection of potential noise-producing components must be moved upstream in the process.

The big question that arises is the relationship between the NVH testing of individual gears and the expected NVH behavior on the final transmission assembly. The assumption made in the past regarding ICE is that the gearboxes were so complex and full of gears that it was impossible to identify a direct relationship between the behavior of the individual gears and the complete assembly. With the growing implementation of BEV, it is now believed that the simpler layout of the transmission has made it possible to reveal the impact of the gears on the complete assembly. Moreover, the requirement for NVH testing of the box assembly became tighter in the BEV, forcing gearbox manufacturers to adopt 100 percent NVH testing on the individual gears.

Furthermore, e-drive applications introduce a major difference as compared to traditional transmissions, because drive and coast flanks now have to be considered equally important when a gear is under test. In fact, energy in e-drive configurations flows in both directions—from the motor to the wheels during positive acceleration and from the wheels to the battery pack during brake—so the transmission must be quiet in both conditions.

To achieve this task more easily, new testing technologies are entering the market. Marposs recently introduced the NVH G-EAR testing machine that works on the Single Flank testing methodology to help its customers identify potential noise-producing gears prior to the assembly into the gearbox. The single flank testing principle is based on one master gear meshing with the component under inspection to detect macrogeometry

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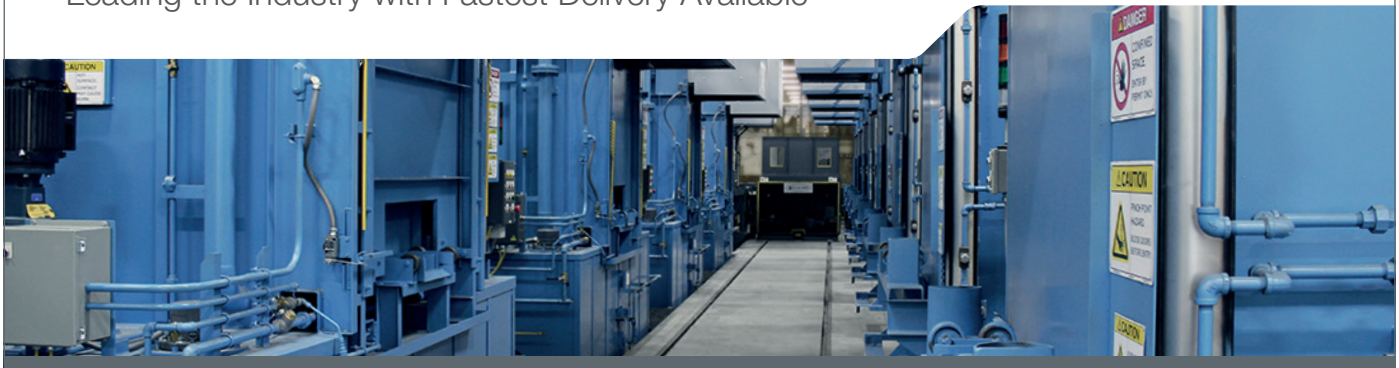

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(nicks, runout, etc.) and microgeometry (gear mesh excitation, ghost orders) defects that are responsible for gear whine and noise phenomena. The ability to achieve high torque and rotational speed, as well as the possibility of adjusting them at will during testing, is one of the major benefits of the application. This allows for the testing of gears in operating conditions almost comparable to those found in the final e-drive.

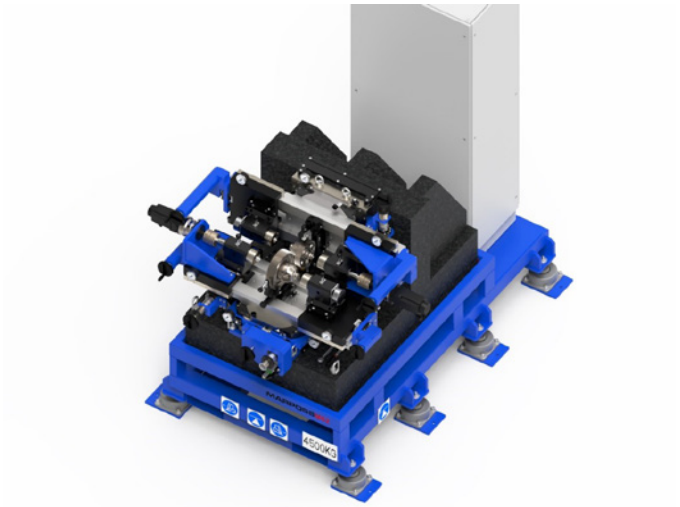

Figure 2—This gear tester from Marposs works on the single flank testing method where a master gear meshes with the component under inspection, identifying defects not detectable with traditional production tests.

Evaluating NVH based upon a single component enables the identification of defects such as microgeometry errors on a gear, helping avoid issues that are much harder to solve at the assembly stage. This represents an invaluable benefit in terms of time and money saved for manufacturers. Moreover, the NVH test allows the identification of defects on the gear flanks that are not normally detectable with the traditional production quality tests (double flank roll checkers, DOB/MdK measurements). These tests are very effective at the early or intermediate stages of the manufacturing process (after hobbing or shaving operations, before and after the heat treatment), while their contribution no longer represents a "plus" when the gears are already ground, polished or honed, which is a normal requirement for gears used in e-mobility.

For instance, a gear that is machined within the manufacturing tolerances and passes the traditional measurements checks may still produce noise at certain frequencies in the gearbox. This event, known as the ripple phenomenon, is responsible for creating a frequency of an amplitude that exceeds the expected threshold (ghost orders). The ghost orders are due to microsurface issues in the profile and lead directions of the gear flanks.

The main source of noise has to be sought in the accelerations that repeat consistently at every part revolution; a part that is geometrically perfect could be noisier than one with a small number of defects as the presence of defects on the teeth allows the energy to spread out. Gear manufacturers are struggling to understand how to introduce a controlled number of variations in the parts to achieve the goal of a silent gear. And here comes the tricky point: from an engineering standpoint, the gear has to be designed and manufactured with the lowest number of possible imperfections to ensure proper mechanical reliability. Yet, on the other hand, the challenge is to introduce form deviations to reduce the amplitude of certain orders during meshing.

Suitable for incorporation into production, the machine is able to achieve 100 percent inspection of tasks, such as identifying the so-called "ghost orders" that represent the major contribution to gear noise in most cases.

While the single flank test is run at a lower speed of 30 rpm, a torsional acceleration test is also performed with measurements taken at high speeds of 500–3000 rpm, at a constant speed/constant torque, at constant speed/ramp torque and at ramp speed/constant torque.

The signal of the sensor is elaborated to obtain a fast Fourier transform (FFT) that shows the amplitude of the frequencies of vibrations, identifying the contribution during different stages. The angular TE (Transmission Error) values are converted into linear data.

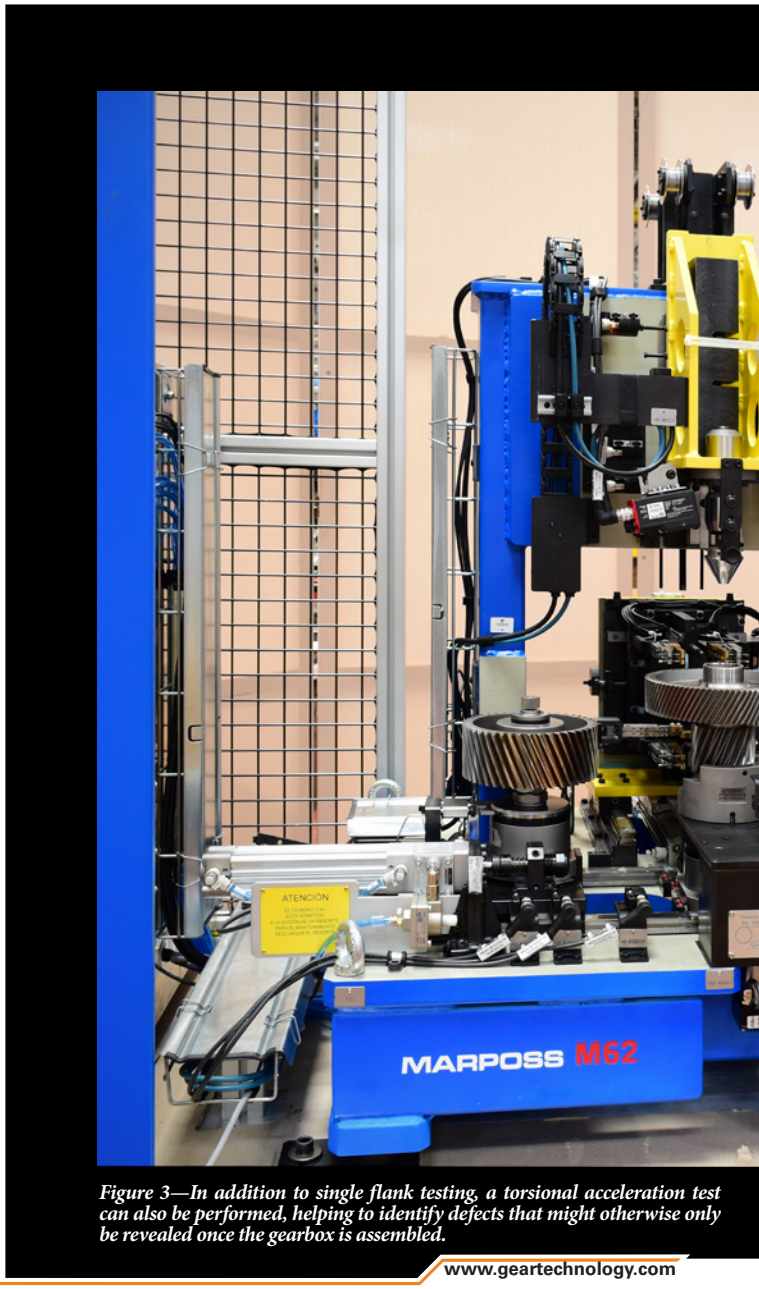

Figure 3—In addition to single flank testing, a torsional acceleration test can also be performed, helping to identify defects that might otherwise only be revealed once the gearbox is assembled.

The Fourier analysis can be used to understand the possible root causes contributing to the nonconformity of the noisy gear. The type of peaks detected over the FFT spectrum of the gear may have different origins, but all of them are related to the manufacturing process. For example, it might be due to an offset (misalignment) that occurred to the grinding wheel, generating eccentricity. In other cases, it may indicate local pitch errors or profile errors due to a division error on the machine tool, or a nonconformity could occur due to an unbalanced grinder or from the vibration of the grinding tool.

Retrieving this type of information can be vital to correctly provide feedback to the manufacturing process to ensure the quality of the gear product.

