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Highlights on the AGMA Foundation (p10) and the AGMA Statistical Programs (p36)

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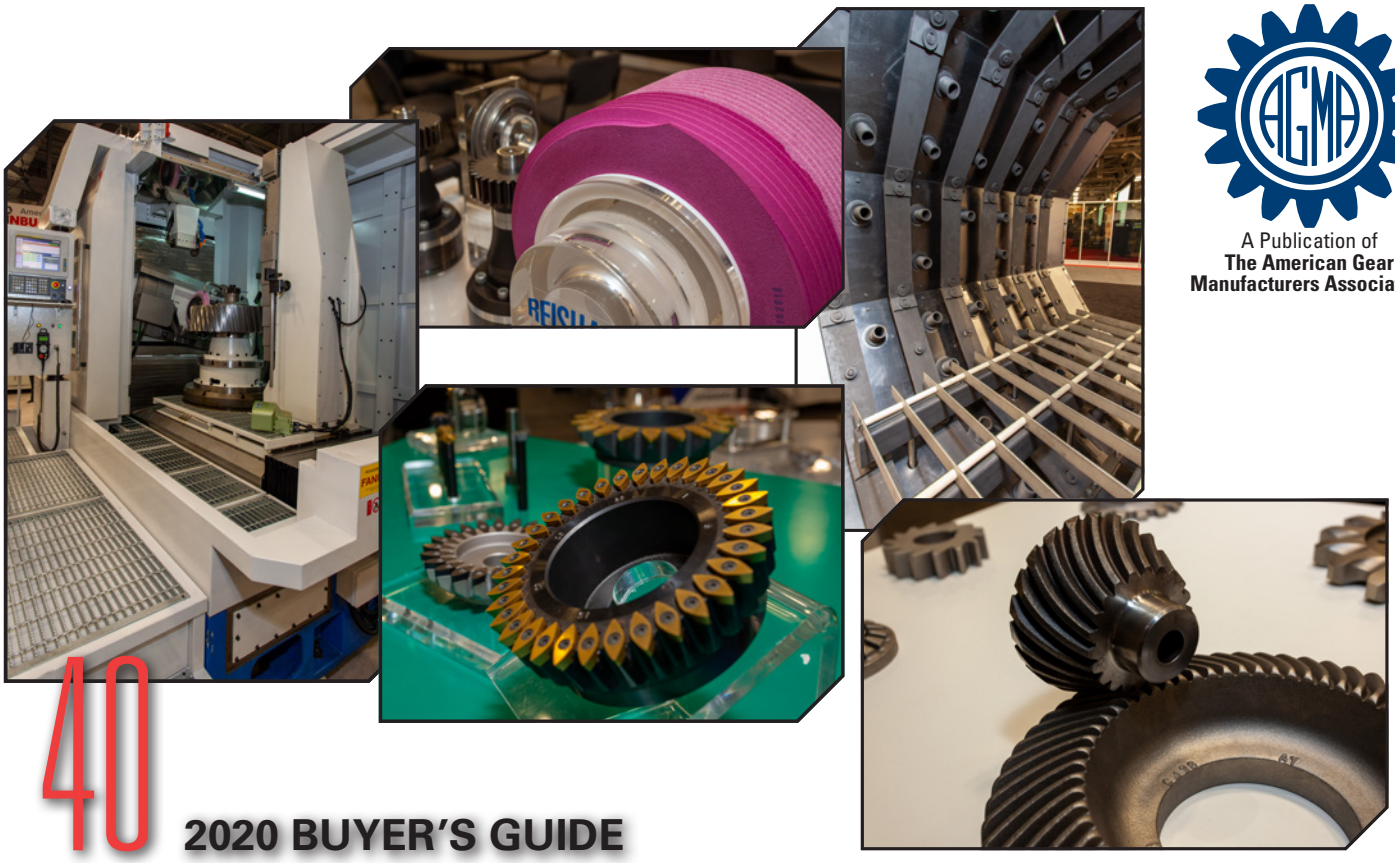

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40 2020 BUYER'S GUIDE

features

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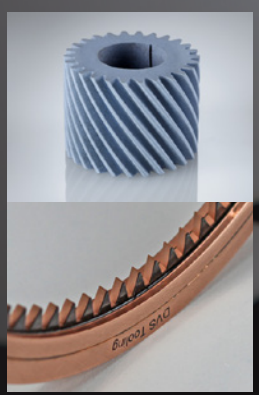

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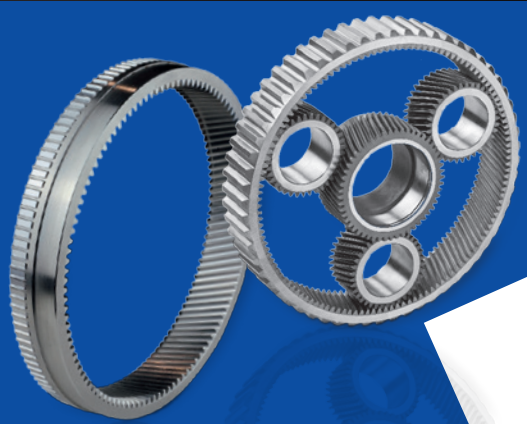

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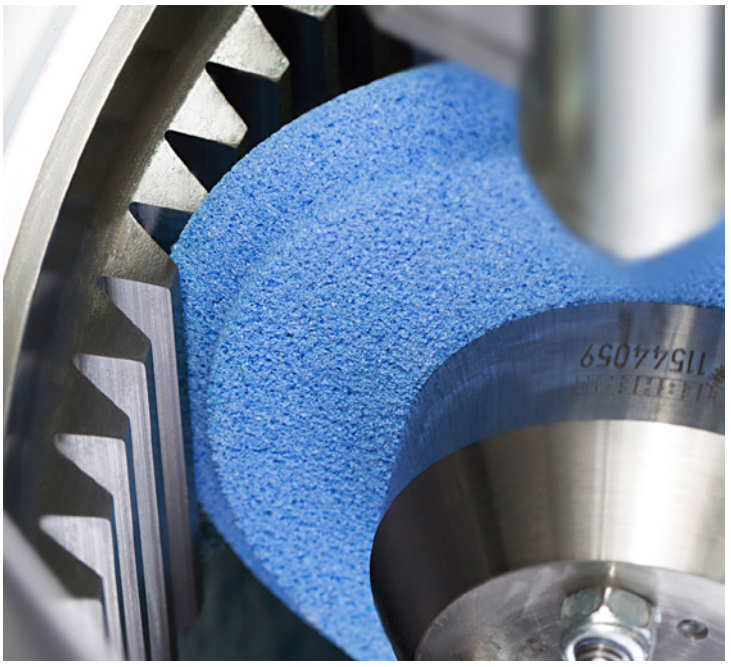

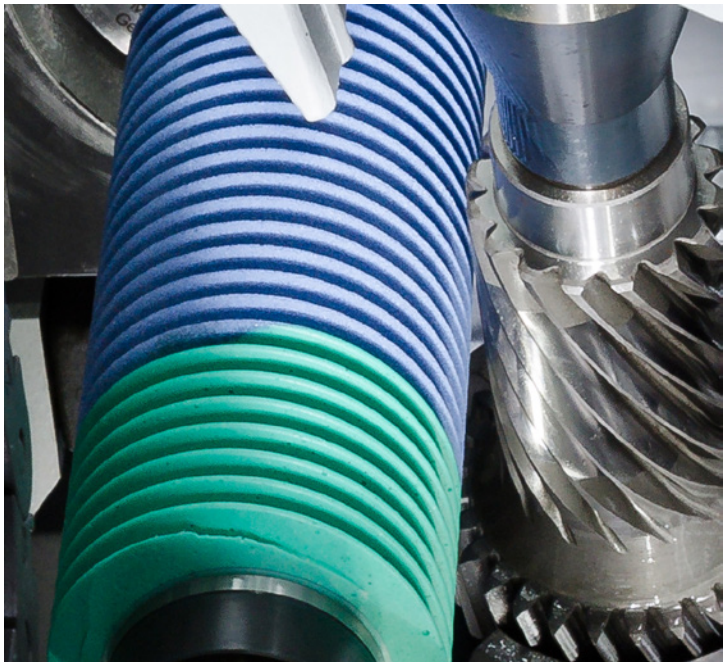

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Watch this complete machining of stepped pinion on the gear skiving machine, LK 280 DC from Liebherr. Learn more here:

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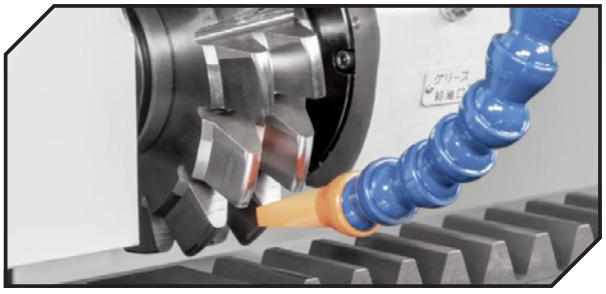

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Gear Talk with Charles Schultz

Resident blogger examines thoughts on gearbox design, going against norms and a free-thinking approach to gears in the latest entries to his blog.:

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

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10-4 GEAR SHAPERS

Photos show before and after remanufactured Fellows Shapers

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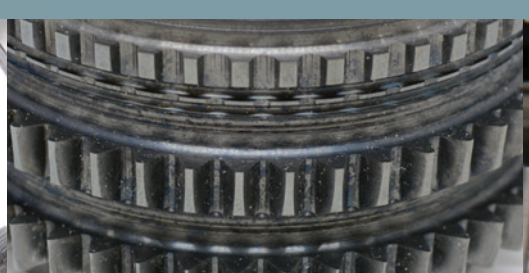

Closing Out the Year — Reasons for Hope

Publisher & Editor-in-Chief
Randy Stott

Phew! Making it to the end of 2020 seems like a victory in and of itself. Between the coronavirus, the economy, the rioting in the streets, the extreme weather events and the fiercely divided presidential race, we've all had a LOT to worry about this year.

But as we draw 2020 to a close, there appear to be at least some reasons for hope.

For example, treatments for COVID-19 have improved, and it looks like we're going to have highly effective vaccines available to large portions of the population by the middle of next year. Although we're in the midst of a terrible wave of outbreaks, and we're definitely not through the struggle yet, there's reason for optimism that there can be a return to normal. We're not there yet, but we can see that it's coming.

Likewise, the presidential race is finally over. As always, some are happy about the result, and others are not. This year more than most, feelings run strong. But regardless of your political affiliation or how you voted, just knowing that it's over gives us a better idea about what the next four years might look like. Change always brings uncertainty. But the level of uncertainty today feels a lot lower than it did a few months ago. Less uncertainty is better for the national psyche. It's better for consumer confidence. And it's definitely better for business.

And it looks like manufacturers are responding. According to the Institute for Supply Management, the U.S. manufacturing economy expanded in October at its fastest rate in more than two years. According to the report, "The October Manufacturing PMI® registered 59.3 percent, up 3.9 percentage points from the September reading of 55.4 percent and the highest since September 2018 (59.3 percent). This figure indicates expansion in the overall economy for the sixth month in a row after a contraction in April, which ended a period of 131 consecutive months of growth."

So as long as things don't take another turn for the worse, it looks like there's reason for optimism there, too.

Here at *Gear Technology*, we're looking forward to 2021. We have high hopes for the gear industry next year. We anticipate that the virus will be under control, which means that the Motion+Power Technology Expo (September 14-16 in St. Louis) has the chance to be a truly spectacular event. We're going to be there, and you should make plans to go, too. You can visit *motionpowerexpo.com* for more information.

And if you're feeling more confident about the future, as we are, maybe it's time to look at some of those investments you've been putting off. Having the latest technology in place is key to ensuring your success as we return to normal. So if you've been thinking about new machine tools, automation or other technology, why not start looking now? This issue's Buyer's Guide (beginning on page 40) is a great place to start, as is the online Buyer's Guide at *www.geartechnology.com*.

But also, don't forget about investing in the information you need to be successful for years to come. The AGMA offers great opportunities in this area. This issue, Mary Ellen Doran describes the AGMA statistical programs (page 36) and how they can help you benchmark against your peers in the industry and better understand where your company might need to improve operations to remain competitive. In addition, information means education, and education in our industry is supported in large part by the AGMA Foundation. Please take a few moments to read John Cross's column (page 10) describing the foundation's successes in recent years. The more people who are aware of these programs — and who actively support them — the stronger our industry can be moving forward.

And who doesn't want a stronger gear industry? As we close out 2020, let's all breathe a collective sigh of relief. But at the same time, let's build our future.

On behalf of the entire *Gear Technology* and AGMA team, I'd like to send all of you our best wishes for success and prosperity in 2021.

Gearing for the Future

John Cross, Chairman of the Board, AGMA

In 2021, the AGMA Foundation begins its 27th year.

It is a critical year for the AGMA Foundation as our industry is facing incredible challenges and opportunities, and AGMA members are asking a great deal from our industry Foundation. For example:

- We need new ways to attract and promote our industry, to make students excited about who we are, and what we do as an industry.
- We need to financially support students and foster their commitment to our sector, so they join us in designing future power transmission solutions.
- We need more training, to ensure our employees are leveraging best practices from design to failure analysis.

AGMA Foundation

What We Did

For the past five years, these three items have been the primary focus areas of the AGMA Foundation. Under the very capable leadership of Scott Miller from Caterpillar, Scott Moss from Comer, and Dean Burrows from Gear Motions and executed by our Executive Director, Cindy Bennett, the AGMA Foundation has made incredible strides responding to these challenges. Over the years, the AGMA Foundation has:

- In 2018 developed and published the industry's first ever promotion program. Entitled "Get Into Gears," this multi-faceted program offers our industry free, downloadable integrated marketing materials members are using at job fairs, tradeshows and other events where prospective employees gather. To date, 133 companies have downloaded the materials, with many making it a significant part of their outreach efforts.
- Since 2010, distributed $312,500 in scholarship support to 45 engineering students. The AGMA Foundation scholarship program is incredibly successful: 87% of graduated students are now working in the mechanical power transmission industry, the majority for AGMA member companies.
- Granted $446,000 to AGMA for the development of 15 new education and training courses for both engineers and operators. Due to this funding, the industry now has up-to-date courses covering gear design, gear failure, gearboxes, and operator training covering grinding, heat treat and gear cutting. More than 5,000 AGMA member company employees have participated in AGMA Foundation-funded training classes in just the past five years!

How it Happened

What did it take to achieve these outcomes, and be part of making a difference, supporting the future of our industry?

In a word — you!

Your leadership, your commitment — and yes, your financial support.

You see, the AGMA Foundation is driven by industry leaders — It's a virtuous cycle of giving — you give your time and money, and we work together to give it back in the form of scholarships, education and training, and industry promotion.

And that is why this is a critical year for the AGMA Foundation. These challenges and opportunities are not going away next year. If anything, COVID-19 has accelerated our need for more people and more support.

That means the AGMA Foundation needs more support. We need more volunteers to be on our AGMA Foundation Board of Trustees. We need more individual and corporate donors. We need you to leverage the AGMA Foundation in order for the entire industry to be as strong as possible.

How can you help?

One way is via a sizable donation — Linda and Bipin Doshi did this in 2018 with a $100,000 financial commitment that has now become the Linda and Bipin Doshi

Past AGMA Foundation Scholarship Winners, (l–r): Yue Peng, scholarships in 2016/2017/2018, University of North Carolina at Charlotte; Tiffany Lim, 2017, The Ohio State University; Denis Lang, 2016, Penn State Erie, The Behrend College; Jack Jaeger, 2017, Waukesha County Technical College; and M.D. Fahad, 2015/2016, The Ohio State University.

Golf Carts ready to roll: for the AGMA Annual Meeting Golf Tournament fundraiser. Unfortunately Covid 19 canceled this event in 2020.

Scholarship. The AGMA Foundation has since granted annual $5,000 Doshi scholarships to two outstanding engineering students.

Another way is a smaller donation -- $100, $500, $1,000 — any amount will be helpful. All personal donations are 100% tax deductible, but adding them all up is where we make a difference. We have been giving away an annual average of $49,000 in scholarships since 2016 and want to continue that pace in order to get a larger number of students (eventually employees) into our industry.

We know it's been a challenging year. We are all in the same place, but via the AGMA Foundation; we are making a noticeable and material difference. We are getting new employees, we are ensuring they are well trained, and we are doing our best to promote this great and noble industry.

A 2018 AGMA Foundation Scholarship Recipient, Caleb graduated from Western Michigan University and is now employed full time at the Eaton Corporation. (pictured with Cindy Bennett, AGMA Foundation Executive Director)

Check out our work at *www.agmafoundation.org*. Click on "Gearing for the Future" to donate online or download a pledge card.

Join us, as we work together to make a difference.

I will close by thanking all of the volunteers through the years that have helped make a difference, Foundation Board members, the Scholarship and Fundraising Committees, and of course our incredible AGMA volunteer leadership team.

Help me make a difference via the work of the AGMA Foundation.

John Cross
Chairman of the Board, AGMA
President and CTO, ASI Drives

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Rebuilding a Legacy

BOURN & KOCH PROVIDES RETROFIT MACHINE FOR GEAR SHAPING

JOE GORAL, BOURN & KOCH

When Bourn & Koch purchased the Fellows Gear Shaper Company in 2002, there was considerable excitement about the possibilities for the little-known machine tool company from Rockford, Illinois. Though the purchase of Fellows wasn't their first foray in to acquiring a gear company, it had been 17 years since Bourn & Koch had bought Barber-Colman's machine tool division, acquiring their gear hobbing machine designs and repair parts and service business. The acquisition of Fellows offered numerous opportunities to expand Bourn & Koch's footprint into the world of gear manufacturing.

Since the acquisition of Fellows in 2002, Bourn & Koch has developed new models of Fellows gear shapers and has been awarded patents on designs that have been incorporated into these machines, most notably the use of flexure plates to increase stiffness in the cutter spindle housing, removing the need for hydrostatic pads. Though their new machine designs offer a long list of cutting-edge technologies, Bourn & Koch has always had a strength in remanufacturing older Fellows gear shapers.

Fellows 10-4 Retrofit by Bourn & Koch.

A typical remanufacture process will not only bring the machine up to today's standards for CNC controls and machine systems but will also restore the machine's alignments or original factory specifications. In essence, it is a new machine using very well-seasoned castings. As one might imagine, the process is time consuming and costly, but typically results in a machine that is two-thirds the price of new. On specialty machine tools, such as gear manufacturing equipment, this can mean considerable costs savings to the customer.