Manufacturers that decide not to adopt an individual NVH gear tester must cope with the concrete possibility of getting a higher number of scraps and noisy gearboxes, without comprehending the real reason for the nonconformity. If a gearbox fails the end-of-line test once it is completely assembled

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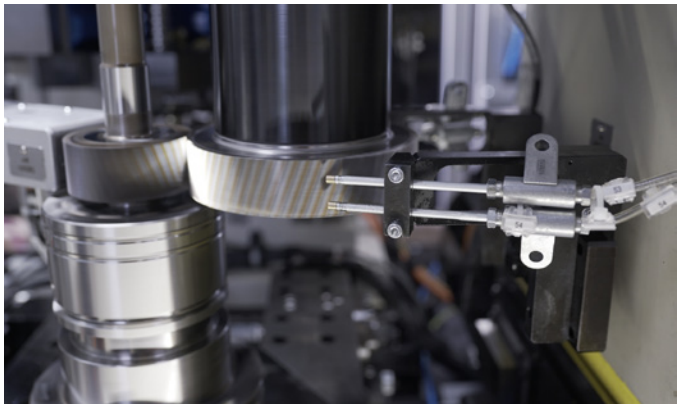


Figure 4—Identifying potential gear defects at the component level is crucial to eliminating transmission noise.

and, consequently, one or more gears are suspected as being the source of the error, then this is often followed by a manual disassembly, the replacement of each gear and the performance of a new measurement of those gears in the laboratory. It appears clear that this approach is time-consuming and far from cost-effective. Other than that, as was stated earlier, is that even remeasuring the gear (with a traditional gear measuring Instrument) might not ensure the identification of the failure. As a matter of fact, a "perfect" gear may still be the cause of any gearbox noise.

The NVH G-EAR tester was developed for gear testing with a specific focus on EV applications, but it is really an evolution of well-known and established technology. The real achievement in gear quality control is the use of noncontact technology for measuring and inspecting gears on the shop floor.

In this respect, Marposs has recently introduced another system that uses laser profile sensors and the optical triangulation principle. As compared to dedicated gear gauging systems or gear laboratory machines, the use of laser technology enables the system to easily adapt to inspecting a variety of gear sizes and shapes in a very short time. The cycle time, in fact, is key. And being fast does not normally match with accuracy.

We previously mentioned that profile and lead characteristics have reached tighter tolerances in gears for electric vehicles, forcing gear producers to seek solutions to keep those parameters under control while still achieving production rates. That is where the noncontact technology applies best.

The laser profilers project a laser line on the gear at a specific angle, collecting data to generate the entire Z-X profile through an image sensor placed behind the optical receiver. The gear is then quickly rotated 360 degrees to collect data points from movement along the Y axis, which is combined with the Z-X

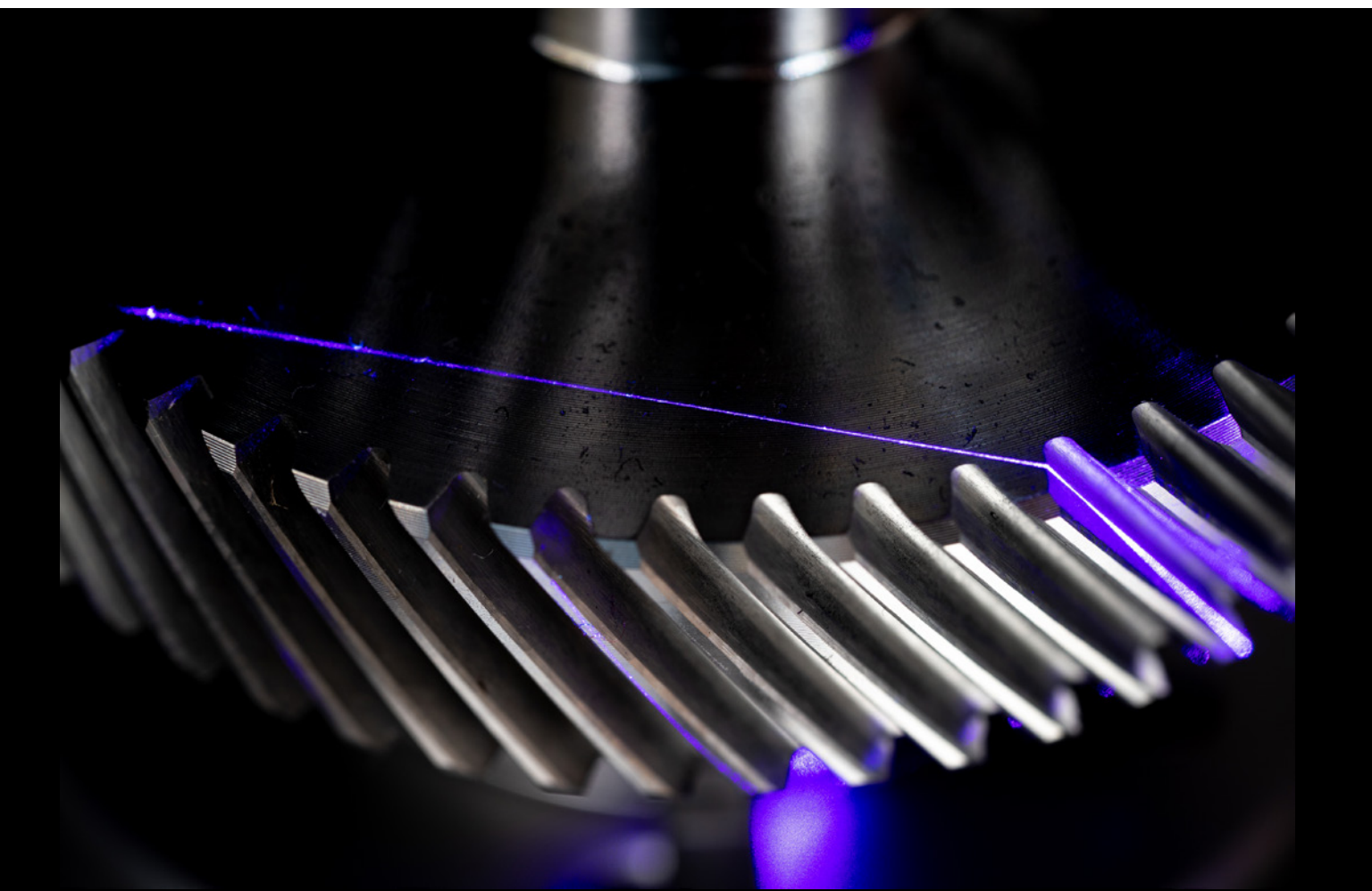
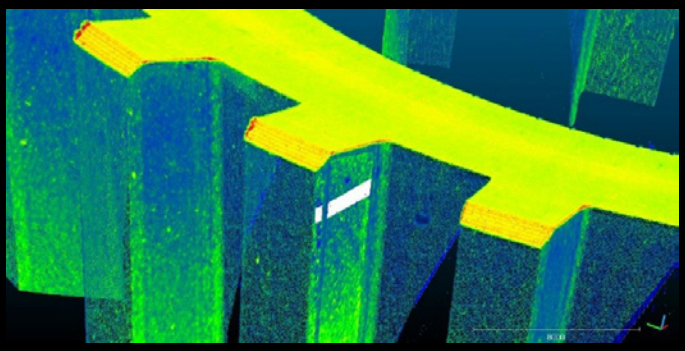


Figure 5—The application of noncontact technology—such as lasers and cameras—is also evolving to tackle the increased need for gear measuring in e-drives.



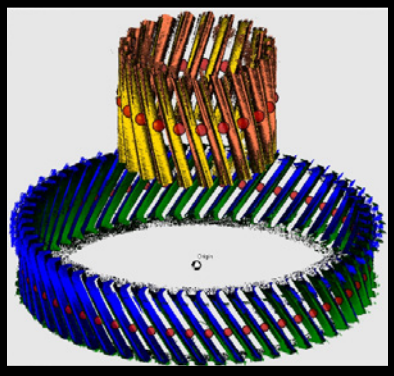


Figure 6—In Marposs' newest system laser profile sensors and the optical triangulation principle help reconstruct a 3D model of the component being measured.

profile to create a complete 3D reconstruction and representation of the part in less than a minute, made possible through specific software algorithms. The system then executes the requested measurement and inspection tasks. Line operators can easily review images and navigate to the desired level of detail to identify any anomalies.

In addition to quality control capability, the multiple laser heads create a point cloud with such a high level of spatial resolution that the details provide a reliable dataset that can also be used for design reviews and final project validation.

With increased demands for lower-noise drivelines driven by the EV market, more pressure is being placed on design and production to solve gear whine and noise issues quickly and efficiently, and this is where technologies such as these will play a key role.

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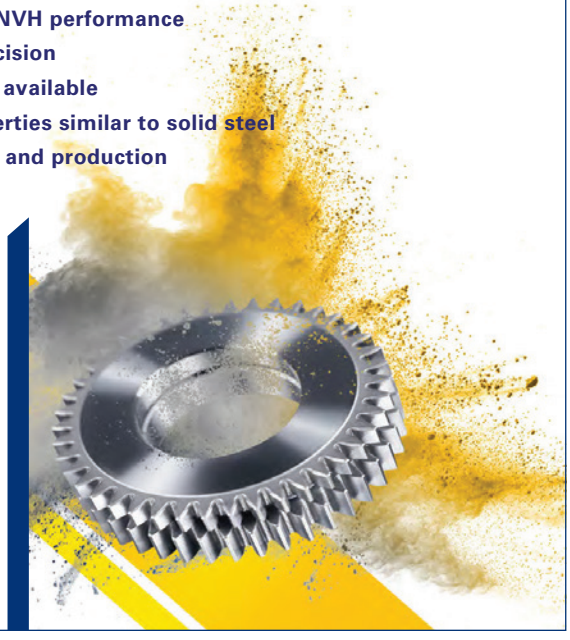

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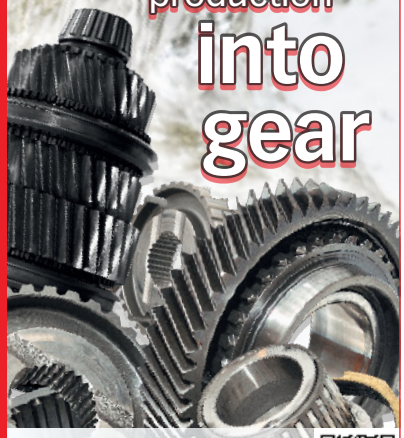

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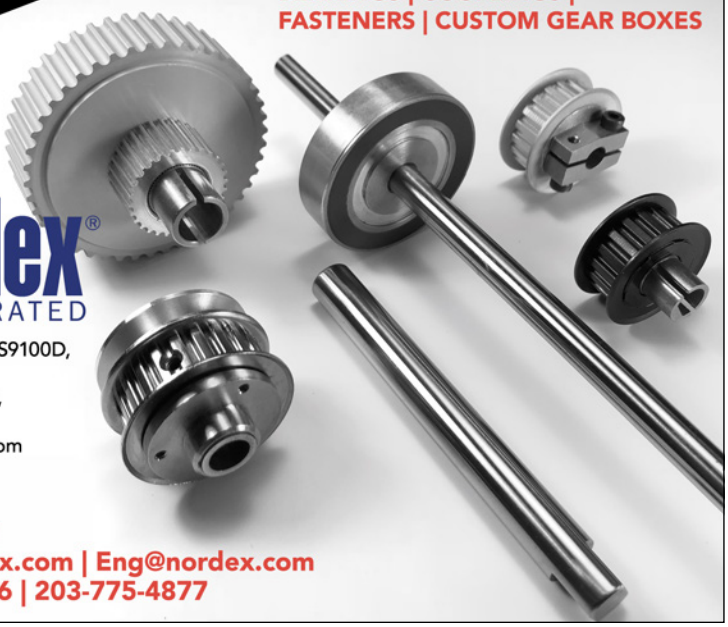

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ABMA Update

Phillip Olson, Director, AGMA Technical Services

The individual components that go into a power transmission system such as gears, bearings, shafts, seals, fasteners, housings, or lubricant, all affect one another. A small tweak to the design of one may require a cascade of other design changes throughout the system. Because of this, the gear engineer should have some knowledge of the design of components besides gears. To that point, for this month's article, I'm taking a sidestep from writing about gears to give an update on bearings; components found in nearly every power transmission system.

In the United States, bearing standards are written by the American Bearing Manufacturers Association, ABMA. ABMA also represents the US bearing industry internationally on ISO standards writing committees. Organizationally, ABMA has one technical committee to manage a catalog of more than forty published standards and work on new standards projects.

For the last few years, the committee's main American standards work has been revising ABMA 8.2, *Rolling Element Bearings—Shaft Mounted—Locknuts, Sleeves, and Locking Devices—Inch Design.* This revision will fix errors from reformatting, including blurry tables and figures, and be a general update to current industry practices. The proposed new revision recently completed a General Ballot commenting period, in June 2023, and has a goal to be published before the end of the year.

The committee also recently reapproved the following 5 standards for another 10-year term of stabilized maintenance:

- ANSI/ABMA 4-1994, *Tolerance Definitions and Gauging Practices for Ball and Roller Bearings*
- ANSI/ABMA 7-1995, *Shaft and Housing Fits for Metric Radial Ball and Roller Bearings - Metric*
- ANSI/ABMA 18.1-1982, *Needle Roller Bearings Radial - Metric Design*
- ANSI/ABMA 18.2-1982, *Needle Roller Bearings Radial - Inch Design*
- ANSI/ABMA 26.2-1994, *Thin Section Ball Bearings - Inch Design*

On the ISO side, ABMA is most active in the Bearing Load Ratings and Life subcommittee of ISO Technical Committee 4. This subcommittee last met in May 2023 where they continued work on two active projects, approved two new projects, and discussed two potential future projects.

The longer-running active projects of the ISO subcommittee are:

- A revision to ISO 16281, *Rolling bearings—Methods for calculating the modified reference rating life for universally loaded bearings.*

and

- Creating a new standard called, ISO 17956, *Rolling bearings—Method for calculating the effective static safety factor for universally loaded rolling bearings.*

The recently approved projects in the ISO subcommittee are:

- A minor revision of ISO 281, *Rolling bearings—Dynamic load ratings and rating life,* which will address comments received from the industry.

and

- A revision to ISO/TR 1281-2, *Rolling bearings—Explanatory notes on ISO 281—Part 2: Modified rating life calculation, based on a systems approach to fatigue stresses,* to address industry comments on the document and bring the document in line with changes in ISO 281.

The potential topics for future ISO subcommittee projects are:

- The creation of a technical report to incorporate surface failure modes into bearing life.

and

- The collection of comments from member nations on oscillating/false brinelling to gauge if a document should be written on the subject.

Additional information on ABMA can be found in the Standards section of the ABMA website, https://www.americanbearings.org. ABMA is always looking for experts in the industry to contribute to bearings standards. For information about joining ABMA, or to ask ABMA standards questions, please contact the ABMA Technical Division at: *aboutaleb@americanbearings.org*

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Profile Shift

Robert Errichello

The objective of this report is to determine the origin of the phrase "profile shift." Several technical books, technical papers, and industrial standards were reviewed for nomenclature associated with profile shift. The phrase "profile shift" translates directly to the German term *"Profilverschiebung,"* which originated in the last quarter of the 19th century. At first, profile shift was used to avoid undercutting pinions with small numbers of teeth. Later, it was recognized that profile shift improved the load capacity of the gear mesh and extended the service life of manufacturing tools.

ISO 21771-1 (Ref. 1) describes the phrase "profile shift" as the displacement of the basic rack datum line from the reference cylinder of the gear away from the root of the gear (actually that describes positive profile shift; negative profile shift is the displacement of the basic rack datum line toward the root of the gear). ISO 21771-1 mentions profile shift 51 times and addendum modification only fifteen times. However, ISO 21771-1 redefined addendum modification from the original phrase "tip shortening coefficient 'k.'" This is bound to cause confusion because the phrase "addendum modification" has been a synonym for profile shift for a very long time.

Heinz Linke (Ref. 2) gives a very thorough discussion of profile shift and provides all the equations necessary for calculating all aspects of profile shift. Linke's textbook mentions profile shift 238 times and addendum modification only seven times. This makes it clear that Linke prefers the phrase "profile shift" rather than addendum modification.

The textbook by Seherr-Thoss (Ref. 3) is a comprehensive treatise of the history of gear theory and gear manufacturing. Chapter 2.23 is especially helpful for understanding the history of profile shift. Quoting from the Seherr-Thoss (Ref. 3) textbook: "Tooth correction is the hallmark of modern toothing. It began with the final decision in favor of involute gearing at the end of the 19th century. At that time, a change was being prepared in the direction that people were moving more and more away from the form tool to the combined, forced movement of the workpiece and the tool. Under these circumstances, the relationship between tool and workpiece began to be considered more closely, including the conditions under which the tip and root circles can be shifted correctly. This is where the technical phrase 'profile shift' came from. It uses the independence of the involute from the reference circle, which Wiebe/ v. Reiche had spoken of in 1861, and it was intended to compensate for the three main disadvantages of the involute gearing, which were already known:"

1. Unequal sliding speeds on tooth crest and root.

2. Undercut with a low number of teeth.

3. Limited resilience.

The American Perspective of Profile Shift

There has been much confusion in the United States regarding profile shift as illustrated by the following list of phrases used in the United States to describe profile shift.

Nomenclature of Profile Shift

1. **Addendum correction**
2. **Addendum Enlargement (Δa)**
3. **Addendum Increment**
4. **Addendum Modification**
5. **Addendum Modification Coefficient**
6. **Center Distance Enlarged (Inches)**
7. **Center Distance Enlarged (Teeth)**
8. **Contraction (ΔN)**
9. **Correction**
10. **Correction Coefficient**
11. **Correction for Undercutting**
12. **Cutter Offset**
13. **Delta Addendum**
14. **Delta Teeth**
15. **Drop-Tooth Design**
16. **Enlarged/Reduced Center Distance**
17. **Enlargement (ΔN)**
18. **Enlargement/Reduction**
19. **Generating Profile Shift Coefficient**
20. **Half-Pitch Hob Pull**
21. **High/Low Addendum**
22. **Hob Offset**
23. **Hob Pull**
24. **Increase/Decrease**
25. **Long/Short Addendum**
26. **Nonstandard Addendum**
27. **Number of Teeth Enlarged/Contracted**
28. **Over/Undersize**
29. **Profile Displacement**
30. **Profile Shift**
31. **Profile Shift Coefficient**
32. **Profile Withdrawal**
33. **Rack Displacement**
34. **Rack Shift**
35. **Rack Shift Coefficient**
36. **Rack Withdrawal**
37. **Unequal Addenda**

American Attempts to Explain Profile Shift

AGMA 913-A98 (Ref. 4) was published to provide a general method for specifying profile shift and rack shift, using gear nomenclature and definitions. It describes the effect that profile shift has on the geometry and performance of gears but does not make specific design recommendations. It generally agrees with the nomenclature and definitions of ISO 21771-1 (Ref. 1), except AGMA 913-A98 defines "rack shift coefficient" whereas ISO 21771-1 defines "generating profile shift coefficient" for the same parameter.

Donald McVittie (1930–2008) (Ref. 5) introduced the phrase "Rack Shift Coefficient 'X'" to explain the European system for Americans.

AGMA 901-A92 (Ref. 6) is the only AGMA gear design document. All other AGMA documents provide methods for analyzing existing gears rather than designing gears. AGMA 901-A92, Annex A, provides complete equations for calculating profile shift, and it explains selecting profile shift for the following criteria:

- Avoiding undercut
- Balanced specific sliding
- Balanced flash temperature
- Balanced bending fatigue life
- Avoiding narrow top lands

Origin of the Phrase "Profile Shift"

The MAAG Gear Book (Ref. 7), clause 1.15, is entitled "Addendum Modification (Profile Shift)," which clearly shows that the phrases "addendum modification" and "profile shift" are used interchangeably. However, in the earlier (1985) MAAG Gear Book, which is in German, clause 1.15 is entitled *Die Profilverschiebung*. This implies that MAAG preferred the phrase "profile shift," and probably only used the phrase "addendum modification" in the English version of the MAAG Gear Book (Ref. 6) to make it recognizable to Americans.

John Colbourne (1937–2016) (Ref. 8) claims the phrase "profile shift" was introduced by Merritt into the gear terminology of the English language. Colbourne explains: "In this book, the name profile shift is used, simply because there are minor objections to each of the alternatives. For example, it would seem odd to refer to the hob offset of a gear, if it is not cut by a hob. The name cutter offset is perhaps an improvement, but it is not suitable for a gear cut by a pinion cutter, because in this case, the profile shift is not equal to the cutter offset. The name correction is a shortened version of an older name; a correction for undercutting, which implies that the only reason for using profile shift is to avoid undercutting. This name has now been largely replaced by the phrase 'addendum modification,' but here again, there is a problem because the profile shift is a measure of the tooth thickness, rather than the addendum length. As we pointed out earlier in this chapter, the addendum a_s of a gear is determined simply by the size of the gear blank. It is, therefore, possible, though unusual, to cut a profile-shifted gear with an addendum of one module, and it is equally possible to cut a stub-toothed gear with no profile shift, and an addendum of less than one module. The value chosen

for the addendum is therefore independent of the profile shift, and the name 'addendum modification' is actually misleading, since it is used to describe a quantity which is really related to the tooth thickness."