Understanding the increasing need for many companies from job shops to OEMs to update their gear manufacturing machinery or to outright add this to their capabilities, Bourn & Koch took the time to rethink their offering to the market for gear shaping machines, focusing on the Fellows 10-4 in particular.

Loyd Koch, co-founder of Bourn & Koch and machine tool guru, headed up the effort to provide a more cost efficient and adjustable version of the Fellows 10-4 to the market. Koch, a former engineer at Sundstrand Machine Tools, knows the rebuilding process like the back of his hand; it is how Bourn & Koch got started in 1975, rebuild and retrofitting Sundstrand's machines. Larry Bourn & Loyd Koch started rebuilding machines in 1971, eventually forming Bourn & Koch in 1975.

Starting with an original Fellows 10-4 serial number 34807, Loyd and the team of gear technicians at Bourn & Koch disassembled the machine, painstakingly inspecting the parts as they were removed to determine if they met OEM tolerances. The parts that did not pass inspection were discarded and replaced with new, manufactured per Fellows OEM prints.

Once disassembled, the bare castings were now a blank canvas for Loyd and the engineering team at Bourn & Koch to start anew, attempting to balance the delicate task of reducing cost while maintaining quality. Any gear shaper whether new, remanufactured, that leaves Bourn & Koch must produce AGMA class 10 gears on all measured features. The goal for the rebuilt machine was to be able to provide a minimum of AGMA class 9 gears. The result was a class 10 gear produced at run-off.

Two of Bourn & Koch's current engineering staff, Wayne Densmore and Steve Ray, started their careers at Fellows, accepting positions with Bourn & Koch when the company was acquired. Densmore is a mechanical engineer by training, responsible for numerous designs both at Fellows and Bourn & Koch that have stood the test of time. Around the office, Densmore has a reputation for designing machine tools that are of an equivalent duty to those made in the heyday of American

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Machine Tools. Ray, a software and controls engineer, has been responsible for development of Bourn & Koch's human machine interface (HMI) software over the past 16 years. He's been an integral part of many new software features on both gear hobbing and gear shaping machines during that time. Both Ray and Densmore were integral to the effort to bring this "new" product to market.

While Fellows produced a reliable, stout, gear shaper, the controls on the machines, much like any electronic component, become obsolete. Bourn & Koch primarily uses Fanuc on their machine tools, from gear hobbers and shapers, to cylindrical and surface grinders. The standard for Bourn & Koch gear machines has been the Fanuc 0i-MF with a PC front end to host their gear manufacturing HMI. Understanding that the needs of the gear manufacturing market vary, Bourn & Koch designed a new CNC package with Fanuc Macro Executor on the 35i CNC control. Bourn & Koch already had a leg up on using this control for their new Blanchard grinders, so the transition from 0i to 35i was a relatively


AGMA 10 gear cut on the 10-4 Retrofit.

painless process. This also provides a familiar programming option to those familiar with Fellows original programming via Macro Executor.

During the design stage of the project, numerous considerations were made as to how the machine could be more accurate and adjustable, while reducing cost. Starting with the machine's x-axis, the team at Bourn & Koch looked at how to simplify the design while increasing infeed accuracy during the gear shaping operation. The decision was made to convert the machine's x-axis for infeed and positioning to direct drive with a ball screw and servo motor. Employing a Fanuc Beta-I 12 servo in lieu of their standard Alpha-I 8 servo, the new design for the x-axis on the machine now has more torque and higher accuracy due to the removal of the gearing in the original design. This also resulted in reduced costs as fewer moving parts are now required.

The same philosophy was applied to the machine's c-axis for the work spindle. Typically, a new or remanufactured 10-4 gear shaper would have a drivetrain through a spline shaft to rotate the table. The machine now has a direct drive work spindle, which improves accuracy and reduces backlash in the drive train. The original design incorporated a gear train and spline shaft to drive the table. With the direct drive design, those components are eliminated, reducing cost both at the time of machine build and during machine ownership. This also offers a mechanical advantage over typical belt drive systems.

forestcitygear.com

At the heart of a gear shaper is its spindle. The stroke and rotation of the spindle are the driving force behind the generation of the gear teeth. Particular attention was paid to how to improve this area of the machine while reducing cost in the rebuild process. To further reduce cost, a Fanuc servo motor was used in place of a Fanuc spindle motor. This also reduces the number of components required to retrofit the machine to CNC including the disc brake but provides the added benefit of programmable quick return stroking.

Floor space is a large concern in many shops these days. With square footage being at a premium, compact machine designs can have a distinct advantage in process to determine what machine will ultimately be selected for purchase. To reduce the footprint, Bourn & Koch considered many aspects of the machine, most notably the guarding package and the hydraulic unit.

A simplified guarding package was designed for this new offering to reduce both cost and required floor space. While the new guarding package is less costly, it does not sacrifice the required safety features and ergonomics requirements that many companies have. The guarding package allows operators easy access to the machine's workzone for setups.

With the removal of the hydrostatic pads and use of a mechanical guide in lieu of hydrostatic, the hydraulic requirements of the machine were greatly reduced. This allowed for a smaller hydraulic unit to be incorporated to the build, further reducing floor space. The new hydraulic unit also runs intermittently, saving on energy costs.

10-4 Retrofit machine workzone.

The new guarding package and smaller hydraulic unit reduced the overall required machine footprint by 16.5 square feet.

Maintainability is a focus of many companies in the machine selection process these days. Extended service contracts and extended warranties are all a sign that companies are looking to ensure the machine can be maintained by experts from the factory. That being said, a gear shaper is not in the same class as a milling or turning machine. They require fine adjustments and specialized knowledge to continually produce high class gears. With that in mind, Loyd and the team at Bourn & Koch worked toward developing methods to easily adjust the machine.

The cutter nut on the spindle was modified to allow it to be adjusted via set screw. The guide attachment is now adjustable via set screw as well.

Further improvements to the c-axis were made through retrofitting the table bearing cap to allow for preload adjust-ment without disassembly. Typically, a Fellows 10-4 gear shaper requires that a spacer be ground to fit in order to set the preload of the table bearing. This step is eliminated in the rebuild process and for future maintenance by incorporating the cap design. Table bearing preload is necessary for producing an accurate gear. With this step simplified, the machine's ability to continually and reliably pro-duce accurate gears over its lifetime is greatly improved.

Overall, the "new" Fellows 10-4 ret-rofit offers companies a cost-effective way to add or upgrade their gear shap-ing capability without sacrificing quality. With Bourn & Koch's OEM support and technical expertise on Fellows, compa-nies can be well assured that they are getting a quality machine backed by a team that knows their gear shaping machine inside and out.

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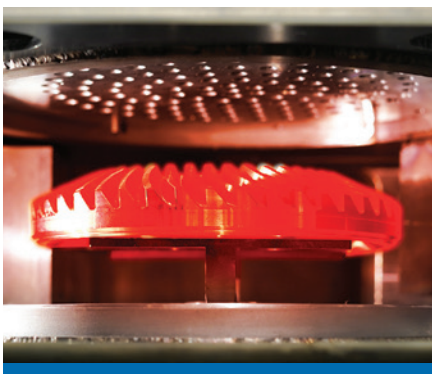

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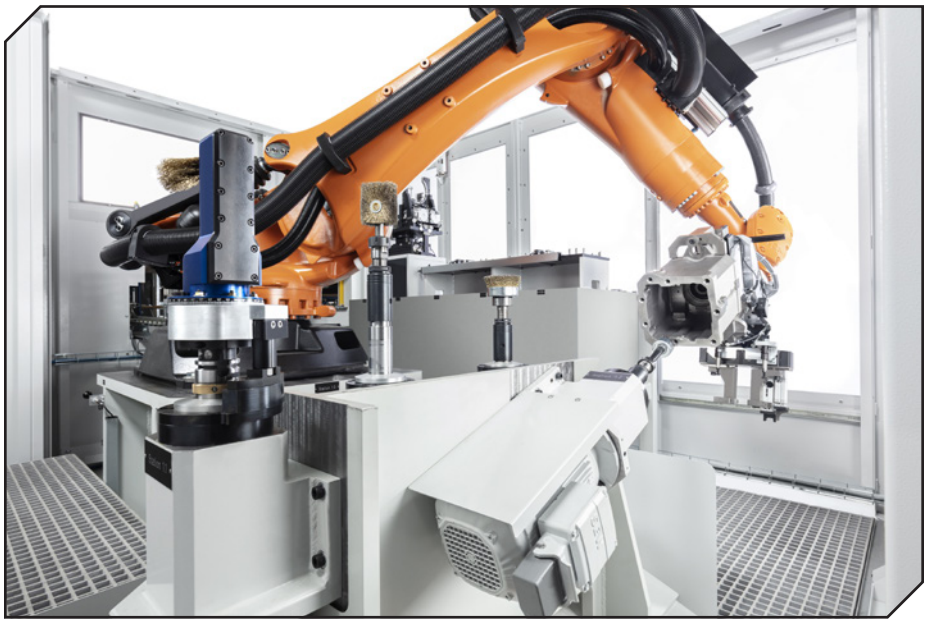
Kadia

INSTALLS DEBURRING-AUTOMATION-CELLS TO INCREASE ZSO PRODUCTION

Kadia's portfolio includes a wide variety of deburring machines, most of which are designed for fully automatic operation with the aid of a robot. At Zerspanungs- und Systemtechnik GmbH (ZSO) in Oberstaufen, the Nürtingen experts implemented three deburr-automation-cells. The tasks of these systems include not only deburring the workpieces, but the robots also take over the complete handling for mechanical processing.



For ZSO, it is clear that quality, process reliability, and productivity must be raised to a maximum level, and this is only possible if processes are consistently automated. For this reason, ZSO has invested heavily in handling systems and the networking of its machinery in recent years. Of the 35 processing machines currently in use, a third are already fully automated.

One of the most recent projects was particularly important for ZSO Managing Director Carsten Binder, Ph.D.: The handling and deburring of grey cast iron housings for mobile hydraulic pumps weighing up to 26 kilograms. These are, for example, pumps for the hydraulic systems in construction machinery. The housings go directly from the foundry to ZSO, where they are

manufactured - ready for assembly.

"Our plan was to have a robot carry out all the recurring processes," said Binder. "Deburring would also be possible on the machine tool, but a robot is the far more cost-effective solution for this."

In Kadia, ZSO finally found a partner with the corresponding expertise in the fully automatic deburring of heavy workpieces. After a short time, the design engineers in Nürtingen presented a concept that convinced the ZSO managers. It is based on a 6-axis robot with a payload of 120 kg and a reach of 2.5 m. Kadia's customers receive such solutions completely from a single source. That means the scope of supply includes the process development, robot, cell, gripper, deburring stations, and tools including special solutions. Not to forget, of course, the sequence programming with all safety-relevant designs.

Kadia delivered a first automation cell in April 2019, a second in September and a third in January 2020.

"It is important for our customers that we were able to increase process reliability and thus product quality during deburring," said Binder. "All edges are now deburred absolutely evenly, and according to customer requirements, there are no variations in the execution. In addition, the robot never forgets an edge or thread. This means that reworking is also a thing of the past."

For more information:
Kadia Inc.
Phone: (248) 446-1970
www.kadiausa.com

GWJ Technology
INTRODUCES TBK 2014 UPDATE

GWJ Technology introduces new features with latest software release of *TBK 2014*. With the newest version of the calculation software the user gets a powerful tool to determine, dimension and optimize gearboxes. Just as in previous versions, existing modules were improved and optimized.

Several new functions and settings are included in the software update. For example, additional options for the profile shift sum as well as for the profile shift coefficients were added, new basic rack profiles for plastic gears according to ANSI/AGMA 1106-A97 were integrated and the load capacity of plastic gears can now be calculated according to VDI 2736 in the cylindrical gear module.

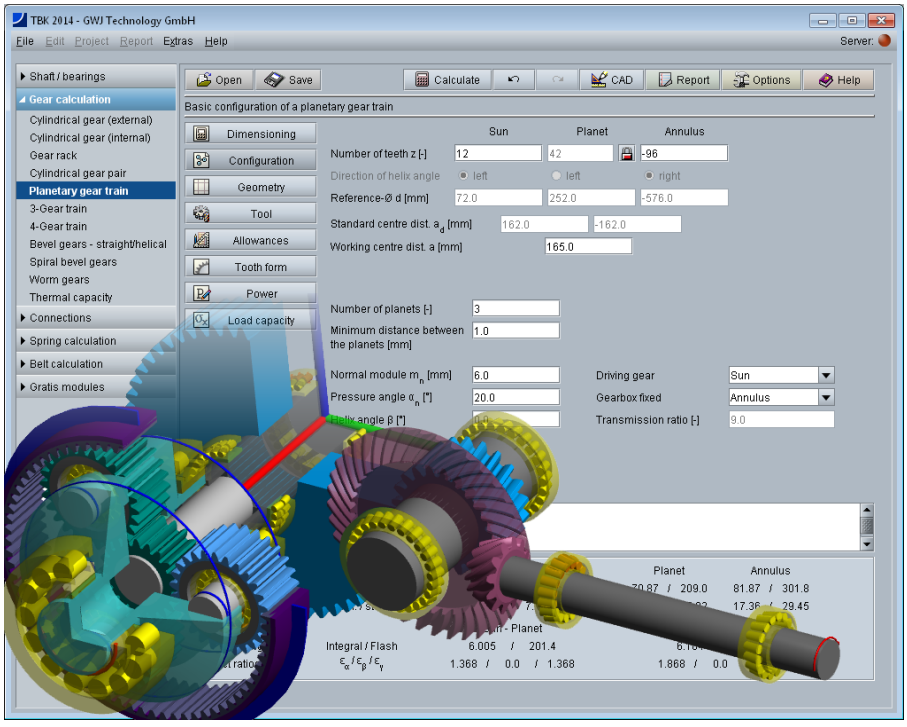
The first plastic materials were added to the general material database. For this, the temperature-dependent material properties such as fatigue strength and E-module were approximated in detail from available diagrams in VDI 2736 and stored accordingly.

Pairings of plastic/plastic as well as plastic/metal are supported. In the load capacity calculation of worm pairings, the calculated power losses can be overwritten or specified individually. This means that the load capacity calculation can be better adapted to the results of test bench trials.

Both versions of DIN 743 (version 2000 and 2012) are now available for calculating the fatigue strength and safety against permanent deformation of shafts. The desired version can be selected in the settings menu. The default standard is now the version DIN 743: 2012.

Also worth mentioning is the support of the latest software version *SystemManager* in conjunction with *TBK 2014*. Optimized usability and new functions make working with *TBK 2014* and the *SystemManager* more efficient, especially with regard to more complex systems like multi-stage cylindrical gearboxes or planetary gear sets.

For more information:
GWJ Technology GmbH
Phone: +49 (0) 531-129 399-0
www.gwj.de



Reishauer

OFFERS WHEEL MOUNTING CART FOR GEAR GRINDING MACHINES

The Reishauer Wheel Mounting Cart, ErgoMount, enables the machine operator to ergonomically and safely change grinding wheels and clamping tool arbours up to a weight of 40 kg. The unit has been designed for the RZx60 gear grinding machine series. It allows the direct mounting of a grinding wheel on the main spindle without any additional tools. Thanks to the well-thought-out fast-changeover system and the relevant load-bearing elements, the changeover between the setups for grinding wheels and clamping arbours is done in next to no time. The electrical lifting axis is controlled by a joystick and makes for comfortable operation.

The mounting cart complies with all relevant machine and working guidelines; offers fast and safe changing of grinding wheels and workpiece clamping arbours; an integrated grinding wheel setup device, pivotable by 90°; fast-changeover system with ball lock pin; clear layout of operating elements and readout instruments; storage positions for two grinding wheel and 3 clamping arbours; includes a generously dimensioned and lockable tooling drawer; excellent maneuverability and compact design.

For more information:
Reishauer
Phone: (847) 888-3828
www.reishauer.com

TCI Precision

OFFERS SPECIALIZED 'ROUND-TO-SQUARE' MACHINE-READY BLANKS

TCI Precision Metals has announced the addition of specialized round stock conversion to squared, high precision Machine-Ready Blanks.

Depending on job specifications or customer preference, round and square, precision Machine-Ready Blanks are now available, starting from round raw stock. "Some customers prefer to start with round stock material even when the finished machine-ready material needs to be square, but most of the time it comes down to alloy selection and availability," said Ben Belzer, president and COO of TCI Precision Metals. "For example, 144 Cold Finished Carbon

Steel and 465 Stainless Steel are both far more readily available in round stock. There tends to be more waste converting round materials to square machine-ready blanks, but if specifications or material availability dictate, TCI can now efficiently deliver on the request with our 'round to square' milling services," added Belzer.

TCI sawing, milling, and grinding equipment are all designed for high volume production and are configured to convert and prep virtually all materials to precision machine-ready specifications much more efficiently than most shops can do in-house.