Donald McVittie (1930–2008) (Ref. 9) criticized the European method of profile shift and proposed a "T-factor" based on tooth thickness. He claimed that the T-factor method was a more clearly defined and useful parameter. However, the T-factor proposal was not widely accepted.

ISO/TR 4467 (Ref. 10) states "Since Lasche showed empirically in 1889 the advantage of an addendum modification of the teeth for the life of tramway gears geometrical, kinematic, and dynamic studies of the gear have shown the importance of the addendum modification in relation to all the characteristics of the gear pair." Therefore, the concept of profile shift existed as early as 1889. Oskar Lasche (1868–1923) was the first director of AEG (*Allgemeine Elektrizitäts-Gesellschaft,* or German General Electric Company), which was founded in 1909. It is unlikely that Lasche used the phrase "profile shift," and the profile-shifted AEG gears became known simply as "AEG gears."

Tofa Khiralla (1908–1983) (Ref. 11) used the nomenclature of long and short addendum gears and provided several examples of profile-shifted gears with diagrams of specific sliding. Furthermore, he emphasized the benefits of all-recess action gears.

Henry Merritt (1899–1974) (Ref. 12) stated: "The artifice of displacing the generating rack had long been known and having been used to avoid undercutting otherwise present in small pinions, it was termed 'correction for undercutting' and later 'correction.' In B.S. 2519:1954 (Glossary of Terms and Definitions for Toothed Gearing) the artifice was re-named 'addendum modification.' But addenda may be modified in other ways, and the terms themselves are unwieldy and do not give convenient derivatives. The author, therefore, here uses the phrase 'profile shift' [borrowed from Professor Takashi Nakada]." See the later discussion of reference Ref. 17.

The German version of DIN 3992 (Ref. 13) has the title *"Profilverschiebung bei Stirnraedern mit Aussenverzahnung,"* ("Profile Shift for Cylindrical Gears with External Teeth"). However, the internet lists the title as "Addendum modification of external spur and helical gears."

Allan Candee (1884–1971) (Ref. 14) discussed the details of undercut as follows: "When standard proportions of gear teeth were first adopted, the dedendum was made equal to the addendum plus clearance, for all numbers of teeth. In an involute gear with a small number of teeth, the space depth then extends below the base circle, and from there down the profile was customarily made straight and radial. This would result in interference with a gear having a large number of teeth. Later when generating methods of tooth cutting came into use, a fillet curve was produced by the generating motion, and in a pinion with too small a number of teeth some of the involute may be cut away above the base circle. It then became a practical problem to know how to determine the amount of contact lost when gears were dimensioned according to the standard rules. It was soon realized that by decreasing the dedendum in a pinion, the cutting away of the involute could be avoided, while the usual whole depth could be retained by increasing the addendum, standard generating could still be used. It has therefore long been the recommended practice to design pinions with "long addendums" so that undercut does not occur, and tables of recommended pinion dimensions have been included in American Standards for the past twenty-five years." Note: In 2023, Candee's past 25 years become the past 87 years.

Darle Dudley (1917–2003) (Ref. 15) used the terminology of long and short addendum gears and showed an example of an undercut pinion with 12 teeth and compared it with a 12-tooth pinion with a profile shift coefficient of x = 0.35 and no undercut. Furthermore, in addition to avoiding undercut, he discussed the many benefits of profile shift.

Wilfred Davis (Ref. 16) defined "addendum modification" (also known as "addendum correction," "profile displacement," or "rack shift") as a variation from nominal dimensions for the addendum, dedendum, and reference circle tooth thickness employed in involute gearing. He explained further that "x" is the addendum modification coefficient, and the phrases "profile displacement," "profile withdrawal," "profile shift," and "rack shift" are also used for this displacement. Davis provides equations in Data Sheet 15 for three options of tip circle diameters:

- Full-length teeth
- Standard working depth
- Standard tip-to-root clearance

Takashi Nakada (1908–2000) (Ref. 17) entitled his textbook "Involute Profile Shifted Gears." Nakada acknowledged books by Earle Buckingham, Henry Merritt, and Professor Adalbert Shiebel. Buckingham did not use the phrase "profile shift," Merritt claimed he borrowed the phrase "profile shift" from Professor Nadada, and Professor Schiebel used the term *"Profilverschiebung"* ("profile shift").

Earle Buckingham (1887–1978) (Ref. 18) provided all the equations required for calculating the geometry of trochoids, tooth fillets, and undercut. However, he avoided using the nomenclature of profile shift. Buckingham is credited with the introduction of the involute function, which is needed for calculations of operating pressure angle and sum of the profile shift coefficients.

DIN 870 (Ref. 19) is entitled *"Zahnräder, Profilverschiebung bei Evolventenverzahnung,"* ("Gears, Profile Shift with Involute Gearing,") DIN (1931).

Karl Kutzbach (1875–1942) (Ref. 20) reported on the state of gear manufacturing existing in 1925. Kutzman used the term *"Profilverschiebung"* ("profile shift") and mentioned the phrase "tooth correction." According to Linke (Ref. 2), Kutzman's work formed the basis for the first edition of DIN 870 published in 1931.

Adalbert Schiebel (1872–1931) (Ref. 21) wrote the first edition of Zahnrader in 1921. However, only the fourth edition was currently available, which was written by Professor W. Lindner in 1957. Therefore, since the fourth edition was completely revised, it is not possible to determine whether Schiebel used the phrase "profile shift." To explain further, the foreword to the fourth edition is quoted below:

After the death of Professor Schiebel in the year 1931, Professor Königer from the University Giessen revised the second volume of the third Edition in 1934.

The now available revision of volume II in the fourth edition includes the developments of the past 20 years as well as the standards and nomenclature which were established during this time. The calculation of helical gears was conducted in close orientation to Volume I. In the new edition, it was considered, that due to the inaccuracies in manufacturing, the conditions for strictly mathematical calculations are only limited. The effort for the derivation of the equations of the statical indeterminate systems is therefore in no relation to the obtainable results. It appears therefore acceptable for the practical use to present simplifications which capture the obvious relationships.

For spiral bevel gears, the methods which are established today are presented according to their importance. This also applied for the bevel gears with offset, which are widely applied as hypoid gears in automobiles.

The graphical methods from Schiebel, for the analysis of worm gear transmissions where preserved, yet, in order to make it easier for the reader, the attempt was made to develop clearer graphics. A section about hollow surface worms was added.

A new addition is a short chapter about the basics of the measuring methods for gears.

Transmission examples with different gear types were added in the last Chapter. I am thanking especially the companies who made examples of their latest transmissions available.

Also in this edition, the tables with calculation examples are in the addendum in order to facilitate the use of this book for the practical gear engineer.

—W. Lindner, Hagen, March of 1957

Max Folmer (1873–1941) (Ref. 22) is credited with introducing the term "V-gear" (profile-shifted gears on the reference center distance, i.e., $\Sigma x = 0$) in 1919. His gear research between 1917 and 1919 was of great importance for the theory of gearing. Quoting from the textbook by Seherr-Thoss (Ref. 3): "Folmer belongs next to Euler (1762), Kaestner (1781), V. Langsdorf (1802), Wiebe (1861), Reuleaux (1865), Hartmann (1893), Stribeck (1894) and Lasche (1899) to the great fathers of scientific gear theory in Germany, because he added an important building block to our gear technology, on which the German gear wheel standardization could also be based."

Max Maag (1883–1960) (Ref. 23) presented a lecture in Winterthur in 1917 where he described the "MAAG Tooth System," which he developed in 1908. Maag expressly avoided using the phrase "profile shift" most likely because MAAG commercial interests were best served by a proprietary system. He admitted that the theory behind the MAAG Tooth System was known for a long time before Maag perfected the MAAG Tooth System, but there was no manufacturing process to implement it until MAAG developed a rack cutter with sufficient precision. In 1908, Max Maag visited Sam Sunderland in England to view his newly invented rack-type gear planer. Maag immediately recognized that the Sunderland planer was based on the correct principle. Maag bought two Sunderland planers, but soon realized the machines could not produce gears that were accurate enough. Therefore, after acquiring the patents, Maag set about completely overhauling the machine to improve its capability to achieve the highest accuracy possible. In 1910, Maag opened a small workshop to produce the first gears according to the MAAG Tooth System. In 1912 he obtained a patent for a "Procedure for the production of involute gearing of any pitch and pressure angle." The first four MAAG planing machines were shipped in 1913. This was followed by the development of the first MAAG grinding machine that followed the generating process using two plate-shaped grinding wheels, the active edges of which represented the flanks of an ideal rack tooth. In 1916, he founded the MAAG Gear Wheel Company in Zurich. Max Maag, presented the lecture: "The MAAG gears and their importance for the machine industry," held on April 20, 1917, at the Winterthur technical association."

In the lecture, Maag described the MAAG Tooth System and explained its advantages presented in Figure 1.

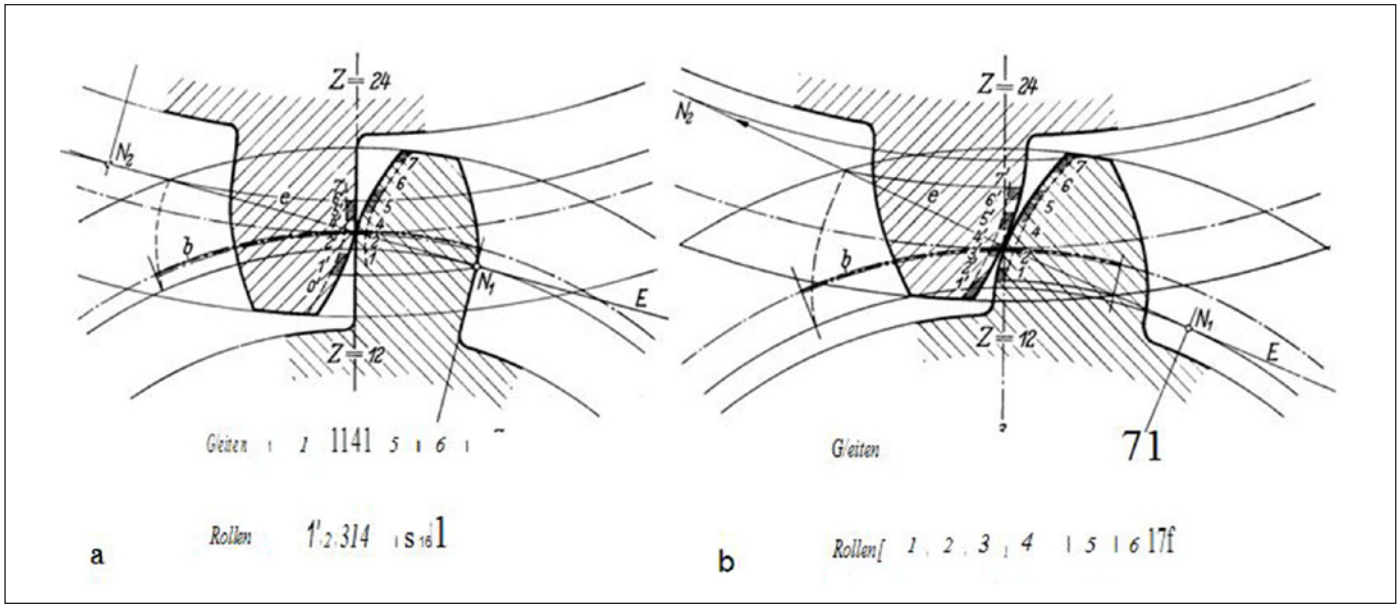

Figure 1—Teeth form cut by a milling cutter (left) and teeth generated by a rack cutter (right).

The teeth according to the left side of Figure 1, which Maag called "normal teeth," are made by a milling cutter, whereas the right image shows teeth made according to MAAG's method.

The most obvious difference lies in the different tooth thicknesses. In the case of normal gearing, the tooth thickness at the pitch circle is always equal to half the pitch. However, since the involute root lengths are very close to the pitch circles and the root profile is inside the base circles and runs radially, the tooth thickness in the root circles, i.e., at the steepest point of the highest stress, is always the smallest and even smaller on the pinion tooth that is subjected to the most frequent stress. The right of Figure 1 shows that the conditions are much more favorable in that the tooth thickness is greatest at the root and is somewhat larger on the pinion tooth than on the wheel tooth. The shape of the teeth offers the greatest possible resistance to fracture.

Because the root profiles on the left in Figure 1 are formed almost entirely by the radial extensions, they have no value for the transmission of motion. In addition, a large portion at the top of the wheel tooth is completely useless since it makes no contact on the short portion of the root profile of the pinion tooth. When the teeth engage, only very short portions of the profile make contact, which are correspondingly heavily stressed. In contrast to this, the image on the right in Figure 1 shows the active profiles of the MAAG teeth are very long and reach from the tip to near the root circles. Almost the entire profile takes part in the transmission of movement, so that the contact is distributed over much larger portions than with the normal teeth shown on the left image in Figure 1. Because of the large differences in length of the profiles that work together, this is mainly sliding in the case of normal gearing, whereas in the more balanced conditions in the case of MAAG gearing it is predominantly rolling. This is the reason for the significantly lower and equal slide to roll ratios, more moderate wear, and better efficiency of the MAAG gearing.

Finally, the lower profile curvature is less on the MAAG gears, which have approximately twice as large profile radii as those of normal teeth, which means that the resulting lower contact stress allows far higher loads on the gear teeth. These fundamental differences have been achieved by the simple means of appropriately selecting the outside diameter and the pressure angle. Theoretically, this was of course known for a long time, but in practice it was only made possible by using the advantages offered by MAAG's manufacturing process.

Max Maag remained the managing director of MAAG until he retired in 1927.

Summary

Although the theory and practice of profile-shifted gears was known as early as Oskar Lasche's work in 1889, it is not likely that the phrase "profile shift" was known. Therefore, because of the importance of Folmer's contributions, I believe it is fair to credit him with introducing the phrase "'profile shift' in 1919."

Conclusions

1. The theory of profile shift was developed in the last quarter of the 19th century.

2. Oskar Lasche empirically proved the advantages of profile shift in 1889.

3. Max Maag developed the "MAAG Tooth System" for profile-shifted gears in 1908, and manufactured rack-shaped, carburized, hardened, and ground gears of high accuracy in 1915.

4. Max Folmer probably originated the phrase "profile shift" in 1919.

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Load Capacity Evaluation of Production-Related Geometry Adjustments via STEP Import in *BECAL*

Using the Example of a Freeform Milled Bevel Gear

Dr.-Ing. Thomas Glaser (VOITH), Dr.-Ing. Stefan Schumann (TU Dresden)

Bevel gears are widely used in various industrial applications, such as automotive, aerospace, and marine industries, due to their ability to transfer power between non-parallel shafts. The conventional manufacturing of bevel gears involves several time-consuming and costly processes, including gear blank preparation, gear cutting, and gear finishing. The increasing demands on gear components regarding increasing power density, reducing installation space, reducing weight, and increasing efficiency are also reflected in the design of gear components. The reduction of installation space and weight as well as the increase in power density often leads to an optimized wheel body design that interacts with the gearing in terms of load capacity and stiffness. This leads to an increase in the required geometric degrees of freedom (DOFs). Due to the resulting complex wheel body shapes and different production-related effects, production-related geometry adjustments may also be necessary. Tools for evaluating the gearing in combination with the wheel body shape and its influences nowadays form the basis for unlocking the holistic optimization potential of transmission components.

Based on these high requirements for the gearing, the model for calculating the load-bearing capacity must not fall short. With the help of the FVA program package *BECAL,* it is possible to carry out a tooth contact analysis based on the exact geometry with very high accuracy. Thus, in contrast to standardized, simplified calculation methods (Ref. 1), microgeometry is included in a load distribution calculation and local load capacity verification is possible.

In this article, we introduce the STEP import feature of *BECAL* and review the underlying theoretical approaches. In addition, fields of application are identified and finally illustrated with an explicit use case. The use case in this article is a free-form pre-milled large bevel gear on which production-related geometry adjustments have been applied. We will explore various approaches to manipulating the geometric DOFs and their impact on the final gear geometry. Also, the results of the underlying calculation without production-related geometry adjustments are compared with the results including the geometry adjustment. The BE- and FE-Method are used for calculation and the differences in the results are discussed. The results of this study provide valuable insights into the use of higher-order calculation methods and free-form milling for the bevel gear design and manufacturing process and contribute to the advancement of the manufacturing industry.

BECAL Methodology and Theory

The programme package *BECAL* (BEvel gear CALculation) has been developed for several decades at the Chair of Machine Elements on behalf of the FVA (Research Association for Drive Technology). Starting from a manufacturing simulation, it maps the complete tooth contact by means of a simulation of the same. By simulating the manufacturing process, the calculations are based on the exact geometry. The flank topography determined point by point is combined into a compensation surface, which is used for the load-free rolling simulation. The results of this simulation are the contact lines and the corresponding contact distances. These are used in the load distribution calculation. The necessary deflections are split into linear and non-linear influence numbers. The linear compliance is determined numerically with BEM or FEM, the non-linear contact stiffnesses are based on Hertzian theory. The load distribution calculated in this way is calculated locally for each flank point and forms the basis for the local load capacity verifications against pitting, micropitting, scuffing and tooth root fracture. This local calculation is based on a local usage of well-known and validated standards like ISO 10300 (Ref. 1) and FVA 411 (Ref. 11). Figure 1 shows the basic calculation procedure of *BECAL*.

If the bevel gear is not manufactured using the cutter head process, but is free-form milled or forged, for example, the exact geometry of the gears must be specified point-by-point or via a STEP file. Via the standardized STEP interface, the gear geometry can be read directly into *BECAL*. Flanks and root surfaces can be recognized via a feature designation and approximated by means of compensation surfaces. These are then used for the tooth contact simulation as described above.

Due to the higher degrees of freedom with this type of geometry import, forging in the heel and toe area can also be mapped. However, this means that simplified approaches such as the combination of 2D BEM and analytical regression for the width load distribution according to Schaefer [9] lose their validity. In *BECAL,* therefore, a possibility was created to calculate the linear influence figures (compliance due to bending, thrust, pressure, and the wheel body) by means of FEM in a generally valid way. The calculation of the nonlinear contact deformation can remain unchanged, as this only has significant effects in the close range.

An influence number method can also be used to infer the root stress from the load distribution. For this purpose, as with the determination of linear compliance, singular loads are imposed on the FEM model. To eliminate the influence of the singularities, the same model is calculated with a restraint in the center of the tooth, and the deformation results are subtracted from the first model. Here, however, the entire tensor of the root stresses at each node must be stored and not just the deformation along the direction of the force as in the case of yielding in contact. After calculating the load distribution, the "influence tensors" can be superposed based on the respective loads.

This method, starting from a STEP model, via influence numbers by FEM and contact stiffnesses via an extended Hertzian theory, makes it possible to calculate the load distribution and, based on this, also the root stress distribution of almost arbitrarily shaped bevel gears with very high precision.

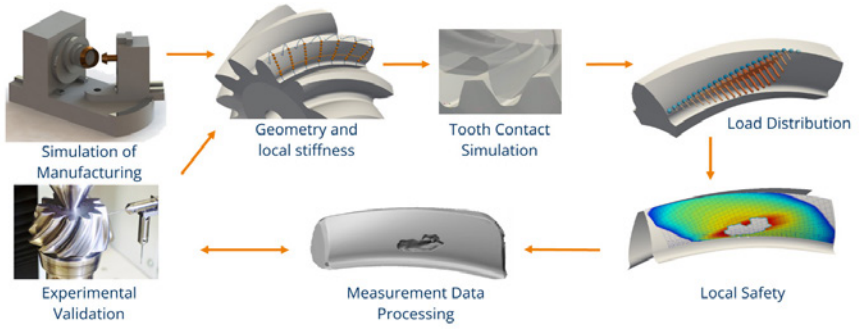

Figure 1—BECAL *procedure of calculations.*

To prove these accuracies, many FEM contact calculations were carried out, which served as a reference for a corresponding comparison (Ref. 10). Maximum deviations in the range of a few percent always occurred in the load distribution. Qualitative distribution of flank pressure and tooth root stress based on FEM influence numbers and influence vectors calculation are shown in Figure 2.

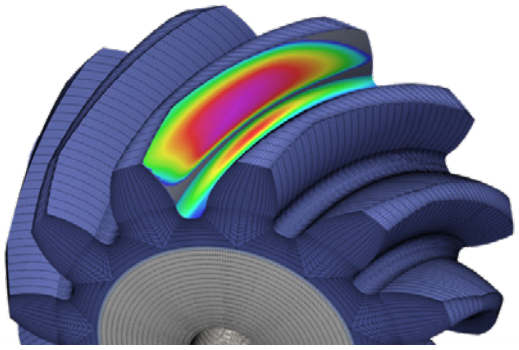

Figure 2—Qualitative distribution of flank pressure and tooth root stress based on FEM influence numbers and influence vectors.

Use Case

In the following, an application of the load capacity evaluation via *BECAL*'s STEP import is presented using the example of a free-form pre-milled bevel gear set.