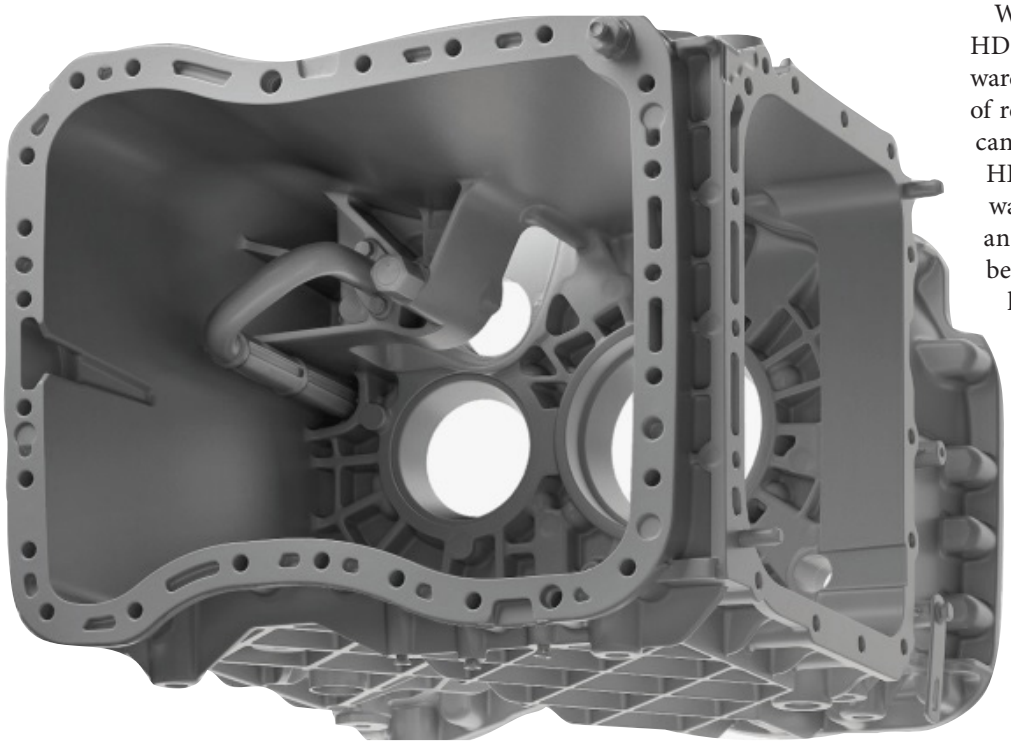
Machine-Ready Blanks from TCI Precision Metals help shops increase throughput up to 25%. With a single purchase order customer receive custom precision blanks ready to load directly into their CNC machining centers. Precision blanks eliminate the need for in-house sawing, grinding, flattening, squaring operations and outside processing. Each blank arrives deburred, clean and to customer specifications — guaranteed as close as +/- .0005" dimensionally and as close as .002" flatness, squareness, and parallelism. Customers are able to use the time they previously spent in setup and prep for more productive use of CNC machining centers, adding to their bottom-line profitability.

For more information:
TCI Precision Metals
Phone: (800) 234-5613
www.tciprecision.com

Artec 3D

DOUBLES RESOLUTION FOR HANDHELD SCANNERS

Artec 3D, a developer and manufacturer of professional 3D hardware and software, has announced fthe successful development of a proprietary AI Engine that more than doubles the resolution of its Eva and Leo handheld scanners to 0.2 mm in a newly released HD Mode. Artec 3D is the first and only company to utilize deep convolutional neural networks to reconstruct 3D surfaces and improve the quality of 3D models. With HD Mode, users can create exceptionally accurate, low-noise scans of smaller, more detailed objects with complex surfaces, as well as large, intricate objects. HD Mode is free and available now for all Eva and Leo users via Artec 3D's latest scanning and data processing software, Artec Studio 15.



"With the help of in-house developed training techniques and CNNs, we've managed to squeeze more information from the same amount of data captured from our existing 3D Eva and Leo scanners and get a much richer and denser representation of the scene being scanned," said Gleb Gusev, CTO of Artec 3D. "Now we're able to receive up to 64 times more measurements from the same scanners, which more than doubles the resolution of the final model and significantly decreases noise. Another advantage of our new approach is the much more accurate reconstruction of the surfaces this technique provides compared to standard algorithms."

"We are committed to creating lifelong Artec 3D users, not only by developing the industry's most cutting-edge new 3D technologies, but also ensuring that the performance of our existing solutions is continuously being enhanced," said Artyom Yukhin, President and CEO of Artec 3D. "The release of HD mode, powered by a first-of-its-kind neural network, is an extraordinary milestone for the 3D scanning industry that our users can benefit from right away. It's incredibly rare for any company to release such a significant upgrade at no cost, but we want users to rest assured that when they invest in our technology it will continue to pay off for years to come."

Artec 3D has a deep history in computer vision and AI, creating AI algorithms for its own 3D facial recognition devices, as well as for technology industry leaders. Most notably, Artec 3D's team of AI experts worked with Apple to help develop its Face ID. Now, Artec 3D has leveraged its expertise to apply AI not only to 3D faces, but to 3D objects of any kind. The convolutional neural network powering Artec 3D's AI Engine in Studio 15 software has been trained using millions of data points and hundreds of thousands of 3D models to ensure optimum performance in HD Mode.

When an Eva or Leo operator turns on HD Reconstruction, they can look forward to scans with unparalleled degrees of resolution, coverage, and detail. They can also select the desired density for HD scans, from a standard 1X all the way up to an astonishing 36X for Eva and 64X for Leo. To experience the benefits of HD Mode, users must utilize computers with NVIDIA GPUs and 2 GB (Eva) / 4 GB (Leo) of video RAM for proper scanning and data processing. NVIDIA is the Artec 3D recommended graphics card brand for Artec Studio users.

HD Mode allows users to scan more detailed objects in over twice the resolution, with Eva and Leo scanners. This mode easily captures sharp and thin edges in higher definition. Even complex structures with various hard-to-scan surfaces, such as those featuring holes and gaps, varying depths and angles, and recessed areas are now systematically reconstructed in every single frame to deliver the best possible scan. With HD Mode, tricky surfaces, such as those that are deep black, shiny, or covered in hair or fur, are also easier to digitize with incredible detail. HD mode has an elite level of noise reduction in both raw data and final model, making scanned objects ready for reverse engineering, as well as many other applications, without needing any editing.

For more information:
Artec 3D
Phone: (669) 292-5614
www.artec3d.com/portable-3d-scanners/hd-mode

NACHI

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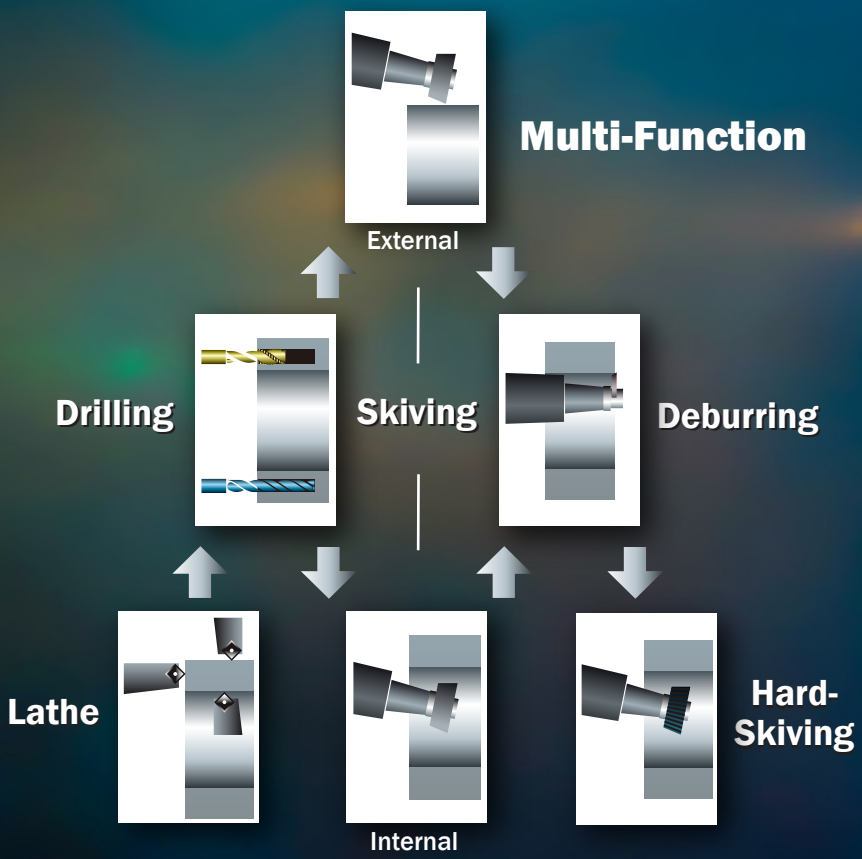

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EMAG

WINS RED DOT AWARD FOR FOR AI SOLUTION

The factories of the future are connected — in every respect: Machines communicate with each other regarding errors or required maintenance, while providing essential information to production planners that can control the machines from one central point. With this system, planners can create intelligent production systems that can manage tasks even more efficiently. With the creation of a new modular ecosystem, that has just won the Red Dot Award (Best of the Best), the EMAG Group has made this vision a reality, simplifying both operation and networking of the machines. Initial applications used by customers have been impressive in demonstrating how the entire production process is made much more transparent and efficient with this system.

Many experts forecast a "chaotic" future for production including constantly changing parts and fluctuating batch sizes, requiring the use of extremely flexible production solutions. In the end, this can also mean that, where five machines used to be necessary for handling different components, there could be only one in the future — capable of doing everything, perfectly connected to the production network. This, however, means that the focus on system operation is greater than ever: It has to be as intuitive, uniform and simple as possible — just like a smartphone — so as not to overwhelm the operator.

Extensive networking, self-explanatory operation — with this goal in mind, the EMAG Group started developing EDNA (which stands for EMAG DNA) three years ago, with the help of various partner companies. The entire process was very sophisticated and ambitious, as the EMAG Group consists of many subsidiaries that all specialize in different technologies and applications. Together, they develop complex manufacturing systems provided to a customer entirely from a single source. With that in mind, the envisioned ecosystem had to benefit all EMAG solutions as a uniform operator interface and IoT machine core. "Therefore, we discussed the requirements in a series of workshops and coordinated each development step with experts from the EMAG companies," explains Peter Strohm, business development manager IoT at EMAG.

The solution has been available for a while now, and has won over its initial users: feedback is showing that using EDNA significantly increase OEE. "With this research, we estimate that a return on investment is possible after about a year — if the collected data is analyzed and used to plan future actions," says Strohm. But how exactly are these successes possible?

1. IoT Core: Bridge to the Smart Factory

First, let's take a look at the EDNA IoT CORE of EMAG, with the diverse options for expanding it with hardware and software components: The EDNA CORTEX software runs on the powerful industrial PC and makes data available using various protocols, such as MQTT and REST, or — in the future — OPC-UA. With EDNA CORTEX, production data is processed, aggregated and analyzed. It is possible to flexibly adapt the scale on which the IPC is used: only locally within a standalone machine, connected to an edge solution of the company or networked with the cloud. At the same time, the solution has a completely modular software architecture that can be implemented in the specific IT infrastructures of the EMAG customers. "The solution is completely open and offers various standard

Game Changer

With Gleason's new Hard Finishing Cell (HFC), fast, automated production of 100%-certified precision gears is a reality. HFC connects GX Series Threaded Wheel Grinding and the new GRSL Gear Rolling System with Laser Scanning in a Closed Loop; gear checking, analysis and correction are done in-process, in real time.

www.gleason.com/HFC

Total Gear Solutions Gleason

interfaces. Connecting additional sensors, for example vibration sensors, and integrating products from other machine manufacturers is no problem," emphasizes Strohm.

As a result, users can access a large range of value-added applications. This currently includes the following apps: "Parts Quantity Forecast" (estimated output quantity per shift), "Cycle Time Monitor" (current cycle times of machines or lines), "Smart Tool Change" (information on remaining tool life), "OEE Monitor" (detailed breakdown of current OEE) as well as apps for checking "machine health" (condition of the axes) and "machine status" (traffic light system signaling readiness for operation). "All in all, users get a more comprehensive overview of active production. Another significant point to keep in mind is that many more possibilities will open up in the future," explains Strohm. "The range of available apps is constantly being expanded and data analysis is becoming more and more comprehensive. And this means: Added value is created for the customer and is immediately noticeable in the form of increased productivity. The approach is future proof and easy to implement." The latter also applies to the question as to which EMAG machines are compatible with all of this: From retrofitting of virtually any model from the past two decades to integration into new machines, everything is possible. Another feature of EDNA is our new concept for operation using an intuitive HMI, which is now available for the MIND-L 1000 induction hardening machine from EMAG eldec. The roll-out for other machine technologies at other subsidiaries is in progress.

2. Smartphone Like Dashboard

Of course there are questions regarding the usability of the entire approach — and the term "app" is already a good first sign: The front-end design of the EDNA Life Line dashboards is based on modern tablets and smartphones. "Users already know the underlying operating philosophy from their daily lives. This means that they can learn how to use the operating interface much faster, which in turn has a positive effect on process reliability," explains Ricarda Schuhmann, who is responsible for design and strategy at intuity, one of EMAG's development partners. A first glance the dashboard immediately confirms this assessment: Data is presented in appealing visualizations in individual widgets. Users can determine what exactly is shown and in which layout. The clear structure pays off — quite literally: Early warnings are signaled for anomalies, the end of tool lives or machine wear. This prevents overlooked rejects and unplanned downtimes. Production planners, operators and others have access to the dashboard from anywhere — for example on their smartphone. "Three basic principles governed our joint development: simplicity, consistency and networking," adds Lukas Siegele from intuity. "The end result embodies these principles in every respect. It lays the foundation for the chaotic and fully networked production of the future."

For more information:
EMAG LLC
Phone: (248) 477-7440
www.emag.com

Lucifer Furnaces

BUILDS TOP LOAD ING FURNACE FOR MEDICAL MANUFACTURER

Lucifer Furnaces recently supplied a Top Loading Furnace to a leading tooling manufacturer. Model TL7-481818 has a chamber size of 48" H × 18" W × 18" L and heats to 2,300°F. Heavy gauge, coil wound, low watt density heating elements in 6 removable holders are controlled as 3 separate zones to provide uniform heating. The furnace chamber is insulated with 6½ inches of multilayer insulation for energy efficient operation and low outside shell temperature. The hinged doors are insulated with 5" thick pyro-bloc insulation. Controls include a Eurotherm Nanodac/Honeywell master/slave arrangement. In addition to the top loading door, the furnace is designed with a side door for easy service access into the chamber. This furnace joins a 2nd Lucifer Furnace already in use for the production of dies to cut fabric to make N95 masks for the medical industry. These furnaces are completely wired, assembled, and shipped ready for connection to a main power supply.

For more information:
Lucifer Furnaces
Phone: (800) 378-0095
www.luciferfurnaces.com

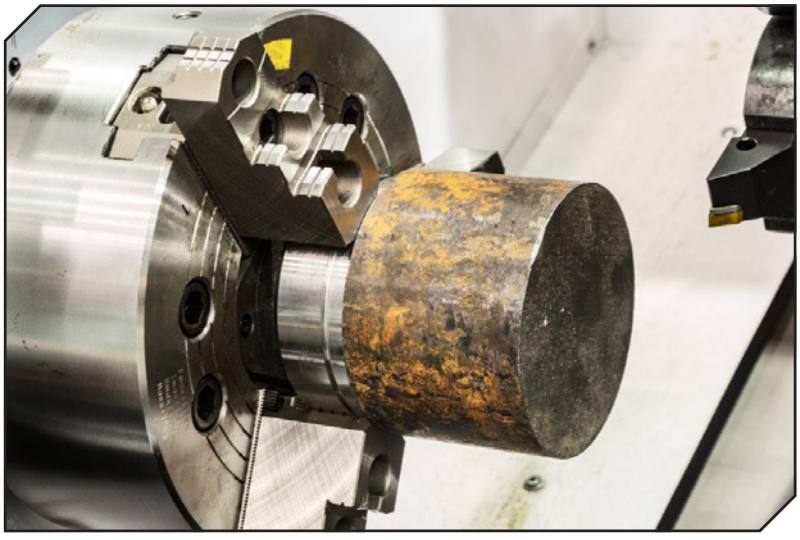
Dillon Manufacturing

OFFERS CHUCKS FOR VARIOUS WORKHOLDING APPLICATIONS

Dillon Manufacturing offers their full line of chucks for various workholding applications. Application chucks such as the universal ball lock power chuck can grip the ID or OD of castings or forgings and have jaws which pivot up to 5-degrees for a firm grip on uneven surfaces. Inside or outside draw down chucks, which are sealed to prevent chips and coolant from entering the chuck body, pull the workpiece down to location for superior accuracy, especially on parallel and perpendicular surfaces. Auto-indexing chucks, with positions of 4x90°or 8x45°, machine multiple surfaces in a single clamping. Retractable jaw shaft chucks, which machine shafts in a single clamping operation, allow jaws and face drivers to be changes so that different shaft sizes can be machined. Additional application chucks available include inside or outside pin arbor chucks, inside clamping mandrels, outside collet chucks, diaphragm chucks, gear chucks, finger chucks, compensating chucks, and aluminum wheel chucks.

Dillon application specialists are experienced in workholding requirements for many industries, and are available to assist with chuck and jaw selection. Like all Dillon products, their chucks are made in the USA in ISO 9001:2015 registered facilities.

For more information:
Dillon Manufacturing, Inc.
Phone: (888) 909-0894
www.dillonmfg.com



HMC and Liebherr

Collaborate on Large Scale Gear Production Project

Edited by Matthew Jaster, Senior Editor

A visit to the HMC Gears plant in Indiana kicked off an extensive project which resulted in the creation of a unique solution for exceptional demands: With the LC 4000, Liebherr forges new paths in large-scale gear cutting production and unites diverse machining methods in one highly efficient machine for the American gear specialist.

The HMC Gears plant is located south of the small town of Princeton, Indiana surrounded by fields and broad plains. For 100+ years, the company has been a well-known specialist for gears and gearboxes for various industries. They are one of the few manufacturers in the world to produce gears with a diameter of up to eight meters. HMC is proud of its many years of expertise, fast delivery times, and excellent service. Always placing the highest quality demands on both itself and its suppliers.

As a supplier for the coal and steel industry the company also specializes in spare parts for large equipment for deep and open-cast mining. Every day counts: If the giant machines are idle, the operator of the mine or conveyor system incurs losses which can quickly go into six figures, but a planned part exchange is not always easy either, since the machines and equipment often run for Adecades. This means that the design drawings may be old or no longer available. Almost every part is therefore critical. This is about custom-made devices and very small batch sizes, often in massive dimensions and with highly demanding geometries.

The HMC factory in southern Indiana.

A Case for Liebherr

Gears with herringbone or double helical gears are often used in mines and conveyor systems. These particularly quiet-running gears are used when large forces need to be transferred. The special arrangement of the gear prevents the occurrence of axial forces, which minimizes bearing wear. However, herringbone gears are complicated and expensive to produce. HMC needed to acquire an efficient machine with the latest technology. This machine would need to replace several planing machines and be able to manufacture spur, helical, double helical, or herringbone gears, handling diameters between 2 1/2 to four meters. This was an investment decision which would require great trust in the supplier and its expertise.

The LC 4000 from Liebherr can machine gears with a diameter of up to 4½ meters and a weight of up to 36 tons.

Although they did not have such a machine in their portfolio, Liebherr was happy to design and manufacture a prototype for this specific customer requirement. Liebherr was familiar with the desired specifications but had not yet united them all together in one machine of this size. The LC 4000 can machine gears with a diameter of up to 4 1/2 meters and a weight of up to 36 tons.