Through developments in the fields of tools, processing machines, and strategies, freeform milling has emerged as a promising alternative manufacturing method that can also produce gears with high accuracy and efficiency (Refs. 2–7). Free-form milling is a five-axis machining process that enables the production of complex geometries with a high degree of flexibility. One of the key advantages of freeform milling is the ability to manipulate the geometric degrees of freedom (DOFs) to achieve the desired gear geometry. The geometric DOFs include the tooth profile, tooth surface orientation, tooth surface curvature, and tooth thickness. The manipulation of these DOFs is critical to producing gears with high accuracy and efficiency. Due to the possibility of process integration and the possibility of manufacturing on universal machines and with the use of standard tools, free from milling offers great potential in the field of single-part, small-series, and prototype production.

As already mentioned, in addition to load-bearing capacity-related changes, production-related geometry adaptations can also be made. Such adjustments may be necessary to accommodate deviations that occur during the manufacturing process or to optimize manufacturing processes in terms of processing time. Especially for large components, the issue of heat treatment and the associated changes in volume and shape must be considered. The flatness deviation resulting from the heat treatment can be in the millimeter range for large ring gears. To prevent this deviation, a negative root allowance or a root taper adjustment can be made.

For gears that are ground after heat treatment, a pre-machining close to the final contour can be used to optimize the stock allowance distribution and therefore reduce the material to be removed at the finishing process. The use of a protuberance can also reduce the risk of grinding burn and grinding notches in the tooth root area. The tooth root area can also be optimized in terms of manufacturability and cost. For example, the use of a circular radius can reduce the number of milling paths required and thus the machining time compared to a rolled root geometry. In addition, the process parameters that determine accuracy and machining time, such as step over, feed rate, etc. can be adapted to different gear areas according to their requirements to reduce machining time. In addition, topological tooth root optimization could be implemented by free-form milling. Figure 3 shows an example of a bevel gear set in which the tooth root area has been adjusted due to manufacturing reasons and on which the different functional areas tooth flank (blue), bearing point (red), and gear body (gray) are highlighted in color.

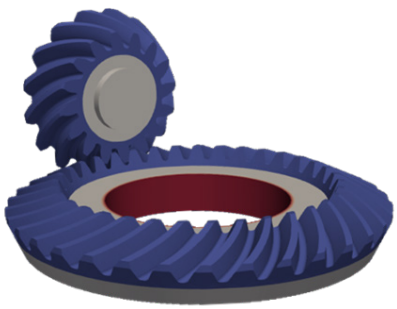

Figure 3—Example BECAL*-representation of bevel gear set.*

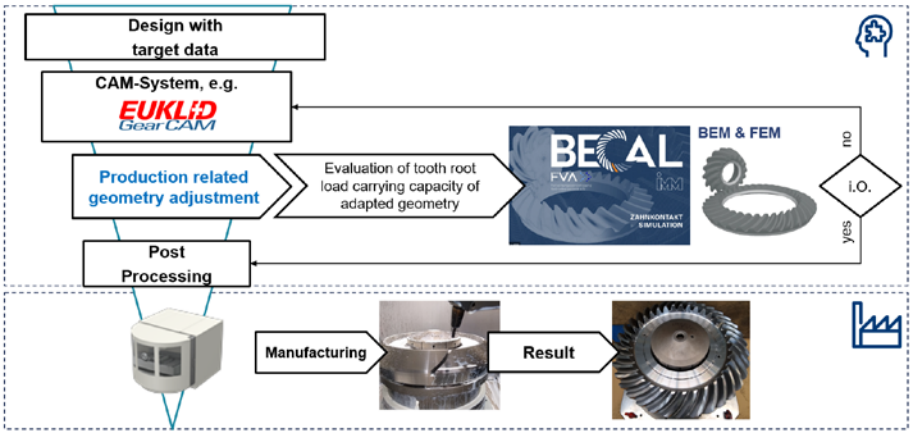

Figure 4—Possible evaluation and manufacturing process.

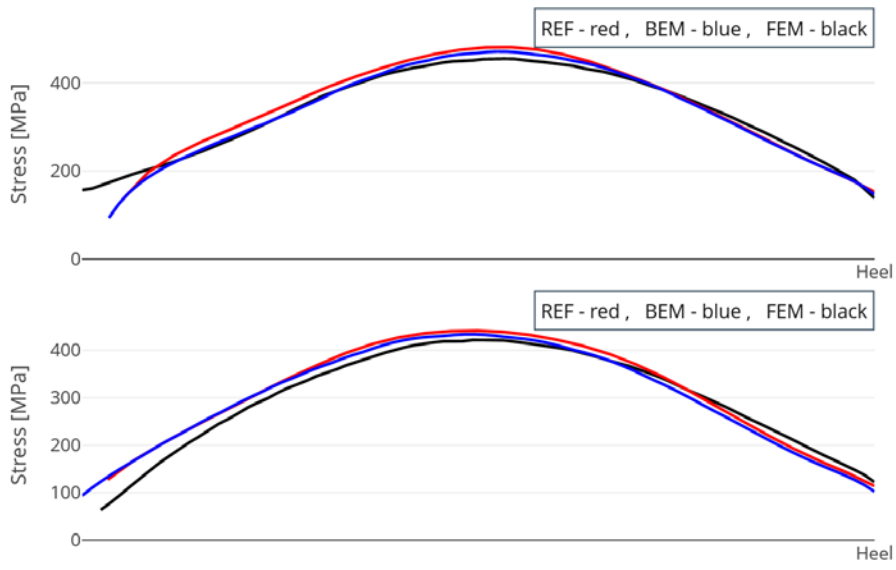

Figure 5—2D Tooth root stress distribution.

If production-related changes are made to the gearing or the wheel body, these must be evaluated regarding their influence on the load-bearing capacity. Figure 4 shows the basic process of how such an evaluation process could look like. In the following example, *Euklid GearCAM* was used as CAM-system because it is a very versatile solution for 5-axis gear machining (Ref. 8).

The application example considered here is a large bevel gear used in a marine application which is premachined by freeform milling and finished by peeling in the hard state. The tooth root area was adapted for manufacturing reasons (e.g., protuberance) to withstand the changes in shape and volume resulting from heat treatment and optimize the hard machining process. To evaluate the influence of this production-related geometry adaptation, the results of the standard design are compared with those of the adapted geometry via the above-mentioned *BECAL* STEP import. Since only the tooth root area was adapted, only the tooth root safety is discussed below. The underlying load case is a fictitious load case to demonstrate the calculation method. Results of the tooth root stress and consequently safeties are scalable depending on the load. In the first step, the results calculated using the BE method are discussed and compared with the results of the FE method. Figure 5 shows the course of the tooth root stress over the tooth width.

The course of the tooth root stress was not negatively influenced by the production-related geometry adjustments. A reduction in tooth root stress can be observed due to the choice and execution of the adjustments. This reduction in tooth root stress leads to a

	Ref. Geometry	Adjusted Geometry	
Method	**BEM**	**BEM**	**FEM**
Root safety, SF_pinion [-]	1.55	1.70	1.76
Root safety, SF_wheel [-]	1.72	1.87	1.92
Delta, pinion / wheel [%]		**+ 10% / + 9%**	**+ 13.5 % / + 12%**

Table 1—Calculation result.

calculated increase in safety of between 9 and 13.5 percent. The results of the different calculation variants are summarized in Table 1.

The difference found here between the two calculation methods can be attributed to the simplified distribution of the stress in the width direction. While the stress distribution in the calculation with the FEM is precisely calculated numerically in both the height and width directions, a numerical calculation only takes place in the height direction in the BE-based method. Here, a simplified analytical approach is used in the width direction, which cannot represent all geometric influences.

Summary and Outlook

The results presented were able to show that via the STEP import in *BECAL,* the load capacity evaluation considering the wheel body influences and high DOFs of transmission components via higher-order computational methods such as BEM and FEM offers a suitable solution. In addition, the advantages of free-form milling were demonstrated by means of a suitable application case. Furthermore, the load-bearing capacity can be positively influenced by a suitable execution of production-related geometry adjustments in addition to the manufacturing process. This offers great optimization potential.

Dr.-Ing. Thomas Glaser studied mechanical engineering B.Eng. and product development and manufacturing M.Eng. at the University of Applied Sciences in Aalen. During his master's degree, he worked as a research assistant at the Institute of Drive Technology in Aalen, focusing on the series development of bevel gearboxes.

He obtained his Ph.D. degree in mechanical engineering focusing on the 5-axis machining of bevel gears in cooperation between Aalen University and the Technical University of Dresden.

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He obtained his Ph.D. degree in mechanical engineering focusing on asymmetric bevel gears at TU Dresden in 2015.

In 2017, he became a senior engineer at the Chair of Mechanical Elements with the main field of work being load-bearing capacity.

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Ross Wegryn-Jones

JOINS BOURN & KOCH

Ross Wegryn-Jones, National Sales Manager, Bourn & Koch

Bourn & Koch, Inc. of Rockford, IL, is pleased to report that Ross Wegryn-Jones has recently joined the company as national sales manager. He will be responsible for the sales of gear manufacturing machines, precision grinding machines, and specialty machine tools for unique manufacturing applications. This includes Bourn & Koch horizontal gear hobbers; Fellows gear shapers; Blanchard rotary surface grinders, and Bourn & Koch's new MT3 vertical grinding machine.

Drawn to the rich history of machine tool manufacturing at Bourn & Koch, Wegryn-Jones looks forward to supporting their existing customer base and to growing Bourn & Koch's presence across North America. Bourn & Koch is primarily known for supporting many familiar names in American machine tool manufacturing, such as Bullard, Blanchard, DeVlieg, and Fellows. Ross will work to increase awareness and further development of the custom solutions Bourn & Koch can provide from this legendary portfolio of machine tool technology.

"I'm truly honored to join the Bourn & Koch team—with their deep bench of engineering and technical knowledge," Wegryn-Jones explains. "To say I am impressed with Bourn & Koch's legacy machine tool designs would be an understatement, and this is NOT a company that is resting on its laurels. I'm quite eager to engage with our vast customer base and help spread the message of Bourn & Koch's ingenious machine tool solutions for the modern era!"

He brings 30 years of experience in the manufacturing industry to this new role with his most recent posts as regional sales manager at Jet Edge Waterjet Systems and previously with Mitsubishi Heavy Industries, promoting their gear manufacturing solutions. Wegryn-Jones started in manufacturing sales for Aercology mist collectors, where he first became familiar with Blanchard grinders, working with customers to help better control the coolant mist that those machines produce. He will be looking to reconnect with the owners of those Blanchard machines.

bourn-koch.com

Solar Atmospheres of California

ADDS AIRBUS APPROVAL

Solar Atmospheres of California (SCA) is pleased to announce the company is now Airbus approved for heat treating.

Frank Trujillo, director of sales for Solar Atmospheres of California, states, "Many Airbus suppliers were in need of a heat treater in the West that could process parts, plates, and bars in support of increased Airbus production rates. SCA is proud to be a partner on the Airbus Team!"

With a wide range of furnaces, SCA is capable of processing very small pieces or loads of 50,000 pounds and up to 24 feet in length. This approval will translate into improved lead times and greater efficiencies for all Airbus suppliers that require heat-treat services in the western region.

solaratm.com

Nidec Machine Tool America

INSTALLS 5-AXIS LAMDA500

Nidec Machine Tool America has begun preparations for the installation of the LAMDA500 DED 3D printing system. The LAMDA500, a 5-axis CNC laser DED system, has a build envelope of 500 mm X 500 mm X 500 mm.

According to Hirohisa Kuramoto, global additive manufacturing marketing director, "The LAMDA500 installation at our Wixom, MI, facility emphasizes our full commitment to the North American market. We will partner with customers to make samples and test parts as well as perform process development in Michigan." Kuramoto indicated that testing started in June of 2023.

Using a Nidec exclusive proprietary nozzle design with local shielding of the melt pool, the LAMDA series of DED 3D printers do not require an environmental chamber for inert gas. Rather, the nozzle, designed with the use of CFD, provides the largest available shielded area for DED printing of reactive materials such as titanium and aluminum. LAMDA observes the molten state of the metal with a camera and stores the images as traceability data for the printing process, while its unique high-speed image processing algorithm

instantly feeds back changes in feature values to the laser oscillator and mechanical equipment to modify the laser irradiation energy, printing speed, etc. to stabilize printing quality.

Nidec first prototype high accuracy DED machine was produced in 2014, with large scale (2,000 mm X 1,500 mm X 1,600 mm) machine deliveries beginning in 2020.

nidec-machinetoolamerica.com

Forest City Gear

HIRES KEVIN ROGERS AS QUOTING ENGINEER

Kevin Rogers, Quoting Engineer, Forest City Gear

Forest City Gear is proud to announce the hire of Kevin Rogers as quoting engineer. Some of his responsibilities in this role include reviewing and generating new requests for quotes and working with clients to determine their orders' special requirements.

According to Director of Technical Operations Jeff Mains, "Kevin has progressed very rapidly with understanding FCG's overall capabilities, what the customer's needs are, and the best solution we can provide to them."

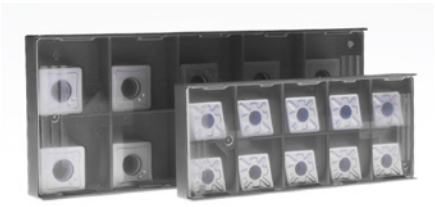
Prior to joining Forest City Gear's team, Rogers worked for GE Aviation for 15 years. Rogers held multiple roles during his time there, starting as a manufacturing/quality engineer and working up to lead manufacturing specialist.

"Employee engagement, knowledge, and professionalism make FCG a great place to work. I am in awe with how the manufacturing floors are set up, and how willing each person is to help their coworkers succeed," said Rogers. "I am happy to be part of the FCG team."

forestcitygear.com

Seco Tools

SWITCHES TO RECYCLABLE PACKAGES



With ambitious targets of being 90 percent circular by 2030 and becoming carbon-neutral by 2050, Seco is making a major move towards sustainability by switching to product packaging made from recycled materials.

"We believe that to be a sustainable business, we must act with economic, environmental, and social responsibility, all while taking advantage of the opportunities that arise from the integration of sustainability in our value chain," said Maria Blomqvist, head of sustainability and EHS at Seco.

The move is part of the continuing push to work with sustainability in an active and structured way. Seco aims to recycle as much raw material as possible and to increase the efficiency of manufacturing processes—the effect of these efforts will be the continued reduction of waste and improved consumption of energy and water.

"We aim to be recognized as responsible manufacturers and to take resolute actions on sustainability, and as part of that we are switching our product packages and packaging material to sustainable packages made from recyclable material," says Eva Söderberg, product manager product packaging at Seco. "Sustainability is built into every one of our strategic pillars and it forms a part of our vision. We follow four objectives that guide our sustainability work—we aim to be regarded as one of the sustainability role models in our industry, we increase circularity by driving the shift to a circular economy, we reduce our climate impact and we put safety on top of the agenda, as our employees are our most valuable resource."

The new sustainable packages will replace the previous versions made for inserts that have been in use since 2008 and which were made from virgin materials. The new packaging will be made of recycled material which mainly comes from discarded packaging plastic from households, and the increased use of recycled plastic will improve sustainability by reducing carbon emissions while helping Seco to reach the goal of 90 percent circularity by 2030.

In 2021, the virgin plastic used for insert boxes consisted of about 122 tons of plastic and generated approximately 173 tons of CO^2, and solid tool boxes generated approximately 35 tons of CO^2. The short-term goal for 2023 is to convert 17 tons into recyclable material in the product packages which is equivalent to 14 percent of the total amount being used. In 2024 the amount will reach 99 tons or 81 percent. Seco will save around 131 tons of CO^2 emissions compared to 2021 by replacing virgin plastic with recycled material.

The introduction of recycled materials will see the color of insert boxes change from pure white to a darker grey color, which is most efficient from a sustainability point of view.

Until now, Seco has used white DC packaging boxes made of Kraft Liner, with an overlay of white linen paper, a material that requires an additional bleaching process which generates waste and is harmful to the environment. The average overall percentage of recycled raw material used in the white boxes used by Seco is calculated to be 77.2 percent, while the new brown packaging boxes will consist of 100 percent recyclable material.

In the Asia Pacific Distribution Center (ADC) Seco will shift boxes made from 77.2 percent recyclable material to new designs made with 100 percent recyclable material. In the America Distribution Center (UDC) the recyclable material will go from 20 to 100 percent, while the China Distribution Center (SDC) is transitioning from white recycled paper to brown recycled paper, with the bleaching process being stopped entirely.

Since 2020, the filling material in the boxes has consisted of paper filling rather than plastic bubble sheets, and the updated brown boxes will be branded with an inked black Seco logo which will be more environmentally friendly than printing a blue logo on white boxes.

"Every year vast amounts of waste are generated from packaging, and our goal is to break that cycle. We want our packaging to be part of a circular, sustainable economy. We are constantly looking for new ways, materials, and processes to ensure that our business can reach its sustainability goals," said Blomqvist.

secotools.com

Sandvik Coromant

PARTICIPATES IN AUTOMOTIVE METAL-CUTTING RESEARCH

Sandvik Coromant has announced its participation in Rota 2030, a federal government program designed to support and boost Brazil's automotive sector. The company will contribute to R&D projects on an ongoing basis to educate the next generation of talent, establish fiercer competition among automakers and ensure the continued development of cutting-edge technologies and processes.

Rota 2030 is an initiative backed by the Fundação de Apoio da UFMG (Fundep) to establish a long-term policy for the automotive and automotive parts sectors by stimulating investment and strengthening companies in the sector. The program is based on three main areas—reestablish competition within the national automotive tools industry, develop safe biofuels and other alternative combustion methods, and enable connected vehicle technology.

Sandvik Coromant will participate in the program's toolmaking area since this is its main area of activity in Brazil. The initiative aims to solve the key challenges faced by automotive machine shops—low productivity and gaps in technological knowledge—to enable Brazilian manufacturers to become more competitive in a global market. Sandvik Coromant's contribution to the project will be hosted at its regional Sandvik Coromant Center in Jundiaí, where it has a dedicated team that supports the development of machining processes using its metal cutting tools and testing capabilities.

Sandvik Coromant has had strong relationships with academic institutions in Brazil and has provided support and education in machining processes to customers, researchers, and students in the field for many years. Thanks to these well-established relationships and a strong presence in the metal cutting tools sector for automotive applications, Sandvik Coromant is well-suited to offer technical expertise and access to the latest innovation in cutting tools to enable R&D projects.

So far, the organization has participated in three research projects—one that explores a new concept of mold production through polymer injection, another in the development of advanced deposition technologies in die-casting tooling, and a third in the design and manufacturing of tooling for composite parts.

Sandvik Coromant invites students, academics, and industry professionals to conduct R&D testing at its Jundiaí Center using its selection of metal-cutting tools as part of each of these projects. R&D projects under Rota 2030 typically last between one and two years, and the research results are then shared with automotive partners to improve processes and streamline production industrywide.

"Participating in Rota 2030 is a win-win for Sandvik Coromant. The automotive industry is our main area of activity in Brazil, so our knowledge and services are well suited to support the development of the sector," explained Aldeci Santos, responsible for the Sandvik Coromant Center in Jundiaí.

"It also gives us the opportunity to stay up to date with the latest developments in the machining sector, as well as the technologies used by our customers and partners. Being involved in developing the latest innovations guides our product development strategy to ensure our products closely meet the needs of our customers."

sandvik.coromant.com

Stäubli Group

APPOINTS NEW CFO

Roger Schnüriger, Chief Financial Officer and member of the Executive Committee, Stäubli Group

Stäubli has appointed Roger Schnüriger as its new group chief financial officer (CFO) and member of the group executive committee as of June 1, 2023.

With Schnüriger, Stäubli is recruiting an experienced manager, who has a strong track record in successfully transforming and developing global finance functions for industrial companies. The new appointment therefore perfectly matches Stäubli's current business strategy for strong international growth, which the Group intends to maintain in the period ahead.

Schnüriger has most recently served as Group CFO for the medical device company Medela. He brings with him over 20 years of financial and international management experience gained in functional and division leadership roles at multinational groups Sonova, DKSH and Syngenta. He is known for his clear focus on achieving business objectives and establishing strong governance frameworks in complex and matrixed enterprises.

"We are fortunate to have found in Roger Schnüriger such a valuable contributor to the further implementation of our business strategy, and we look forward to fostering the expansion of the entire Stäubli Group together," said Gerald Vogt, CEO.

Schnüriger holds an Executive MBA from London Business School and advanced diplomas in Treasury, Risk and Corporate Finance.

staubli.com

September 11–14—Fabtech 2023

Fabtech returns to McCormick Place in Chicago for North America's largest metal forming, fabricating, welding, and finishing trade show. Fabtech provides a convenient 'one-stop shop' venue where you can meet with 1,300+ suppliers, discover innovative solutions, and find the tools to improve productivity and increase profits. There is no better opportunity to network, share knowledge and explore the latest technology. Gain insights into industry trends that will help you prepare for what's ahead, all here in one place. The Fabtech Conference combines 60–90 minutes sessions and workshops covering the latest in advanced fabrication technology, workforce, and management topics. Pick and choose the sessions right for you and build an agenda to provide the key insights and solutions to all your manufacturing and production challenges.