A project driven by team spirit and the will to succeed

Robert "Bob" Smith III, HMC's CEO, explains how HMC came to take on this complex project together with Liebherr: "We were looking for a gear cutting center where we could carry out every stage of production, from rough-cutting to internal machining. During a visit to our plant, Liebherr demonstrated their profound expertise and attention to detail and, ultimately, they were the only supplier prepared to take on this challenge."

This was the prelude to a long and constructive development phase, during which the specific requirements were defined.

"HMC is a demanding customer in the best sense. It has high quality standards and expects a first-class product. In this sense, our two company philosophies fit together perfectly. This was reflected in the very fair negotiations and the consistently positive and

Interior of the LC 4000 from Liebherr.

constructive discussions," said Dr. Oliver Winkel, head of technology application at Liebherr.

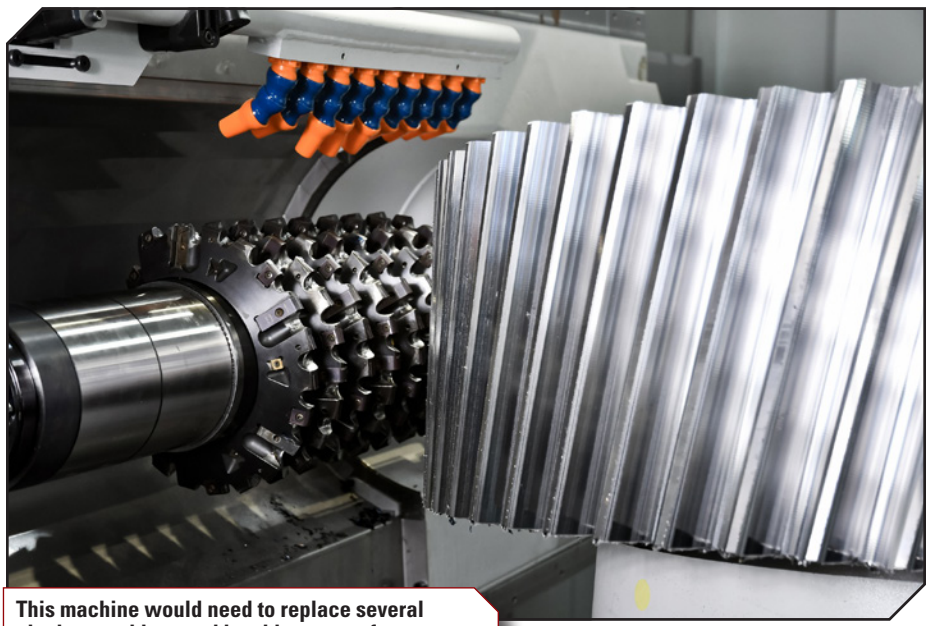
"We have been extremely satisfied with Liebherr's service, their quick response times and the technical support they have provided," Smith added.

In December 2015, following intensive preliminary discussions, a detailed kick-off took place in Princeton, resulting in a specifications sheet containing over 100 points. A great deal had to be constructed from scratch. Examples of this would be an over four-meter long finger milling head for external gears, a second main column, and not least a special machining unit for internal finger milling. The project was characterized by great transparency and open discussions. Liebherr provided HMC with all the provisional results in the form of drawings, photos, videos, and measurement results.

Setbacks were also communicated: "Both parties wanted success and at Liebherr everyone really pulled together," said Peter Wiedemann, head of sales gear cutting machines at Liebherr and now managing director at Liebherr Verzahntechnik GmbH. The pre-acceptance of the machine finally took place in October 2017 in Kempten. During the spring of 2018 it was shipped and put into operation on site. The install was handled by a team of service technicians from Kempten (Germany) and the USA.

Innovative gear cutting center for gear hobbing, form and 4-axis milling

The machine offers great flexibility within its components. It contains an innovative direct drive hob head and an additional finger milling head. The additional head machines external and internal gears from its own main column opposite the hobbing head. This enables machining with gear hobbing, form and 4-axis milling methods on a single machine. Creating the optimal setup for the manufacture of herringbone and double helical gears. The technology was specially customized to the requirements and dimensions of this application. The head has a very long Y axis in order to minimize the thermal influences on the machining results and therefore optimizing the component quality. Another advantage is offered by targeted chamfering with a ball nose end mill. The process design software, *Euklid GearCAM*, contains data management for workpieces, tools for 4-axis milling, and can simulate the process. It calculates the required hobbing paths, feed strategies, and the tool changes.



This machine would need to replace several planing machines and be able to manufacture spur, helical, double helical, or herringbone gears.

An integrated tool changing system with up to 60 storage locations enables the different gear cutting tools to be automatically changed. A scanning probe for gear inspection is also integrated. The machine is capable of achieving accuracies of 12-15 according to the quality standard of the American Gear Manufacturers Association (AGMA), which corresponds to the German DIN standard of 3-6. And which module sizes can be produced by this machine? "There is no upper limit. In principle, it could easily achieve module 100," said Winkel.

Productivity of single and double helical gearing considerably increased

The decisive factor for HMC was the efficiency of the machine in the production of herringbone, double helical gears and in that of conventional helical gears. On the LC 4000 a double helical gear with a diameter of four meters can be manufactured within one to two days. The manufacturing duration using traditional planing machines is more like one to two weeks—which means a three- to fivefold productivity increase! A traditional helical gear can be manufactured on the machine just as efficiently. In this case taking only approx. four hours of machining time for a workpiece diameter of four meters.

By also adding an additional internal milling head to the second tool stand, Liebherr has added a massive value for HMC. This head is able to machine internal keyways or splines. The giant gear, which weighs several tons, does not have to be re-clamped to finish the bore.

"Sometimes it's the little things that make the difference to a purchase," said Wiedemann.

Smith added, "We have been manufacturing gears since 1921. For us, the acquisition of the LC 4000 signifies a quantum leap with regard to our efficiency and delivery times for large gearboxes, as well as the security of having a powerful machine for future requirements."

For more information:

HMC Gears
www.hmcgears.com

Liebherr Gear Technology
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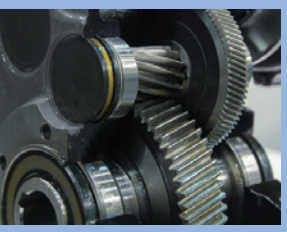

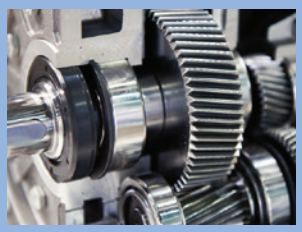
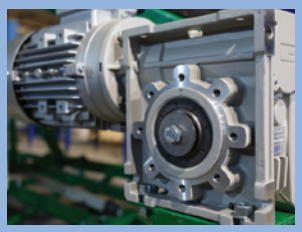
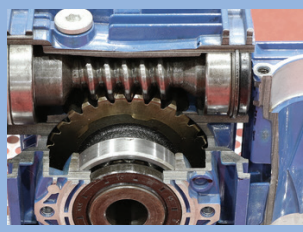

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Why Selective Plating Stops Your Gears from Grinding to a Halt

Mark Meyer, Sales Manager, SIFCO ASC

Gears are a crucial part of many machines, and if they wear and corrode beyond repair it can then be a costly expense to replace them. Mark Meyer, Sales Manager, North America at SIFCO ASC, explains how brush plating can help prevent gears from being damaged and how the process can be used to restore worn or corroded gear components.

When problems occur with gears, maintenance engineers know how much of a headache they can be to fix.

During the manufacturing stage, despite all the modern machining centers, parts can end up undersized — whether that's in the bore, the teeth or the shaft. The extent of these dimensional defects is usually small, but the cost of remanufacturing the entire part would be prohibitive.

When in operation, gears are often subjected to harsh environments, with wear and tear from corrosion or day-to-day running in dusty conditions being common problems.

With small gears, the capital cost of replacing these components in many cases will be tolerable. However, in larger equipment, such as in earth moving, industrial, or marine machinery, it is not just the capital outlay that maintenance engineers must factor in. Not only is the capital cost of larger gears much higher, but there is also the downtime from taking machines out of service that can make the true cost of replacing these components extraordinarily high.

Indeed, downtime is one of the biggest costs that any business can face. In Britain, the impact of machine downtime is costing manufacturers more than £180bn every year (Source: *The Manufacturer*). The study, conducted by Oneserve, found that 3% of all working days are lost annually in manufacturing due to faulty machinery. Eighty-three % of those surveyed also said that they replace machines at least once a year, no doubt carrying huge financial implications and operational costs to do so.

With that said, it is crucial that maintenance costs are kept down, machinery components like gears can be kept in service as long as possible, and, if needed, they can be repaired quickly and effectively.

Brush plating, or selective electroplating, is one proven cost-effective way to build gears back to their original specification and help extend their life.

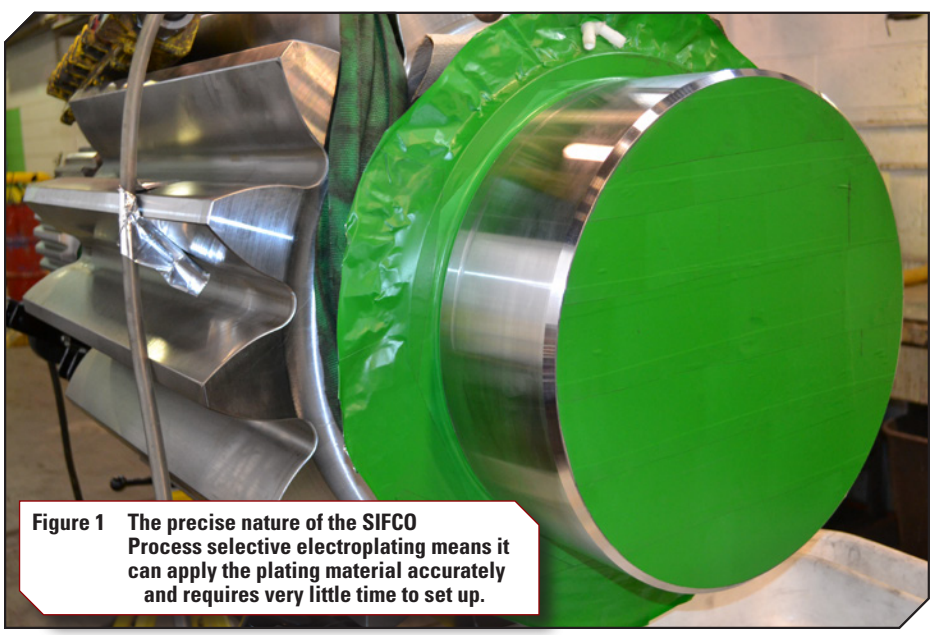

Figure 1 The precise nature of the SIFCO Process selective electroplating means it can apply the plating material accurately and requires very little time to set up.

The Selective Electroplating Process

Selective electroplating, such as the industry-leading SIFCO Process, is a proven, efficient, and economical way of performing surface treatment repairs. The SIFCO Process is a portable plating method used to enhance, repair, and refurbish localized areas on manufactured components.

The process uses fundamental electrochemical principles. An electrolyte solution, which contains ions of the metal to be deposited, is introduced between the negatively charged part to be plated and the positively charged plating tool, or anode. A portable powerpack provides the required direct current and allows precise control of amperage, voltage and plating time for high quality and accurate plating results (Fig. 1).

The circuit is completed when the anode touches the surface of the part to be plated. A suitable wrapping around the tool provides a reservoir to evenly distribute the electrolyte. The current causes the metal ions in the electrolyte to bond with the surface of the part and build up the plating layer. The result is a highly adherent and dense metal plating. The metal or alloy to be deposited can be chosen from over 50 different solutions, which allows the plating material to be tailored to the desired properties of the plating.

Plating can serve a variety of purposes, such as a localized defect repair or bringing an inside diameter (ID) or outside diameter (OD) back to size. Plating can also enhance wear or corrosion resistance exactly where it is needed — even on new parts where it would be prohibitive to make the entire part from a more resistant material.

When assessing parts for repair, it is always important to consider the size

and location of repair required, as well as how much material needs to be plated, as this will determine whether selective plating is appropriate or not.

One example that illustrates two types of repair on the same part was the repair of a pinion gear of a dragline excavator used in surface mining.

Repairing a Damaged Pinion Gear with Selective Electroplating

Working with large gear manufacture and repair specialists Horsburgh & Scott Co., SIFCO ASC's brush plating solutions were used to repair two defects on the 16"-diameter-by-5"-long bearing journal of this gear. They were caused by a seized bearing which damaged the seat and also created a gouge during the removal of the bearing.

The first defect was a 0.030" deep gouge measuring 0.75" wide and 12" long, while the bearing seat was 0.012" undersize after clean-up.

This was considered a good selective plating application because the groove was relatively shallow and could be quickly filled with copper using a 100% tool contact. The undersize condition required only 0.006" thickness of nickel.

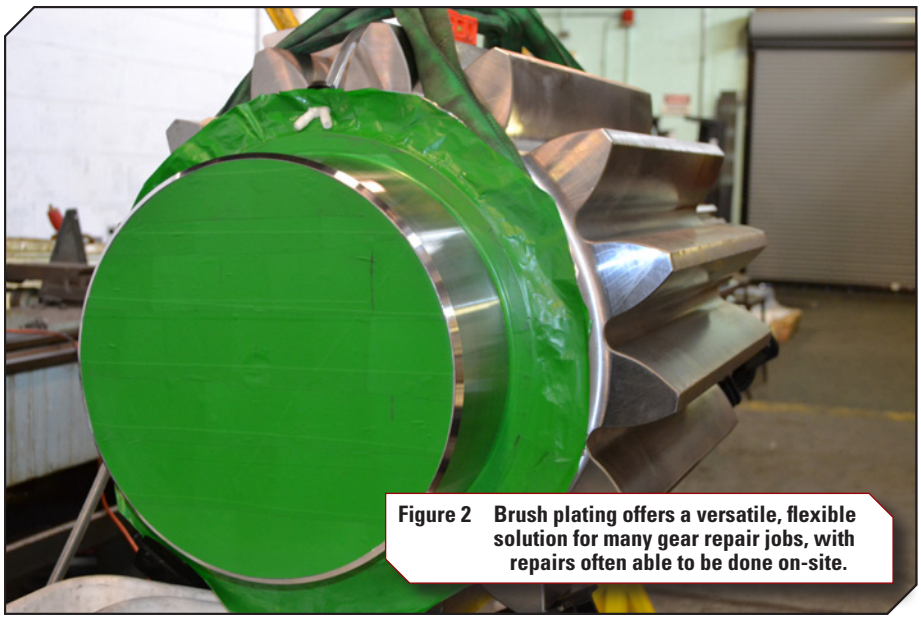

Figure 2 Brush plating offers a versatile, flexible solution for many gear repair jobs, with repairs often able to be done on-site.

Welding to fill the defect was rejected as an option due to the heat and associated structural changes in the metal inherent in the welding process. Meanwhile, machining the entire diameter to remove the defect would have made the diameter 0.060" undersize, and so this was ruled out as well, as it would

have made the journal too impractical for plating at such a high thickness.

For the re-size deposit, the part required a deposit of approximately 30 Rockwell hardness; nickel was chosen to meet that requirement.

First, the gouge was selectively filled with copper to bring it back to the overall OD. The bearing journal was first plated with 0.001" thickness of copper and then masked for the defect repair. A plating anode was used to cover the full length of the gouge, which shortened the plating time. The defect was filled with three layers of copper and hand-finished between layers; the final layer was dressed flush with the OD.

Once the gouge defect was repaired, the entire OD was brought back to size by plating with 0.006" thickness of nickel. After the repair of the two defects, the journal was as good as new and ready to receive a new bearing, making the excavator ready for action once again.

Figure 3 Example of a pinion gear's bearing journal on a dragline excavator being repaired with brush plating.

Building Layers without Compromising Gear Strength, Durability and Specification

As stated, gears used in large applications are expensive to replace if damaged or worn. In many cases, brush plating can return the gear components back to their nominal specification, and in some cases, even exceed the performance of the original material.

With brush plating, a frequently used plating material for repairs is nickel. Other materials such as cobalt are also popular, while certain alloys like nickel tungsten alloys or nickel cobalt alloys can provide their own unique properties. With proper selection of deposition parameters, the grain structure of the nickel can be influenced to yield the desired properties such as hardness and corrosion resistance — thus enabling it to withstand the day-to-day operation that gears are subjected to.

For gears, the most common repairs are shafts, bearing journals, and bores. In certain circumstances, localized damage to teeth may also be considered. For gears that will see corrosive environment, the bores and outside machined surfaces that cannot be painted are also plated when new to provide corrosion resistance.

Figure 4 Often, industrial machinery gears are too large to easily disassemble and too impractical and costly to ship to off-site job shops for repair.

On-Site Selective Plating Brings Down Costs

Another consideration that engineers face with repairing gears is how the maintenance can be achieved while incurring the least cost. Costs can start rising through directly associated expenses like shipping the gear to a job shop, disassembly and reassembly of the gear, and the repair itself. Then there are indirect costs to factor in, such as disruption, downtime and loss of productivity.

Often, the gears that are too large to simply replace are also too large to easily disassemble and too impractical and costly to ship to off-site job shops for repair. Downtime is also prolonged, due to the need to take the gear and machinery apart, wait for it to be repaired, and then sent back and re-assembled.

Brush plating overcomes these obstacles. In many cases, technicians can assess the damage to the gears and make the repairs on-site (Fig. 2).

This was the case for the pinion gear repair on the dragline excavator (Figs. 3 and 5). Of the repair, Dave Niederhelman, Chief Metallurgist, Horsburgh & Scott Co. said: "SIFCO ASC is a well-established partner of Horsburgh & Scott and their ability to work on-site is highly attractive. Over the years they have helped us to find the most efficient ways to repair and maintain our customers' equipment and this has added up to thousands of dollars, hours of downtime, and manpower time saved.

"In this application the SIFCO Process has extended the working life of the gear and improved the failure rate due to the nature of the nickel coating on the journal. The cost of manufacturing and material to replace the gear would have been exorbitant in comparison — as well as causing weeks of downtime."

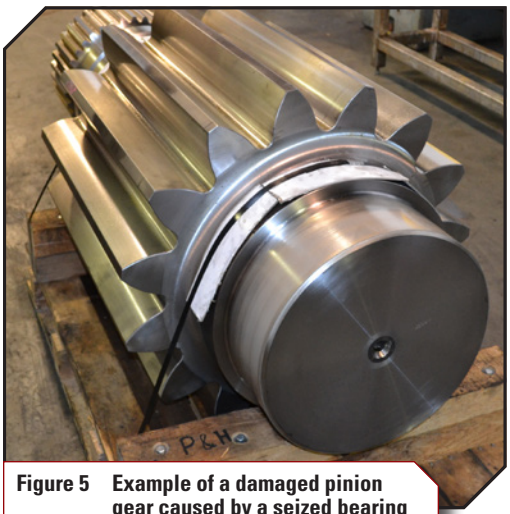

Figure 5 Example of a damaged pinion gear caused by a seized bearing which damaged the seat and also created a gouge during the removal of the bearing.

Brushing Aside Gear Repair Issues

While simple on the surface, gears are complex components, and once they start to wear and tear while in service, it can be an even more complex job to repair them.

Repairs must be well-considered and executed correctly, and the gear must remain strong enough to handle the day-to-day operation or setting that it exists in. Otherwise, it can cost even more than the initial cost of refurbishment, after factoring in downtime and lost productivity costs.

This is where brush plating offers a versatile, flexible solution for many gear repair jobs. Along with being able to make repairs on-site (Fig. 4), the SIFCO Process of selective electroplating is highly effective. The precise nature of selective electroplating means it can apply the plating material accurately and requires very little time to set up. Unlike with alternative repair methods, post-machining or treatment of the gears frequently is not required because plating can be done to size. Due to the low temperature of the process, there is no risk of changing the structure of the base material and with that its properties.

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Mark Meyer is North America Sales Manager for SIFCO ASC. With nearly 30 years of experience in surface coating engineering, and a master's degree in mechanical and process engineering, Meyer is a specialist in industrial coating maintenance and repair projects. In his free time, Meyer is a keen woodworking enthusiast.

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AGMA Statistical Programs Help Guide the Gear Industry

Mary Ellen Doran, Director of Emerging Technology, AGMA

Industry data is the essential factor current leaders need for success in navigating through the uncertainty created by the pandemic and the resulting economic downturn. However, data is only actionable when managers understand and can interpret how that data will affect their companies. It takes special leaders who understand the power of data and are willing to roll up their sleeves and dig in. For the gear industry, leaders can turn to AGMA to get the data they require. They also need to assist in contributing their company's data which is anonymized and held confidentially to help AGMA have the most accurate information. AGMA is here to support by continuing to provide the tools to the industry's leaders to get through these interesting times.

In the Q3-2020 Gear Market Report, released in August, the headline was "*Gear market still driven by COVID-19 shock; obstacles for a fast recovery remain, but optimism gains traction next year*." The experts at HIS Markit gave members a lot to think about before they even showed their first trend line. To no surprise, the Gear Market Report numbers show declines in all ten of the end-user markets that are covered. If you dig into the data, you'll see that gear industry demand in first five months of 2020 was already down 10% from 2019 levels. Nevertheless, gear shipments were only 7% off — showing domestic producers had gained back some market share.

For more than a decade, AGMA has been working with IHS Markit to produce the Gear Market Report. This report is a subscription service for AGMA members, providing them with four quarterly updated reports of valuable manufacturing data including the core gear industry data as well as economic outlooks for the U.S., Canada, Mexico, Latin America, Europe, Japan, China and the Asia-Pacific regions. Besides the four quarterly reports, participants can choose to attend a webinar in the Spring, where the economists from IHS Markit present the data in an easy-to-understand format for the members and leaders. The webinar affords a great opportunity to interact directly with IHS Markit economists and to ask specific questions.

IHS Markit economists have lots of tools at their disposal to get the right data for AGMA. When it comes to the actual gear numbers, they pull this data from the AGMA Monthly Market Trend Report (MMTR). The MMTR is the only way to track actual booking and shipment data from domestic manufacturers of open and enclosed gears and flexible couplings. It is the closest to real-time data compared to other sources. In fact, the Federal Reserve looks to AGMA's monthly reports on shipments in our industrial production (IP) index for the speed changers, drives, gears, and power transmission equipment industry (NAISC 333612 and NAICS 333613).

The MMTR is managed by AMT — The Association for Manufacturing Technology. AGMA utilizes this support for several reasons: AMT has experience with these reports, they have run AGMA's report for more than a decade and they currently manage six benchmarking surveys for their own members as well as for several other associations in manufacturing fields. Using AMT allows AGMA to assure our members that the data is confidential and secure. AGMA members never see individual member information. Participating companies upload their monthly orders and shipments via MTInsight, which is used to estimate an index for each product as well as a market dollar value. All data uploaded is stored and used in compliance with AMT's standards on data confidentiality. Any dollar values given are aggregated to a level that will not reveal an individual company's information. The list of companies submitting data each month is made available; however no other information from an individual company is published.

The MMTR currently covers eight categories in the gear industry:

- coarse pitch gears,
- fine pitch gears,
- worm/speed reducers & gear motors,
- concentric gearmotor/reducer products,
- shaft mounted speed reducers,
- offset parallel shaft and right angle speed reducers,
- mechanical adjustable speed drives,
- flexible couplings.

Participation of all domestic gear manufacturers is highly encouraged. Current participants have commented that it only takes a short time to upload the data each month, and the aggregate data has helped them in many aspects of their business throughout the years.

The third piece of the AGMA Statistical Program is the Operating Ratio Report or ORR. The ORR is an industry-wide report profiling the financial and operating performance of AGMA members. This report is done one time per year, typically in the summer to avoid most tax periods, and participants not only receive the Benchmarking Report, but they also receive an individual Financial Performance Report (FPR). The FPR offers an interactive, dynamic look at the columns of data the user wants to use for benchmarking. And it allows for manipulation of data — to offer more to participants.

"This report saves me work as it is very detailed — showing your performance against other members," explained Steve Chaloupka, vice president of sales and business development, Amarillo Gear Company. "It also allows me to get a feel for the health of the industry. It is a perfect way for me to demonstrate how we are doing in the bigger industry picture."

Chaloupka is also a member of the AGMA Market Intelligence Committee. Chaired by Oxana Sidor, market analyst

for Sumitomo Drive Technologies, the committee keeps AGMA and the reports honest. The members of this committee are individuals from AGMA member companies that actually work with the AGMA statistical program reports and are able to provide feedback to AGMA that assists in tweaking the program to continue to stay current for the needs of gear industry professionals.

Everyone is hearing that these are 'unprecedented times.' But these are the times that show why AGMA is almost 105 years old. AGMA brings its members together to collaborate, discuss imperative topics, and collectively move the membership toward success across disciplines.

So, what happens now? AGMA has taken big steps to assist members in these unprecedented times. The cost for The Gear Market Report was cut in half for 2020 and will stay there for 2021. Full copies of the Q2 report were provided free to members that attended the free IHS webinar earlier in June. And if you missed that, please reach out to AGMA to see the report before subscribing.

AGMA provides its members with valuable tools and resources aimed at increasing members' success. Nevertheless, the association cannot do this without the support of the industry. AGMA needs gear manufacturers to provide current data — especially for the next 24 months — by participating in the Monthly Market Trend Report (MMTR). It is a situation where the more that participate, the better the data. So please reach out today and get involved.

For more information:
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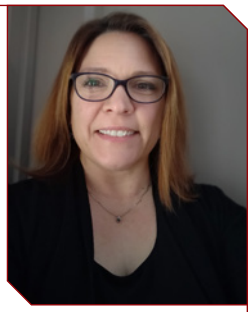

Mary Ellen Doran has been working at AGMA for ten years. In 2018, she moved into the new role of Director, Emerging Technology. Through this role, she developed a new area of work for the association. Now, she and the committee members are able to provide actionable information to gear manufacturers on technologies that may be of importance to their future, or may disrupt their future. The goal of the Emerging Technology Committees is to: "identify, investigate, and inform AGMA members of emerging technologies that may disrupt or significantly impact the gear manufacturing industry." Mary Ellen leads the four emerging technology committees: 3D metal printing/New materials; Electric drive technology; Robotics and automation; and Industrial IoT. Prior to her emerging tech position, she worked in the communications department developing the website, electronic newsletters, and marketing pieces for AGMA. She holds a Bachelor's of Fine Art in graphic design from The Ohio University.

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BOLD LISTINGS throughout the Buyers Guide indicate that a company has an advertisement in this issue of ***Gear Technology***.

But Wait! Where are the Gear Manufacturers Listed?

If you are looking for suppliers of gears, splines, sprockets, gear drives or other power transmission components, see our listing of this issue's power transmission component advertisers on page 60. In addition, you will find our comprehensive directory in the December 2020 issue of ***Power Transmission Engineering*** as well as in our online directory at *www.powertransmission.com.*

Handy Online Resources

The Gear Industry Buyers Guide — The listings printed here are just the basics. For a more comprehensive directory of products and services, please visit our website, where you'll find each of the categories here broken down into sub-categories: *www.geartechnology.com/dir/.*

The Power Transmission Engineering Buyers Guide — The most comprehensive online directory of suppliers of gears, bearings, motors, clutches, couplings, gear drives and other mechanical power transmission components, broken down into sub-category by type of product manufactured: *www.powertransmission.com/directory/.*

How to Get Listed in the Buyers Guide

Although every effort has been made to ensure that this Buyers Guide is as comprehensive, complete and accurate as possible, some companies may have been inadvertently omitted. If you'd like to add your company to the directory, we welcome you. Please visit *www.geartechnology.com/getlisted.php* to fill out a short form with your company information and Buyers Guide categories. These listings will appear online at *www.geartechnology.com*, and those listed online will automatically appear in next year's printed Buyers Guide.

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Nansteel Manufacturing Co.,Ltd
www.nan-steel.com/

ORT Italia
www.ortitalia.com

Ohio Broach & Machine Co.
www.ohiobroach.com

PDM Engineering Pvt. Ltd.
www.pdmengg.net

Parker Industries Inc.
www.parkerind.com

Philadelphia Carbide Co.
www.philacarbide.com

Pinpoint Laser Systems
pinpointlaser.com

Pioneer Broach Co.
www.pioneerbroach.com

Polygon Solutions
www.polygonsolutions.com

Productivity Inc.
www.productivity.com/

QC American
www.qcamerican.com

R.A. Heller
www.raheller.com

Rotec Tools Ltd.
www.rotectools.com

Russell Holbrook & Henderson
www.tru-volute.com

S.S. Tools
www.sstools.net

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

SWG Solutions
www.swgsolutions.com

Saazor
www.saazor.de

Samputensili S.p.A.
STAR SU LLC
5200 PRAIRIE STONE PARKWAY
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.samputensili.com
SEE OUR AD IFC-P1, 63

Sandvik Coromant
www.sandvik.coromant.com

Schnyder SA
www.schnyder.com

Seco Tools Inc.
www.secotools.com/us

Shape-Master Tool Company
www.shapemastertool.com

Slater Tools Inc.
www.slatertools.com

Slone Gear International, Inc.
www.slonegear.com

Solid Metalworking INC. Limited
www.atcarbide.com

Star Cutter Co.
23461 INDUSTRIAL PARK DRIVE
FARMINGTON HILLS MI 48335
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@starcutter.com
www.starcutter.com
SEE OUR AD IFC-P1, 63

Star SU LLC
5200 PRAIRIE STONE PARKWAY
SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
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Steelmans Broaches Pvt. Ltd.
www.steelmans.com

Sunnen Products Company
www.sunnen.com

Super Hobs & Broaches Pvt. Ltd.
www.supercuttingtools.com

Techcellence
www.broachindia.com

Titanium Coating Services Inc.
www.pvdamerica.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

United Tool Supply Ltd.
www.unitedtoolsupply.com

V W Broaching Service, Inc.
www.vwbroaching.com

Vargus USA
www.vargususa.com

Walter USA, LLC
www.walter-tools.com

Watkins Mfg. Inc.
www.saw-lutions.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Wolverine Broach Co., Inc.
www.wolverinebroach.com

Work Out Ind. Com. Imp. e Exp. de Maq. ltda
www.workout.com.br/index-en

Yash International
www.yashtools.com

GEAR BLANKS & RAW MATERIAL

All of the suppliers listed here are broken down by category (bar stock, forgings, gear steel, plastic resins, etc.) at *www.geartechnology.com*.

Accurate Specialties Inc.
www.accuratespecialties.com

Aksan Steel Forging
www.aksanforging.com

All Metals & Forge Group, LLC
www.steelforge.com

American Friction Welding
www.teamafw.com

Amorphology
145 N. ALTADENA DRIVE
PASADENA CA 91107
www.amorphology.com
SEE OUR AD P35

Anihas Castings
www.anihas.com

ArcVac Specialty Steels
www.arcvacsteel.com

Atlas Bronze
www.atlasbronze.com

Aviva Metals
www.avivametals.com/

BGH Specialty Steel Inc.
www.bgh.de

Bharat Forge Ltd.
www.bharatforge.com

Boltex Manufacturing
www.boltex.com

Buehler - An ITW Company
www.buehler.com

CFS Machinery Co. Ltd.
www.dropforging.net

Canton Drop Forge
www.cantondropforge.com

Castalloy
www.castalloycorp.com

Celanese
www.celanese.com

Compressed Gas Technologies Inc.
www.nitrogen-generators.com

Concast Metal Products
www.concast.com

Cornell Forge
www.cornellforge.com

Creative Hi-Tech Ltd.
www.creativehitech.com/

Crucible Industries LLC
www.crucible.com

DSM Engineering Plastics
www.dsm.com

Dayton Forging and Heat Treating
www.daytonforging.com

Deco Products Company
www.decoprod.com

DuPont
plastics.dupont.com

Dura-Bar
www.dura-bar.com

Earle M. Jorgensen Co.
www.emjmetals.com

ElectroHeat Induction
www.electroheatinduction.com

Ellwood City Forge Group
www.ellwoodcityforge.com

Erasteel Inc.
www.erasteel.com

Eutectix, LLC
eutectix.com

Excel Gear
www.excelgear.com

Finkl Steel
www.finkl.com

Fomas USA
www.fomasgroup.com

Forging Solutions LLC
www.forging-solutions.com

Fox Valley Forge
www.foxvalleyforge.com

Fuji Machine America Corp.
www.fujimachine.com

Galaxy Sourcing Inc.
www.galaxysourcing.com

Gibbs Gears Precision Engineers
www.gibbsgears.com

Guven Bronz Metal
www.guvendokum.com

Hunter Chemical LLC
www.hunterchem.com

IMT Forge Group including Clifford-Jacobs Forge
www.imtforgegroup.com

Intech Corporation
www.intechpower.com

Interstate Tool Corp.
itctoolcorp.com

Kuraray America, Inc.
www.kuraray.com

LadyBug Technologies LLC
www.ladybug-tech.com/

Lalson Tools Corporation
www.lalsoncuttingtools.com

Larson Forgings
www.larsonforgings.com

Mackeil Ispat & Forging Ltd.
mackeilforgings.com

Maguire Technologies
www.maguiretech.com

Martin Tool & Forge
www.martinsprocket.com

Masternet Ltd.
www.masternetltd.com

Maxwell Tools Co. USA
www.maxwelltools.com

McInnes Rolled Rings
1533 EAST 12TH STREET
ERIE PA 16511
Phone: (800) 569-1420 or (814) 459-4495
Fax: (814) 459-8443
sales@mcrings.com
mcinnesrolledrings.com
SEE OUR AD P14, 42

McKees Rocks Forgings
www.mckeesrocksforgings.com

Midwest Themal-Vac Inc.
www.mtvac.com

Moore-Addison Precision Plastic Blanking
www.mooreaddison.com

Mosey Manufacturing Co. Inc.
www.moseymfg.com

Nansteel Manufacturing Co.,Ltd
www.nan-steel.com/

National Bronze Mfg. Co.
www.nationalbronze.com

Nichiei Company, Ltd.
www.nichiei-ind.com

Ovako AB
www.ovako.com

PCK Buderus India
www.pck-buderus.com

Parag Casting Co.
www.paragcasting.com

Patriot Forge
www.patriotforge.com

Penticton Foundry Ltd.
www.pentictonfoundry.com

Permanent Steel
www.permanentsteel.com

Perry Technology Corporation
www.perrygear.com

Presrite Corporation
www.presrite.com

QSC Forge & Flange
www.qscforge.com

QuesTek Innovations LLC
www.questek.com

Reade Advanced Materials
www.reade.com

Renishaw Inc.
www.renishaw.com

Rewitec GmbH
www.rewitec.com

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

Schmiedewerke Groeditz GmbH
www.stahl-groeditz.de

Scot Forge
www.scotforge.com

Sedlock Companies
www.sedlockcompanies.com

Sensor Products Inc.
www.sensorprod.com

Somers Forge
www.somersforge.com

Southwest Metal Products Ltd.
www.southwestmetal.com

Spectrum Machine Inc.
www.spectrummachine.com

Steuby Manufacturing Company, Inc.
www.steubymfg.com

Sullivan Steel
sullivansteelservice.com/

Sunbelt-Turret Steel. Inc.
www.sunbeltturretsteel.com

Thyssenkrupp rothe erde USA
www.ringsandbearings.com/

TimkenSteel Corporation
www.timkensteel.com

UMC - United Metals Co.
www.umcmetals.com

United Cast Bar, Inc.
www.unitedcastbar.com

Viking Forge
www.viking-forge.com

Voestalpine High Performance Metals
www.voestalpine.com

Walker Forge
www.walkerforge.com

Watkins Mfg. Inc.
www.saw-lutions.com

Willman Industries Inc.
www.willmanind.com

Yarde Metals
www.yarde.com

Yash International
www.yashtools.com

Zhejiang Qihong Machinery Casting Co., Ltd
www.zjqihong.net/

GEAR MACHINES

All of the suppliers listed here are broken down by category (hobbing machines, bevel gear machines, shaping machines, broaching machines, etc.) at *www.geartechnology.com*.