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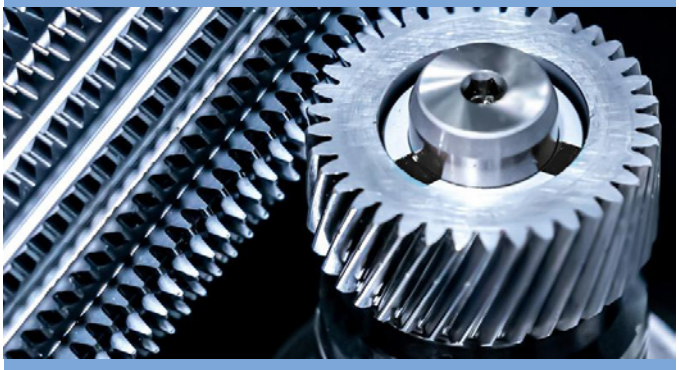
September 13–15—VDI International Conference on Gears 2023



As an accompanying event to the International Conference on Gears 2023, the 5th International Conference on Gears (Garching/Munich) is one of the most important biannual meeting points for the gear manufacturing industry both for technical experts and for decision-makers. Current challenges and solutions are presented and discussed, strongly emphasizing new potentials in productivity and/or the flexibility of gear manufacturing processes. High-level expertise will be ensured by our conference presidents: Prof. Dr.-Ing. Christian Brecher and Prof. Dr.-Ing. Thomas Bergs MBA, WZL, RWTH Aachen as well as Prof. Dr.-Ing. Karsten Stahl, FZG, Technical University of Munich (TUM) in Garching.

geartechnology.com/events/5077-international-conference-on-gear-production-2023

September 18–23—EMO Hannover 2023

The discussions between manufacturing experts at EMO Hannover 2023 will revolve around three main future insights. The future of business will explore Work 4.0, new financing solutions, sales models, and markets. The future of connectivity will delve into the potential of smart production, the IoT and AI. It will be beneficial for smaller companies, as the new technologies create additional perspectives for them. The future of sustainability in production will address the developments related to alternative drives, energy efficiency and, of course, sustainable production. Learn more here:

geartechnology.com/events/5071-emo-hannover-2023

October 17–19—Motion + Power Technology Expo 2023

Produced by AGMA, Motion + Power Technology Expo (Detroit) is a three-day show that connects professionals looking for motion power solutions with manufacturers, suppliers, and buyers. Attendees will find new power transmission parts, materials, and manufacturing processes. Buy, sell, and get business done with organizations in aerospace, automotive, agricultural, energy, construction and more. Hundreds of exhibitors and attendees means MPT Expo is a unique opportunity to find partners that can help fulfill your specific production needs. The show is colocated with Heat Treat 2023 and IMAT 2023.

geartechnology.com/events/5076-motion-power-technology-expo-2023

November 12–15—2023 STLE TFC and E-Mobility Conferences

The 2023 STLE Tribology Frontiers Conference (TFC) will be held November 12–14. The Cleveland event will allow attendees to engage with world-renowned industry, academic and government researchers to learn more about the technical, environmental, and social issues impacting tribology research in the 21st Century. The 2023 STLE Tribology & Lubrication for E-Mobility Conference will be held in conjunction with the TFC from November 14–15. The event will feature educational sessions and networking discussions with leading industry experts covering technical content, analysis, and best practices for addressing the challenges and opportunities associated with electric vehicle technologies and how they will impact the tribology and lubrication field.

geartechnology.com/events/5062-2023-stle-tribology-frontiers-conference-and-tribology-and-lubrication-for-e-mobility-conference

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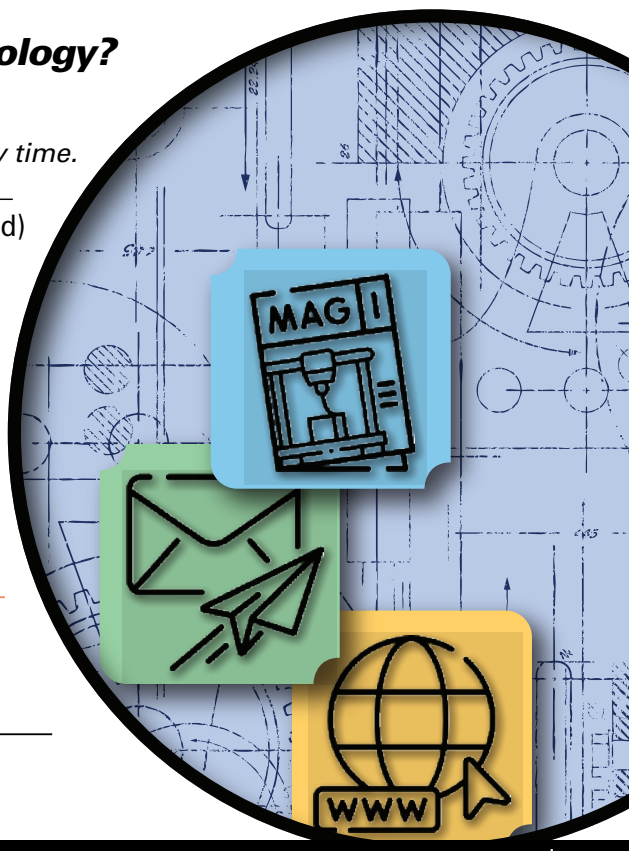

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Primal Printing

Matthew Jaster, Senior Editor

Can a technophile 3D-print a giant replica from the new Transformers film? Of course—it's 2023 and additive manufacturing is enabling engineers to test manufacturing material boundaries daily.

Paramount Pictures, Velo3D, *3D Printing Nerd,* and Adam Savage's *Tested* recently announced an amazing project that uses metal 3D printing to bring Transformers to the real world. To promote the new movie, *Transformers: Rise of the Beasts* (in theaters this summer), Velo3D 3D printed the head of the character Optimus Primal using its Sapphire XC printer.

Both the head and stand featured in the videos are made from Inconel 718, a high-performance nickel-based alloy used by some of today's most innovative space companies. The superalloy is known for its strength, toughness, and corrosion resistance—properties that make it an ideal material to build a real-life Transformer. Real life applications for this material include aerospace, aviation, and gas turbine components, nuclear reactors, and chemical processing equipment.

3D Printing Nerd host Joel Telling explores all the steps to produce a part through laser powder bed fusion—only this part is Optimus Primal's head, not a rocket engine. Telling then takes the head to The Hacksmith, a Canada-based engineer who takes fictional ideas from comics, movies, and video games and makes real, working prototypes of these products. There, they do a series of destructive tests—including stabbing Optimus Primal with a working plasma lightsaber.

"This is one hundred percent 3D-printed," said Telling. "This is using a powder-bed of metal material and the temperature within the chamber is kept subcritical and that laser goes through and brings the material that it hits just above critical so it can weld it together. The machine that printed this is Velo3D's Sapphire XC and it's like two stories tall!"

See the video here:
youtube.com/watch?v=T83P08VDTtg

In Adam Savage's *Tested* video, Savage discusses metal 3D printing and how it's being used to build next generation technologies.

See the video here:
youtube.com/watch?v=DviGCPms9go

The Sapphire XC utilizes eight 1 kW lasers for faster printing at scale. A proprietary noncontact recoater eliminates the risk of part collision, protecting both the build and the recoater while enabling thinner walls and more accurate builds. Standardized and controlled parameter sets, along with automated calibrations, ensure consistent geometric accuracy, surface finish, and validated material properties. As with all Sapphire printers, the XC provides supply chain scalability with one print file per part that works on any Sapphire printer worldwide.

Optimus Primal Statistics at a glance:

Optimus Primal was produced on a Velo3D Sapphire XC, which is capable of printing parts 600 mm in diameter by 550 mm in height. The part is made of Inconel 718, which is used by companies in space to produce rocket-engine parts. The part is shown as printed so you can see the final texture, but the base features portions that have been machine polished, like how parts would be finished after being printed.

Optimus Primal Transformers Head and Stand

Total weight: 225 lbs.
Total dimensions: 600 mm x 380 mm x 300 mm
Total layers: 9,000+
Print time: 160 cumulative hours
Slice time: 3 hours

Inconel 718 material information:

Inconel 718 is a precipitation-hardenable nickel-chromium alloy It is a high-strength, corrosion-resistant material used at temperatures ranging from -423°F to 1300°F

In the coming years, Sapphire XC printers will continue to print much larger parts for its customers in aerospace, energy, defense and even the occasional entertainment application.

velo3d.com

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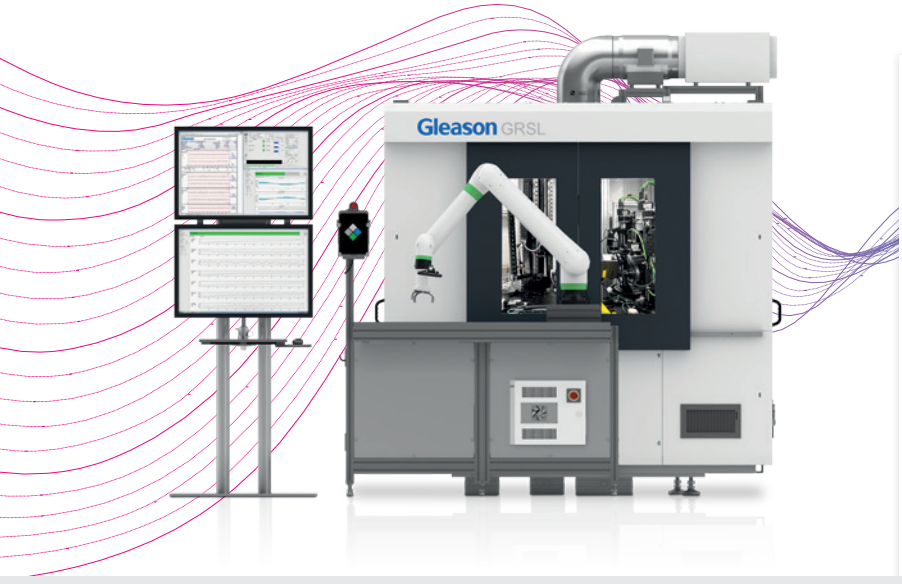

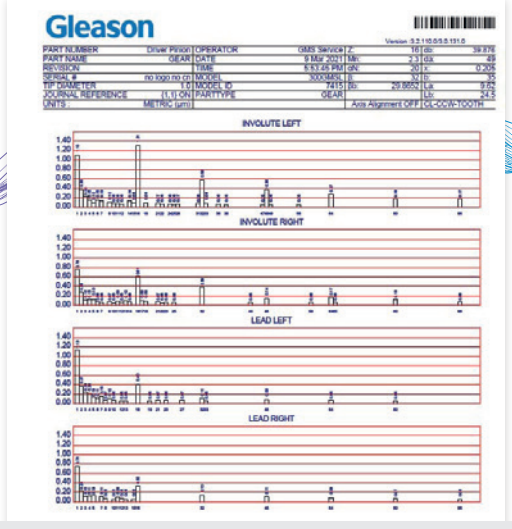

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