ANCA, Inc.
www.anca.com

Abtex Corp.
www.abtex.com

Accu-Cut Diamond Tool Co.
www.accucutdiamond.com

AccuBrass
accubrass.com/

Acme Manufacturing Co.
www.acmemfg.com

Advico
www.advico.co.uk

Affolter
www.rotectools.com

Alliance Broach & Tool
www.alliancebroach.com

American Broach & Machine Co.
www.americanbroach.com

Anderson Cook Inc.
www.andersoncook.com

Apex Broaching Systems
www.apexbroach.com

BUDERUS Schleiftechnik GmbH
www.buderus-schleiftechnik.de

Banyan Global Technologies LLC
www.banyangt.com

Barber-Colman, Div of Bourn & Koch
www.bourn-koch.com

Becker GearMeisters, Inc.
www.maagmachines.com

Blackbox Technologies
www.blackboxtech.in

Bourn & Koch Inc.
2500 KISHWAUKEE STREET
ROCKFORD IL 61104
Phone: (815) 965-4013
Fax: (815) 965-0019
sales@bourn-koch.com
www.bourn-koch.com
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Breton USA
www.bretonusa.com

Broaching Machine Specialties
www.broachingmachine.com

C & B Machinery
www.cbmachinery.com

CNC Center
www.cnccenter.com

Capital Tool Industries
www.capital-tool.com

Chamfermatic Inc.
www.chamfermatic.com

Clemco Industries Corp.
www.clemcoindustries.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Colonial Tool Group
www.colonialtool.com

Comco Inc.
www.comcoinc.com

Compressed Gas Technologies Inc.
www.nitrogen-generators.com

D.C. Morrison Company
www.dcmorrison.com

DMG MORI USA
www.dmgmori-usa.com

DVS Technology America, Inc.
44099 PLYMOUTH OAKS BLVD.
PLYMOUTH MI 48170
Phone: (734) 656-2073
Fax: (734) 656-2091
ralf-georg.eitel@dvs-technology.com
www.dvs-technology.com
SEE OUR AD P3

DVS Universal Grinding GmbH
www.ugrind.de

Danobat Machine Tool Co. Inc.
www.danobatusa.com

Dianamic Abrasive Products Inc.
www.dianamic.com

Donner+Pfister AG
www.dpag.ch

Drake Manufacturing
www.drakemfg.com

EMAG L.L.C.
38800 GRAND RIVER AVE.
FARMINGTON HILLS MI 48335
Phone: (248) 477-7440
Fax: (248) 477-7784
abakun@emag.com
www.emag.com
SEE OUR AD P33

Electronics Inc.
www.electronics-inc.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Abrasives
www.engineeredabrasives.com

Erwin Junker Machinery, Inc.
www.junker-group.com

FFG - Modul
www.star-su.com

Federal Broach & Machine
www.federalbroach.com

Fellows Machine Tools
www.bourn-koch.com

Felsomat USA Inc.
www.felsomat.com

Forst Technologie GmbH & Co. KG
www.forst-online.de

Fuji Machine America Corp.
www.fujimachine.com

GMTA German Machine Tools of America
www.gmtamerica.com

Gearspect s.r.o.
www.gearspect.com

Gehring L.P.
www.gehring.de

General Broach Company
www.generalbroach.com

Georg Kesel GmbH & Co. KG
www.kesel.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
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Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P25, 81

Goldstein Gear Machinery LLC
www.goldsteingearmachinery.com

Great Lakes Gear Technologies, Inc.
www.greatlakesgeartech.com

Greg Allen Company
www.gallenco.com

HÖFLER - A Brand of KLINGELNBERG
www.hofler.com

Haas Multigrind LLC
www.multigrind.com

Hamai Co. Ltd.
www.hamai.com

Hanik Corporation
www.hanikcorp.com

Hans-Juergen Geiger Maschinen-Vertrieb GmbH
www.geiger-germany.com

Hartech
www.hartech.com.tw

Havlik International Machinery Inc.
www.havlikinternational.com

Helios Gear Products
heliosgearproducts.com

Heller Machine Tools
www.heller-machinetools.com

IMPCO Microfinishng
www.impco.com

ITW Heartland
1205 36TH AVENUE WEST
ALEXANDRIA MN 56308
Phone: (320) 762-0138
Fax: (320) 762-5645
info@itwheartland.com
www.itwheartland.com
SEE OUR AD P50

Index Corporation
us.index-traub.com

Index-Werke GmbH & Co. KG Hahn & Tessky
www.index-traub.com/gearing

Involute Gear & Machine Company
46449 CONTINENTAL DRIVE
CHESTERFIELD MI 48047
Phone: (586) 329-3755
Fax: (586) 329-3965
rodney.soenen@involutegearmachine.com
www.involutegearmachine.com
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J. Schneeberger Corp.
www.schneeberger-us.com

JRM International, Inc
www.jrminternational.com

JX Shot Blasting Machine Manufacturer Co., Ltd.
www.jxabrasives.com

James Engineering
www.james-engineering.com

Kapp Technologies
www.kapp-niles.com

Khemka Broach & Spline Gauge
www.khemkabroach.com

Kinefac Corporation
www.kinefac.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
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Klingelnberg America Inc.
118 E. MICHIGAN AVENUE
SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
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Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
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Knuth Machine Tools USA, Inc.
www.knuth-usa.com

Lambda Technologies
www.lambdatechs.com

Leistritz Advanced Technology Corp.
www.leistritzcorp.com

Liebherr America
1465 WOODLAND DR.
SALINE MI 48176
Phone: (734) 429-7225
Fax: (734) 429-2294
info.lgt@liebherr.com
www.liebherr.com
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Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
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Machine Tool Builders
www.machinetoolbuilders.com

Matrix Precision Co. Ltd.
www.matrix-machine.tw

Mazak Corporation
www.mazakusa.com

Meccanica Nova Corporation
www.novagrinders.com

Meister Abrasives USA
www.meister-abrasives.com/USA

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
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Mutschler Edge Technologies
mutschleredgetech.com

Nachi America Inc.
715 PUSHVILLE RD.
GREENWOOD IN 46143
Phone: (317) 530-1001
Fax: (317) 530-1011
info@nachiamerica.com
www.nachiamerica.com
SEE OUR AD P23

Nagel Precision
www.nagelusa.com

Nansteel Manufacturing Co.,Ltd
www.nan-steel.com/

Normac, Inc.
www.normac.com

ORT Italia
www.ortitalia.com

Ohio Broach & Machine Co.
www.ohiobroach.com

Okuma America Corporation
www.okuma.com

PITTLER T&S GmbH
www.pittler.de

PRAEWEMA Antriebstechnik GmbH
praewema.dvs-gruppe.com/

PTG Holroyd
www.holroyd.com

Parker Industries Inc.
www.parkerind.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
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Phoenix Inc.
www.phoenix-inc.com

Pioneer Broach Co.
www.pioneerbroach.com

Precision Finishing Inc.
www.precisionfinishinginc.com

Precision Surfacing Solutions
www.pss-atd.com/

Preco Inc.
www.precoinc.com

Prime Technologies
www.gear-testers.com

QC American
www.qcamerican.com

Röders GmbH
www.roeders.de

Ravjeet Engineering Specialty Ltd.
www.ravjeet.com

Redin Production Machine
www.redinmachine.com

Reishauer AG
www.reishauer.com

Reishauer Corporation
www.reishauer.com

Rotec Tools Ltd.
www.rotectools.com

Russell Holbrook & Henderson
www.tru-volute.com

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

Saacke North America, LLC
saacke-pforzheim.com/

Samputensili S.p.A.
STAR SU LLC
5200 PRAIRIE STONE PARKWAY
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.samputensili.com
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SerWeMa GmbH & Co. KG
www.serwema.de

Setco Precision Spindles
www.setcousa.com

Sinto America
www.sintoamerica.com

Star Cutter Co.
23461 INDUSTRIAL PARK DRIVE
FARMINGTON HILLS MI 48335
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@starcutter.com
www.starcutter.com
SEE OUR AD IFC-P1, 63

Star SU LLC
5200 PRAIRIE STONE PARKWAY
SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
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Steelmans Broaches Pvt. Ltd.
www.steelmans.com

Sunnen Products Company
www.sunnen.com

Surface Finishing Equipment Co.
www.sfecindia.net

Surplex GmbH
www.surplex.com

Thyssenkrupp rothe erde USA
www.ringsandbearings.com/

Toolink Engineering
www.toolink-eng.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

Ultramatic Equipment Co.
ultramatic-equipment.com

WFL Millturn Technologies, Inc
www.wfl-usa.com

WMZ - Werkzeugmaschinenbau Ziegenhain GmbH
www.wmz-gmbh.de

WardJet
www.wardjet.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Wheelabrator
www.wheelabratorgroup.com

Willrich Precision Instrument Company
willrich.com

Wolverine Broach Co., Inc.
www.wolverinebroach.com

Yieh Chen Machinery
www.yiehchen.com

GRINDING WHEELS & ABRASIVE TOOLS

All of the suppliers listed here are broken down by category (diamond wheels, grinding wheels, honing stones, etc.) at *www.geartechnology.com*.

2L Inc.
www.2Linc.com

3M Abrasives
www.3m.com/Abrasives

Abtex Corp.
www.abtex.com

Accu-Cut Diamond Tool Co.
www.accucutdiamond.com

AccuBrass
accubrass.com/

Ajax Tool Supply
www.ajaxtoolsupply.com

Alliance Broach & Tool
www.alliancebroach.com

Banyan Global Technologies LLC
www.banyangt.com

Brighton Laboratories
www.brightonlabs.com

CGW - Camel Grinding Wheels
www.cgwcamel.com

Carborundum Universal Ltd.
www.cumiabrasives.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Comco Inc.
www.comcoinc.com

Continental Diamond Tool Corporation
www.cdtusa.net

DTR Corp. (formerly Dragon Precision Tools)
1261 WILEY ROAD, UNIT K
SCHAUMBURG IL 60173
Phone: (847) 375-8892
Fax: (224) 220-1311
alex@dragon.co.kr
www.dragon.co.kr
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DVS Technology America, Inc.
44099 PLYMOUTH OAKS BLVD.
PLYMOUTH MI 48170
Phone: (734) 656-2073
Fax: (734) 656-2091
ralf-georg.eitel@dvs-technology.com
www.dvs-technology.com
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DVS Tooling GmbH
www.dvs-tooling.de

Diametal AG
www.diametal.ch

Diamond Abrasive Products
www.diamondabrasiveproducts.com

Dianamic Abrasive Products Inc.
www.dianamic.com

Dr. Kaiser Diamantwerkzeuge
www.drkaiser.de

ESGI Tools Pvt. Ltd.
esgitools.com

FFG - Modul
www.star-su.com

Gear Resource Technologies Inc.
www.gear-resource.com

Gehring L.P.
www.gehring.de

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
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Gleason Cutting Tools Corporation
1351 WINDSOR RD.
LOVES PARK IL 61111
Phone: (815) 877-8900
Fax: (815) 877-0264
gctc@gleason.com
www.gleason.com
SEE OUR AD P25, 81

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P25, 81

Graff Diamond Products
www.graffdiamond.com

Great Lakes Gear Technologies, Inc.
www.greatlakesgeartech.com

Greg Allen Company
www.gallenco.com

GritSablare
gritsablare.ro

Helios Gear Products
heliosgearproducts.com

Hermes Abrasives Ltd.
www.hermesabrasives.com

Interstate Tool Corp.
itctoolcorp.com

Involute Gear & Machine Company
46449 CONTINENTAL DRIVE
CHESTERFIELD MI 48047
Phone: (586) 329-3755
Fax: (586) 329-3965
rodney.soenen@involutegearmachine.com
www.involutegearmachine.com
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J. Schneeberger Corp.
www.schneeberger-us.com

JRM International, Inc
www.jrminternational.com

JX Shot Blasting Machine Manufacturer Co., Ltd.
www.jxabrasives.com

Kapp Technologies
www.kapp-niles.com

KlingelnbergAG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD OUTSIDE BACK COVER

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE
SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD OUTSIDE BACK COVER

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD OUTSIDE BACK COVER

Knuth Machine Tools USA, Inc.
www.knuth-usa.com

Lambda Technologies
www.lambdatechs.com

Liebherr America
1465 WOODLAND DR.
SALINE MI 48176
Phone: (734) 429-7225
Fax: (734) 429-2294
info.lgt@liebherr.com
www.liebherr.com
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Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
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Longevity Coatings
www.longevitycoatings.com

Marposs Corporation
www.marposs.com

Matrix Precision Co. Ltd.
www.matrix-machine.tw

Meister Abrasives USA
www.meister-abrasives.com/USA

Modern Gearing
www.moderngearing.com

Mutschler Edge Technologies
mutschleredgetech.com

NAXOS-DISKUS Schleifmittelwerke GmbH
www.naxos-diskus.de

Nagel Precision
www.nagelusa.com

Norton | Saint-Gobain
www.nortonabrasives.com

Osborn International
www.osborn.com

PTG Holroyd
www.holroyd.com

Particular Technology, Inc.
www.particulartechnology.com

Philadelphia Carbide Co.
www.philacarbide.com

Precision Spindle & Accessories Inc.
www.precisionspindleinc.com

Precision Surfacing Solutions
www.pss-atd.com/

QC American
www.qcamerican.com

Radiac Abrasives
www.radiac.com

Ravjeet Engineering Specialty Ltd.
www.ravjeet.com

RedLine Tools
www.redlinetools.com

Redin Production Machine
www.redinmachine.com

Reishauer AG
www.reishauer.com

Reishauer Corporation
www.reishauer.com

Rex-Cut Products, Inc.
www.rexcut.com

S.L. Munson & Company
www.slmunson.com

Samputensili S.p.A.
STAR SU LLC
5200 PRAIRIE STONE PARKWAY
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.samputensili.com
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Schnyder SA
www.schnyder.com

Sitab S.r.l.
www.sitab-abrasives.com

Star Cutter Co.
23461 INDUSTRIAL PARK DRIVE
FARMINGTON HILLS MI 48335
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@starcutter.com
www.starcutter.com
SEE OUR AD IFC-P1, 63

Star SU LLC
5200 PRAIRIE STONE PARKWAY
SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-P1, 63

Steelmans Broaches Pvt. Ltd.
www.steelmans.com

Stella Keramik GmbH
www.stella-gruppe.de

Stone Tucker Instruments Inc.
www.stone-tucker.com

Sunnen Products Company
www.sunnen.com

Toolink Engineering
www.toolink-eng.com

Ultramatic Equipment Co.
ultramatic-equipment.com

Vargus USA
www.vargususa.com

Weldon Solutions
www.weldonsolutions.com

Yash International
www.yashtools.com

HEAT TREATING EQUIPMENT & SUPPLIES

All of the suppliers listed here are broken down by category (batch furnaces, continuous furnaces, induction heating equipment, ovens, etc.) at *www.geartechnology.com*.

A&A Coatings
www.thermalspray.com

AFC-Holcroft
www.afc-holcroft.com

Abbott Furnace Company
www.abbottfurnace.com

Advanced Nitriding Solutions
www.ans-ion.net

Ajax Tocco Magnethermic
www.ajaxtocco.com

Aksan Steel Forging
www.aksanforging.com

Ambrell Precision Induction Heating
www.ambrell.com

Avion Manufacturing Company Inc.
www.avionmfg.com

Bega Special Tools
www.bega.nl

Byington Steel Treating
www.byingtonsteel.com

Cascade TEK
www.cascadetek.com

Compressed Gas Technologies Inc.
www.nitrogen-generators.com

Contour Hardening, Inc.
www.contourhardening.com

DAM Härtetechnik GmbH
www.stopoffpaints.com

DFC Tank Pressure Vessel Manufacturer Co., Ltd
www.dfctank.com

Davron Technologies
www.davrontech.com

Duffy Company, The
www.duffycompany.com

ECM USA
www.ecm-usa.com

EFD Induction Inc.
www.efdinduction-usa.com

EMAG eldec Induction GmbH
www.eldec.net

East Coast Induction
www.eastcoastind.com

ElectroHeat Induction
www.electroheatinduction.com

Eltro Services, Inc.
www.eltroservices.com

Euclid Heat Treating
www.euclidheattreating.com

FPM Heat Treating
www.fpmht.com

Flame Treating Systems, Inc.
www.flametreatingsystems.com

Fredericks Company - Televac
www.frederickscompany.com

Furnaces, Ovens & Baths, Inc.
www.fobinc.com

GH Induction Atmospheres
www.gh-ia.com

Gasbarre
www.gasbarre.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
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Goldstein Gear Machinery LLC
www.goldsteingearmachinery.com

Grieve Corporation, The
www.grievecorp.com

Heavy Carbon Co., LLC
www.heavycarbon.com

Houghton International
www.houghtonintl.com

IHI Ionbond Inc.
ionbond.com

Induction Tooling, Inc.
www.inductiontooling.com

Inductoheat Inc.
inductoheat.com

Inductotherm Corp.
www.inductotherm.com

Infrared Heating Technologies
www.infraredheating.com

Ionitech Ltd.
www.ionitech.com

Ipsen, Inc.
www.IpsenUSA.com

Khemka Broach & Spline Gauge
www.khemkabroach.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD OUTSIDE BACK COVER

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
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Koncar Termotehnika d.o.o.
koncar-termotehnika.hr

Lucifer Furnaces, Inc.
www.Luciferfurnaces.com

Machine Tool Solutions, Inc.
machtoolinc.com

Metallurgical High Vacuum Corp.
www.methivac.com

Motultech
www.motul.com

National Heat Treat
nationalheattreat.com

Nisha Engineers (India)
www.nishagroup.com

Nitrex Inc. - Chicago Operations
www.nitrex.com

Nitrex Inc. - Indiana Operations
www.nitrex.com

Nitrex Inc. - Michigan Operations
www.nitrex.com

Nitrex Metal Inc.
www.nitrex.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
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PhoenixTM
www.phoenixtm.com

Pillar Induction
www.pillar.com

Plus Furnace
www.plusfurnace.com

Preco Inc.
www.precoinc.com

Premier Furnace Specialists Inc.
www.premierfurnace.com

Pro-Beam USA
www.pro-beam.com

Pyromaitre
www.pyromaitre.com

Radyne Corporation
www.radyne.com

Rubig US, Inc.
www.rubig.com

SMS Elotherm North America
us.sms-elotherm.com/en/

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

Seco/Vacuum Technologies LLC
180 MERCER STREET, STE. 100
MEADVILLE PA 16335
Phone: 814-332-8520
Fax: 814-724-1407
Mark.Hemsath@SecoVacUSA.com
www.secovacusa.com
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Seco/Warwick Allied Pvt. Ltd.
www.secowarwick.com

Seco/Warwick Europe S.A.
www.secowarwick.com

Seco/Warwick Group
www.secowarwick.com

Sinto America
www.sintoamerica.com

Solar Manufacturing
1983 CLEARVIEW ROAD
SOUDERTON PA 18964
Phone: (267) 384-5040
Fax: (267) 384-5060
info@solarmfg.com
www.solarmfg.com
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Stack Metallurgical Services, Inc.
www.stackmet.com

Surface Combustion
www.surfacecombustion.com

TM Induction Heating
www.tminductionheating.com

Wickert USA
www.wickert-usa.com

ZRIME
www.zrime.com.cn

Zion Industries
www.zioninduction.com

HEAT TREATING SERVICES

All of the suppliers listed here are broken down by category (carburizing, nitriding, induction hardening, etc.) at *www.geartechnology.com.*

300 Below, Inc.
www.300below.com

ALD Thermal Treatment, Inc.
www.heat-treatment-services.com

Accurate Steel Treating, Inc.
www.accuratesteeltreating.com

Advanced Heat Treat Corp.
www.ahtcorp.com

Advanced Nitriding Solutions
www.ans-ion.net

Ajax Tocco Magnethermic
www.ajaxtocco.com

Akron Steel Treating Company
www.akronsteeltreating.com

Aksan Steel Forging
www.aksanforging.com

American Metal Treating Co.
www.americanmetaltreating.com

American Metal treating, Inc.
www.americanmetaltreatinginc.com

Ampere Metal Finishing
www.amperemetal.com

Applied Process
www.appliedprocess.com

Applied Thermal Technologies
www.appliedthermaltechnologies.com

Avion Manufacturing Company Inc.
www.avionmfg.com

BG&S Peening and Consulting LLC
www.peening-consultants.com

BOS Services Company
www.bosheattreating.com

Bennett Heat Treating & Brazing Co., Inc.
www.bennettheat.com

Best Technology Inc.
www.besttechnologyinc.com

Bluewater Thermal Solutions
www.bluewaterthermal.com

Bodycote Thermal Processing - Highland Heights
www.bodycote.com

Bodycote Thermal Processing - Melrose Park
www.bodycote.com

Boltex Manufacturing
www.boltex.com

Braddock Metallurgical
www.braddockmt.com

Burlington Engineering, Inc
www.burlingtoneng.com

Byington Steel Treating
www.byingtonsteel.com

CST-Cincinnati Steel Treating
www.steeltreating.com

Cambridge Heat Treating Inc.
www.cambridgeheattreating.com

Cascade TEK
www.cascadetek.com

Certified Steel Treating
www.certifiedsteeltreat.com

Chicago Flame Hardening
www.cflame.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Complete Heat Treating
www.completeht.com

Continental Heat Treating, Inc.
www.continentalht.com

Contour Hardening, Inc.
www.contourhardening.com

Cryogenic Institute of New England, Inc.
www.nitrofreeze.com

Cryoplus Inc.
www.cryoplus.com

Curtiss-Wright Surface Technologies
www.cwst.com

Dayton Forging and Heat Treating
www.daytonforging.com

Duffy Company, The
www.duffycompany.com

ECM USA
www.ecm-usa.com

EFD Induction Inc.
www.efdinduction-usa.com

ERS Engineering Corp.
www.ersengine.com

Eagle Tool Company Inc.
www.eaglebroach.com

East-Lind Heat Treat, Inc.
www.eastlind.com

ElectroHeat Induction
www.electroheatinduction.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Heat Treat, Inc.
www.ehtinc.com

Erasteel Inc.
www.erasteel.com

Euclid Heat Treating
www.euclidheattreating.com

FPM Heat Treating
www.fpmht.com

Felsomat USA Inc.
www.felsomat.com

Flame Metals Processing Corporation
www.flamemetals.com

Flame Treating Systems, Inc.
www.flametreatingsystems.com

Forst Technologie GmbH & Co. KG
www.forst-online.de

General Metal Heat Treating, Inc.
www.generalmetalheat.com

General Surface Hardening Inc.
www.gshinc.net

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
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Härterei Reese Bochum GmbH
www.hardening.com

Heat Treating Services Corporation of America
www.htsmi.com

Hi TecMetal Group
www.htg.cc

Horsburgh & Scott Co.
www.horsburgh-scott.com

Hudapack Metal Treating
www.hudapack.com

IHI Ionbond Inc.
ionbond.com

IMT Forge Group including Clifford-Jacobs Forge
www.imtforgegroup.com

Induction Hardening Specialists
inductionhardeningspecialists.com

Induction Services, Inc.
www.inductionservicesinc.com

Induction Tooling, Inc.
www.inductiontooling.com

Inductoheat Inc.
inductoheat.com

Industrial Hard Carbon LLC
industrialhardcarbon.com

Industrial Metal Finishing, Inc.
www.indmetfin.com

Infrared Heating Technologies
www.infraredheating.com

Ionic Technologies Inc.
www.ionic-tech.com

Ionitech Ltd.
www.ionitech.com

Khemka Broach & Spline Gauge
www.khemkabroach.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
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PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
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Kowalski Heat Treating
www.khtheat.com

Lalson Tools Corporation
www.lalsoncuttingtools.com

Lambda Technologies
www.lambdatechs.com

Mackeil Ispat & Forging Ltd.
mackeilforgings.com

Magnetic Inspection Laboratory
www.milinc.com

Magnum Induction
www.magnuminduction.com

McLeod and Norquay Ltd.
www.mcleodandnorquay.com

Metallurgical Processing, Inc.
www.mpimetaltreating.com

Metallurgical Solutions, Inc.
www.met-sol.com

Metlab
www.metlabheattreat.com

Mid-South Metallurgical
www.midsouthmetallurgical.com

Midwest Themal-Vac Inc.
www.mtvac.com

Nachi America Inc.
715 PUSHVILLE RD.
GREENWOOD IN 46143
Phone: (317) 530-1001
Fax: (317) 530-1011
info@nachiamerica.com
www.nachiamerica.com
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National Heat Treat
nationalheattreat.com

Nisha Engineers (India)
www.nishagroup.com

Nitrex Inc. - Chicago Operations
www.nitrex.com

Nitrex Inc. - Indiana Operations
www.nitrex.com

Nitrex Inc. - Michigan Operations
www.nitrex.com

Nitrex Inc. - Nevada Operations
www.nitrex.com

Nitrex Metal Inc.
www.nitrex.com

Oerlikon Balzers - PPD Division
www.oerlikon.com

Ohio Vertical Heat Treat
www.ov-ht.com

Ovako AB
www.ovako.com

Paulo
www.paulo.com

Penna Flame Industries
www.pennaflame.com

Penticton Foundry Ltd.
www.pentictonfoundry.com

Peters Heat Treating
www.petersheattreat.com

Pillar Induction
www.pillar.com

Precision Finishing Inc.
www.precisionfinishinginc.com

Precision Heat Treating Co.
www.precisionheat.net

Preco Inc.
www.precoinc.com

Pro-Beam USA
www.pro-beam.com

Rex Heat Treat
www.rexht.com

Rockford Heat Treaters
www.rockfordheattreaters.com

Rubig US, Inc.
www.rubig.com

SMS Elotherm North America
us.sms-elotherm.com/en/

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

SWD Inc.
www.swdinc.com

Sedlock Companies
www.sedlockcompanies.com

Solar Atmospheres
1969 CLEARVIEW ROAD
SOUDERTON PA 18964
Phone: 855-934-3284
Fax: (215) 723-6460
info@solaratm.com
www.solaratm.com
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Somers Forge
www.somersforge.com

Specialty Steel Treating Inc.
www.sst.net

Spectrum Thermal Processing
www.spectrumtp.com

Stack Metallurgical Services, Inc.
www.stackmet.com

Sun Steel Treating Inc.
www.sunsteeltreating.com

Super Systems Inc.
www.supersystems.com

Thermetco Inc.
www.thermetco.com

Thermex Metal Treating Ltd.
www.thermexmetal.com

Thermtech
www.thermtech.net

Thyssenkrupp rothe erde USA
www.ringsandbearings.com/

TimkenSteel Corporation
www.timkensteel.com

Titanium Coating Services Inc.
www.pvdamerica.com

Treat All Metals, Inc.
www.treatallmetals.com

United Gear and Assembly, Inc.
www.ugaco.com

VaporKote, Inc.
www.vaporkote.com

WPC Treatment Co., Inc.
www.wpctreatment.com

Wickert USA
www.wickert-usa.com

Willman Industries Inc.
www.willmanind.com

ZRIME
www.zrime.com.cn

Zion Industries
www.zioninduction.com

INSPECTION EQUIPMENT

All of the suppliers listed here are broken down by category (gages, CMMs, analytical gear inspection machines, bevel gear testers, etc.) at *www.geartechnology.com*.

A.G. Davis - AA Gage
www.agdavis.com

AB Dynamics
www.abd.uk.com

ABTech Inc.
www.abtechmfg.com

AIS Technologies Group
aistechgroup.com

Accu-Cut Diamond Tool Co.
www.accucutdiamond.com

Advent Tool and Manufacturing Inc.
www.advent-threadmill.com

Advico
www.advico.co.uk

Ajax Tool Supply
www.ajaxtoolsupply.com

Aksan Steel Forging
www.aksanforging.com

Alliance Broach & Tool
www.alliancebroach.com

American Stress Technologies, Inc.
www.astresstech.com

Andec Mfg. Ltd.
www.andec.ca

Ash Gear & Supply
www.ashgear.com

Avalon International Corporation
www.avalongateway.com

Becker GearMeisters, Inc.
www.maagmachines.com

Blackbox Technologies
www.blackboxtech.in

Bourn & Koch Inc.
2500 KISHWAUKEE STREET
ROCKFORD IL 61104
Phone: (815) 965-4013
Fax: (815) 965-0019
sales@bourn-koch.com
www.bourn-koch.com
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Broach Masters / Universal Gear Co.
www.broachmasters.com

Buehler - An ITW Company
www.buehler.com

CN Technical Services Ltd (CN Tech)
www.cntech.co.uk

CNC Center
www.cnccenter.com

Capital Tool Industries
www.capital-tool.com

Carl Zeiss Industrial Metrology LLC
www.zeiss.com/metrology

Celanese
www.celanese.com

Certified Comparator Products (CCP)
www.certifiedcomparator.com

Comtorgage Corporation
www.comtorgage.com

Dino-Lite
www.dinolite.us

Donner+Pfister AG
www.dpag.ch

Drewco Workholding
www.drewco.com

Dyer Company
dyergage.com

Emuge Corp.
www.emuge.com

Erwin Junker Machinery, Inc.
www.junker-group.com

Euro-Tech Corporation
www.eurotechcorp.com

FARO Technologies, Inc.
www.faro.com

FHUSA-TSA
www.fhusa-tsa.com

FPM Heat Treating
www.fpmht.com

Flexbar Machine Corporation
www.flexbar.com

Foerster Instruments Incorporated
foerstergroup.com

Fredericks Company - Televac
www.frederickscompany.com

Frenco GmbH
www.frenco.de

Fuji Machine America Corp.
www.fujimachine.com

Furnaces, Ovens & Baths, Inc.
www.fobinc.com

Gage Assembly Company
www.gageassembly.com/

Gearspect s.r.o.
www.gearspect.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
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Gleason Metrology Systems
300 PROGRESS ROAD
DAYTON OH 45449
Phone: (937) 859-8273
Fax: (937) 859-4452
gleason-metrology@gleason.com
www.gleason.com
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Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P25, 81

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
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Goldstein Gear Machinery LLC
www.goldsteingearmachinery.com

Great Lakes Gear Technologies, Inc.
www.greatlakesgeartech.com

Greg Allen Company
www.gallenco.com

HVH Industrial Solutions
hvhindustrial.com

Hanik Corporation
www.hanikcorp.com

Hansford Sensors
www.hansfordsensors.com/us/

Helios Gear Products
heliosgearproducts.com

Hexagon Metrology
www.hexagonmetrology.us

HobSource Inc.
834 E. RAND RD,
SUITE 2
MOUNT PROSPECT IL 60056
Phone: (847) 398-8320
Fax: (847) 398-8326
sales@hobsource.com
www.hobsource.com
SEE OUR AD P62

Hydra-Lock Corporation
www.hydralock.com

ITW Heartland
1205 36TH AVENUE WEST
ALEXANDRIA MN 56308
Phone: (320) 762-0138
Fax: (320) 762-5645
info@itwheartland.com
www.itwheartland.com
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Innovative Analytical Solutions
www.steelanalyzer.com

Interstate Tool Corp.
itctoolcorp.com

Involute Gear & Machine Company
46449 CONTINENTAL DRIVE
CHESTERFIELD MI 48047
Phone: (586) 329-3755
Fax: (586) 329-3965
rodney.soenen@involutegearmachine.com
www.involutegearmachine.com
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Kapp Technologies
www.kapp-niles.com

Khemka Broach & Spline Gauge
www.khemkabroach.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
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Klingelnberg America Inc.
118 E. MICHIGAN AVENUE
SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
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HUECKESWAGEN 42499
GERMANY
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Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
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L.S. Starrett Co.
www.starrett.com

LDB Corporation
ldbcorp.com

Lambda Technologies
www.lambdatechs.com

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1465 WOODLAND DR.
SALINE MI 48176
Phone: (734) 429-7225
Fax: (734) 429-2294
info.lgt@liebherr.com
www.liebherr.com
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MRO Electric and Supply
www.mroelectric.com/

Maheen Enterprises
www.maheenbroaches.com

Mahr Inc.
www.mahr.com

Marposs Corporation
www.marposs.com

Miller Broach
www.millerbroach.com

Mitutoyo America Corporation
www.mitutoyo.com

The Modal Shop
www.modalshop.com

Modern Gearing
www.moderngearing.com

Mutschler Edge Technologies
mutschleredgetech.com

Nachi America Inc.
715 PUSHVILLE RD.
GREENWOOD IN 46143
Phone: (317) 530-1001
Fax: (317) 530-1011
info@nachiamerica.com
www.nachiamerica.com
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Newage Testing Instruments
www.hardnesstesters.com

Nichiei Company, Ltd.
www.nichiei-ind.com

Ono Sokki Technology, Inc.
www.onosokki.net

Optical Gaging Products, Inc. (OGP)
www.ogpnet.com

PCE Instruments
www.pce-instruments.com/english

Parker Industries Inc.
www.parkerind.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
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Phase II
www.phase2plus.com

Pinpoint Laser Systems
pinpointlaser.com

Pioneer Broach Co.
www.pioneerbroach.com

Precision Devices, Inc.
www.predev.com

Precision Gage Co., Inc.
www.precisiongageco.com

Prime Technologies
www.gear-testers.com

Proceq USA, Inc.
www.proceq-usa.com

Promess Inc.
www.promessinc.com

Proto Manufacturing
12350 UNIVERSAL DRIVE
TAYLOR MICHIGAN 48180
Phone: 1 (313) 965-2900
Fax: 1 (734) 946-0974
info@protoxrd.com
www.protoxrd.com
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Quality Vision Services (QVS)
www.qvsi.com

RAM Optical Instrumentation, Inc.
www.ramoptical.com

Ravjeet Engineering Specialty Ltd.
www.ravjeet.com

Renishaw Inc.
www.renishaw.com

Reska Spline Products Co.
www.reskasplinegauge.com

Russell Holbrook & Henderson
www.tru-volute.com

SMS Elotherm North America
us.sms-elotherm.com/en/

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

Samputensili S.p.A.
STAR SU LLC
5200 PRAIRIE STONE PARKWAY
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.samputensili.com
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Schnyder SA
www.schnyder.com

Sensor Products Inc.
www.sensorprod.com

SerWeMa GmbH & Co. KG
www.serwema.de

Slone Gear International, Inc.
www.slonegear.com

Spline Gage Solutions
splinegagesolutions.com

Star Cutter Co.
23461 INDUSTRIAL PARK DRIVE
FARMINGTON HILLS MI 48335
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@starcutter.com
www.starcutter.com
SEE OUR AD IFC-P1, 63

Star SU LLC
5200 PRAIRIE STONE PARKWAY
SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
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Stone Tucker Instruments Inc.
www.stone-tucker.com

Stotz Gaging Co.
www.stotz-usa.com

Stresstech Oy
www.stresstech.com

Sunnen Products Company
www.sunnen.com

Super Hobs & Broaches Pvt. Ltd.
www.supercuttingtools.com

Surplex GmbH
www.surplex.com

Techcellence
www.broachindia.com

TechnoMax Inc.
www.technomax-j.com

Tokyo Technical Instruments USA Inc.
www.tti-geartec.jp

USA Borescopes
www.USABorescopes.com

United Tool Supply
851 OHIO PIKE
CINCINNATI OH 45245
Phone: (513) 752-6000
Fax: (513) 752-5599
info@united-tool.com
www.united-tool.com
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View Micro-Metrology
www.viewmm.com

WMZ - Werkzeugmaschinenbau Ziegenhain GmbH
www.wmz-gmbh.de

Wenzel America
www.wenzelamerica.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Westport Gage
www.westportcorp.com

Willrich Precision Instrument Company
willrich.com

Zoller Inc.
www.zoller-usa.com

LUBRICANTS

All of the suppliers listed here are broken down by category (coolants, gear greases, gear oils, plastic gear lubricants, etc.) at *www.geartechnology.com.*

A.W. Chesterton
chestertonlubricants.chesterton.com/en-us

Aarna Lube Private Ltd.
www.aarnalube.com

Aerospace Lubricants, Inc.
www.aerospacelubricants.com

American Chemical Technologies, Inc.
www.americanchemtech.com

American Refining Group, Inc.
www.amref.com

Avalon International Corporation
www.avalongateway.com

BASF
www.basf.com/lubes

BFK Solutions LLC
bfksolutions.com

Blaser Swisslube Inc.
www.blaser.com

Bodycote Thermal Processing - Melrose Park
www.bodycote.com

Brighton Laboratories
www.brightonlabs.com

Byington Steel Treating
www.byingtonsteel.com

Carborundum Universal Ltd.
www.cumiabrasives.com

Castrol Industrial North America Inc.
www.castrol.com/industrial

Chemtool Inc.
www.chemtool.com

Cimcool Fluid Technology
www.cimcool.com

Cortec Corporation
www.cortecvci.com

Daubert Cromwell
www.daubertcromwell.com

Des-Case Corporation
descase.com

Dillon Chuck Jaws
2115 PROGRESS DRIVE
SPRINGFIELD, OH 45505
Phone: (800) 428-1133
Fax: (800) 634-6480
Sales4@dillonmfg.com
www.dillonmfg.com
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Etna Products, Inc.
www.etna.com

ExxonMobil Oil Corp.
www.mobilindustrial.com

Fuchs Lubricants Company
www.fuchs.com

General Magnaplate
www.magnaplate.com

HVH Industrial Solutions
hvhindustrial.com

Hangsterfer's Laboratories
www.hangsterfers.com

Hoffmann Filter Corporation
www.hoffmannfilter.com

Houghton International
www.houghtonintl.com

Hydrotex
www.hydrotexlube.com

Industrial Speciality Lubricants Co. (ISLUB)
www.islub.com

Isel Inc.
www.iselinc.com

Klüber Lubrication North America L.P.
www.klubersolutions.com

Lubegard / International Lubricants Inc.
www.lubegard.com

Lubrication Engineers
www.lelubricants.com

Lubriplate Lubricants Co.
129 LOCKWOOD STREET
NEWARK NJ 07105
Phone: (973) 589-4432
Fax: (800) 347-5329
www.lubriplate.com
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ML Lubrication Inc.
www.ml-lubrication.com

Microsurface Corporation
www.ws2coating.com

Moncktons Machine Tools, LLC
www.mmtproductivity.com/

Motultech
www.motul.com

Nansteel Manufacturing Co.,Ltd
www.nan-steel.com/

Nye Lubricants
www.nyelubricants.com

Particular Technology, Inc.
www.particulartechnology.com

Petro Lubes Inc.
www.petrolubesinc.com

PetroChoice
www.PetroChoice.com

Petronomics Mfg. Group, Inc.
www.petronomics.com

Productivity Inc.
www.productivity.com/

RedLine Tools
www.redlinetools.com

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

SWD Inc.
www.swdinc.com

Shell Lubricants
www.shellus.com

Summit Industrial Products
www.klsummit.com

Sunnen Products Company
www.sunnen.com

Syn-Tech Ltd.
www.syn-techlube.com

Tecsia Lubricants USA
www.tecsialube.com

Texas Refinery Corp.
www.texasrefinery.com

TheLubricantStore.com
www.thelubricantstore.com

United Tool Supply Ltd.
www.unitedtoolsupply.com

Voelker Sensors, Inc.
www.vsi-oil.com

Whitmore
whitmores.com

oelheld U.S., Inc.
www.oelheld.com

MACHINE TOOLS

All of the suppliers listed here are broken down by category (milling machines, turning machines, grinding machines, etc.) at *www.geartechnology.com*.

1Factory
www.1factory.com

2L Inc.
www.2Linc.com

A&A Coatings
www.thermalspray.com

ADF Systems Ltd.
www.adfsys.com

ANCA, Inc.
www.anca.com

AX Control, Inc
www.axcontrol.com/

Accu-Cut Diamond Tool Co.
www.accucutdiamond.com

AccuBrass
accubrass.com/

Acieta
www.acieta.com/robotics-products/gripper-systems/

Acme Manufacturing Co.
www.acmemfg.com

Advico
www.advico.co.uk

Aksan Steel Forging
www.aksanforging.com

Alliance Broach & Tool
www.alliancebroach.com

Almco Finishing & Cleaning Systems
www.almco.com

American Broach & Machine Co.
www.americanbroach.com

Ampere Metal Finishing
www.amperemetal.com

Andec Mfg. Ltd.
www.andec.ca

Arbortech Corporation
www.arbortech.com

BFK Solutions LLC
bfksolutions.com

BUDERUS Schleiftechnik GmbH
www.buderus-schleiftechnik.de

Balanstar Corp
www.balanstar.com

Barber-Colman, Div of Bourn & Koch
www.bourn-koch.com

Becker GearMeisters, Inc.
www.maagmachines.com

Best Technology Inc.
www.besttechnologyinc.com

Bhagwan Udyog
www.bhagwanudyog.com

Blackbox Technologies
www.blackboxtech.in

Bohle Machine Tools, Inc.
www.bmtbohle.com

Bourn & Koch Inc.
2500 KISHWAUKEE STREET
ROCKFORD IL 61104
Phone: (815) 965-4013
Fax: (815) 965-0019
sales@bourn-koch.com
www.bourn-koch.com
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Breton USA
www.bretonusa.com

Brighton Laboratories
www.brightonlabs.com

Broaching Machine Specialties
www.broachingmachine.com

C & B Machinery
www.cbmachinery.com

CNC Center
www.cnccenter.com

CNC Design Pty Ltd
www.cncdesign.com

Capital Equipment LLC
www.capitalequipment.com

Capital Tool Industries
www.capital-tool.com

Carborundum Universal Ltd.
www.cumiabrasives.com

Castrol Industrial North America Inc.
www.castrol.com/industrial

Cleaning Technologies Group/Ransohoff
www.ctgclean.com

Clemco Industries Corp.
www.clemcoindustries.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Colonial Tool Group
www.colonialtool.com

Comco Inc.
www.comcoinc.com

Cortec Corporation
www.cortecvci.com

Cosen Saws USA
www.cosensaws.com

Creative Automation, Inc.
www.cautomation.com

Crest Ultrasonics Corp.
www.crest-ultrasonics.com

Curtiss-Wright Surface Technologies
www.cwst.com

D.C. Morrison Company
www.dcmorrison.com

DFC Tank Pressure Vessel Manufacturer Co., Ltd
www.dfctank.com

DISKUS WERKE Schleiftechnik GmbH
www.diskus-werke.de

DMG MORI USA
www.dmgmori-usa.com

DVS Technology America, Inc.
44099 PLYMOUTH OAKS BLVD.
PLYMOUTH MI 48170
Phone: (734) 656-2073
Fax: (734) 656-2091
ralf-georg.eitel@dvs-technology.com
www.dvs-technology.com
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DVS Universal Grinding GmbH
www.ugrind.de

Danobat Machine Tool Co. Inc.
www.danobatusa.com

Daubert Cromwell
www.daubertcromwell.com

Des-Case Corporation
descase.com

Drake Manufacturing
www.drakemfg.com

Duffy Company, The
www.duffycompany.com

EMAG L.L.C.
38800 GRAND RIVER AVE.
FARMINGTON HILLS MI 48335
Phone: (248) 477-7440
Fax: (248) 477-7784
abakun@emag.com
www.emag.com
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Eagle PLC
www.eagleplc.com

ElectroHeat Induction
www.electroheatinduction.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Abrasives
www.engineeredabrasives.com

Erwin Junker Machinery, Inc.
www.junker-group.com

Euro-Tech Corporation
www.eurotechcorp.com

FPM Heat Treating
www.fpmht.com

Felsomat USA Inc.
www.felsomat.com

Firbimatic Metal Cleaning Division
www.metalcleaning-firbimatic.com

Flexbar Machine Corporation
www.flexbar.com

Foerster Instruments Incorporated
foerstergroup.com

Forst Technologie GmbH & Co. KG
www.forst-online.de

Fuji Machine America Corp.
www.fujimachine.com

Furnaces, Ovens & Baths, Inc.
www.fobinc.com

GH Induction Atmospheres
www.gh-ia.com

GMN USA LLC
www.gmnusa.com

GMTA German Machine Tools of America
www.gmtamerica.com

Galomb Inc.
www.injectionmolder.net

Gehring L.P.
www.gehring.de

General Broach Company
www.generalbroach.com

General Magnaplate
www.magnaplate.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
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Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
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GoHz Inc.
www.gohz.com

Goldstein Gear Machinery LLC
www.goldsteingearmachinery.com

Great Lakes Gear Technologies, Inc.
www.greatlakesgeartech.com

Guardair Corporation
www.guardair.com

HPI Processes, Inc.
www.hpipro.com/

Haas Multigrind LLC
www.multigrind.com

Hans-Juergen Geiger Maschinen-Vertrieb GmbH
www.geiger-germany.com

Hardinge Inc.
www.hardinge.com

Havlik International Machinery Inc.
www.havlikinternational.com

Heiko Machine Tools
www.heikomachine.com

Heller Machine Tools
www.heller-machinetools.com

Hines Industries
www.hinesindustries.com

HobSource Inc.
834 E. RAND RD,
SUITE 2
MOUNT PROSPECT IL 60056
Phone: (847) 398-8320
Fax: (847) 398-8326
sales@hobsource.com
www.hobsource.com
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Hoffmann Filter Corporation
www.hoffmannfilter.com

Hy-Pro Filtration
www.hyprofiltration.com

IHI Hauzer Techno Coating B.V.
www.hauzer.nl

IHI Ionbond Inc.
ionbond.com

IMPCO Microfinishng
www.impco.com

Index Corporation
us.index-traub.com

Index-Werke GmbH & Co. KG Hahn & Tessky
www.index-traub.com/gearing

Industrial Hard Carbon LLC
industrialhardcarbon.com

Inovatec Machinery
www.inovatecmachinery.com/

Interstate Tool Corp.
itctoolcorp.com

Ion Vacuum (IVAC) Technologies Corp.
www.ivactech.com

J. Schneeberger Corp.
www.schneeberger-us.com

Jenfab
www.jenfab.com

K+S Services, Inc.
www.k-and-s.com

KGK International Corp.
www.kgki.com

Kennametal Inc.
www.kennametal.com

Kinefac Corporation
www.kinefac.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD OUTSIDE BACK COVER

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE
SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
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Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
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Knuth Machine Tools USA, Inc.
www.knuth-usa.com

Kollmorgen
www.kollmorgen.com/en-us/home/

Kwikmark Inc.
www.kwikmark.com

LadyBug Technologies LLC
www.ladybug-tech.com/

Lafert North America
www.lafertna.com

Lambda Technologies
www.lambdatechs.com

Laser Tools Co.
www.lasertoolsco.com

Liebherr America
1465 WOODLAND DR.
SALINE MI 48176
Phone: (734) 429-7225
Fax: (734) 429-2294
info.lgt@liebherr.com
www.liebherr.com
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Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
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Longevity Coatings
www.longevitycoatings.com

MRO Electric and Supply
www.mroelectric.com/

Machine Tool Builders
www.machinetoolbuilders.com

Machine Tool Solutions, Inc.
machtoolinc.com

Matrix Precision Co. Ltd.
www.matrix-machine.tw

Mazak Corporation
www.mazakusa.com

Meccanica Nova Corporation
www.novagrinders.com

Meister Abrasives USA
www.meister-abrasives.com/USA

Metallurgical High Vacuum Corp.
www.methivac.com

Metallurgical Processing, Inc.
www.mpimetaltreating.com

Methods Machine Tools Inc.
www.methodsmachine.com

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
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Modern Gearing
www.moderngearing.com

Moncktons Machine Tools, LLC
www.mmtproductivity.com/

Mutschler Edge Technologies
mutschleredgetech.com

NTC America Corporation
www.ntcmc.com

Nachi America Inc.
715 PUSHVILLE RD.
GREENWOOD IN 46143
Phone: (317) 530-1001
Fax: (317) 530-1011
info@nachiamerica.com
www.nachiamerica.com
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Nagel Precision
www.nagelusa.com

Nansteel Manufacturing Co.,Ltd
www.nan-steel.com/

National Heat Treat
nationalheattreat.com

Normac, Inc.
www.normac.com

Oerlikon Balzers USA
www.oerlikon.com/balzers/us

Ohio Broach & Machine Co.
www.ohiobroach.com

Okuma America Corporation
www.okuma.com

PITTLER T&S GmbH
www.pittler.de

PRAEWEMA Antriebstechnik GmbH
praewema.dvs-gruppe.com/

PTG Holroyd
www.holroyd.com

Paramount Enterprises
parentnashik.com/brand/

Penna Flame Industries
www.pennaflame.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
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Philadelphia Carbide Co.
www.philacarbide.com

Phoenix Inc.
www.phoenix-inc.com

Pinpoint Laser Systems
pinpointlaser.com

Pioneer Broach Co.
www.pioneerbroach.com

Precision Finishing Inc.
www.precisionfinishinginc.com

Precision Spindle & Accessories Inc.
www.precisionspindleinc.com

Precision Surfacing Solutions
www.pss-atd.com/

Preco Inc.
www.precoinc.com

Pro-Beam USA
www.pro-beam.com

Promess Inc.
www.promessinc.com

QC American
www.qcamerican.com

Röders GmbH
www.roeders.de

R.A. Heller
www.raheller.com

RAM Optical Instrumentation, Inc.
www.ramoptical.com

Reade Advanced Materials
www.reade.com

Redin Production Machine
www.redinmachine.com

Renegade Parts Washers and Detergents
www.renegadepartswashers.com

Renishaw Inc.
www.renishaw.com

Rewitec GmbH
www.rewitec.com

Riten Industries, Inc.
www.riten.com

Rotary Engineering Corporation
www.rotarymandrels.com

Russell Holbrook & Henderson
www.tru-volute.com

SMS Eletherm North America
us.sms-eletherm.com/en/

SWD Inc.
www.swdinc.com

Samputensili S.p.A.
STAR SU LLC
5200 PRAIRIE STONE PARKWAY
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.samputensili.com
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Schunk
www.schunk.com

Schutte LLC
www.schutteusa.com

SerWeMa GmbH & Co. KG
www.serwema.de

Setco Precision Spindles
www.setcousa.com

Sinto America
www.sintoamerica.com

Slater Tools Inc.
www.slatertools.com

Slone Gear International, Inc.
www.slonegear.com

Solid Metalworking INC. Limited
www.atcarbide.com

Somers Forge
www.somersforge.com

Star Cutter Co.
23461 INDUSTRIAL PARK DRIVE
FARMINGTON HILLS MI 48335
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@starcutter.com
www.starcutter.com
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Star SU LLC
5200 PRAIRIE STONE PARKWAY
SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
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Stotz Gaging Co.
www.stotz-usa.com

Sunnen Products Company
www.sunnen.com

Super Hobs & Broaches Pvt. Ltd.
www.supercuttingtools.com

Surplex GmbH
www.surplex.com

Titanium Coating Services Inc.
www.pvdamerica.com

Toolink Engineering
www.toolink-eng.com

Toolmex Corporation - Lathe group
www.toolmexlathes.com

Toshiba Machine Co.
www.toshiba-machine.com

Tribo Surface Engineering LLC
www.tribosurfaceengineering.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

Ultramatic Equipment Co.
ultramatic-equipment.com

Ultrasonic LLC
www.ultrasonicllc.com

United Grinding
grinding.com

VaporKote, Inc.
www.vaporkote.com

Venture Mfg. Co.
www.venturemfgco.com

View Micro-Metrology
www.viewmm.com

Voelker Sensors, Inc.
www.vsi-oil.com

WFL Millturn Technologies, Inc
www.wfl-usa.com

WMZ - Werkzeugmaschinenbau Ziegenhain GmbH
www.wmz-gmbh.de

WardJet
www.wardjet.com

Watkins Mfg. Inc.
www.saw-lutions.com

Weldon Solutions
www.weldonsolutions.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Westfalia Technologies
www.westfaliausa.com

Wheelabrator
www.wheelabratorgroup.com

Wolverine Broach Co., Inc.
www.wolverinebroach.com

Yaskawa Motoman
www.motoman.com

Zhejiang Qihong Machinery Casting Co., Ltd
www.zjqihong.net/

oelheld U.S., Inc.
www.oelheld.com

RESOURCES

All of the suppliers listed here are broken down by category (associations, education, publications, research institutes, etc.) at *www.geartechnology.com*.

AGMA - American Gear Manufacturers Association
SEE OUR AD P38–39
1001 N. FAIRFAX STREET
SUITE 500
ALEXANDRIA VA 1587
Phone: (703) 684-0211
Fax: (703) 684-0242
croson@agma.org
www.agma.org

AGMA Media
www.geartechnology.com

AMT - The Association for Manufacturing Technology
www.amtonline.org

ASM International
www.asminternational.org

American Bearing Manufacturers Association
www.americanbearings.org

American Wind Energy Association
www.awea.org

BUDERUS Schleiftechnik GmbH
www.buderus-schleiftechnik.de

Balanstar Corp
www.balanstar.com

Banyan Global Technologies LLC
www.banyangt.com

CTI - Car Training Institute
SEE OUR AD P61
PRINZENALLEE 3
40549 DUESSELDORF
GERMANY
Phone: +(49) 211-9686-3000
cti.euroforum.de/en

DVS Technology America, Inc.
SEE OUR AD P3
44099 PLYMOUTH OAKS BLVD.
PLYMOUTH MI 48170
Phone: (734) 656-2073
Fax: (734) 656-2091
ralf-georg.eitel@dvs-technology.com
www.dvs-technology.com

DVS Tooling GmbH
www.dvs-tooling.de

Drive Systems Technology, Inc.
www.gear-doc.com

FVA GmbH
SEE OUR AD P57,59
LYONER STRASSE 18
FRANKFURT / MAIN HESSEN 60528
GERMANY
Phone: +49 69 6603-1663
Fax: +49 69 6603-2663
info@fva-service.de
www.fva-service.de

FZG
www.fzg.mw.tum.de

Forging Industry Association
www.forging.org

Gear Research Institute
APPLIED RESEARCH LABORATORY
PENNSYLVANIA STATE UNIVERSITY
UNIVERSITY PARK PA 16802
Phone: (814) 865-5832
aci101@arl.psu.edu
www.gearresearch.org

Gehring L.P.
www.gehring.de

Gleason Corporation
SEE OUR AD P25, 81
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com

Gleason Cutting Tools Corporation
SEE OUR AD P25, 81
1351 WINDSOR RD.
LOVES PARK IL 61111
Phone: (815) 877-8900
Fax: (815) 877-0264
gctc@gleason.com
www.gleason.com

Gleason-Hurth Tooling GmbH
SEE OUR AD P25, 81
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com

Goldstein Gear Machinery LLC
www.goldsteingearmachinery.com

Guardair Corporation
www.guardair.com

Hannover Fairs USA
www.hfusa.com

Helios Gear Products
heliosgearproducts.com

The Herring Group Inc.
www.heat-treat-doctor.com

KISSsoft AG
SEE OUR AD P81
ROSENGARTENSTRASSE 4
BUBIKON 8608
SWITZERLAND
Phone: 0041 (0)55 254 20 70
Fax: 0041 (0)55 254 20 71
info@KISSsoft.ag
www.KISSsoft.ag

Kapp Technologies
www.kapp-niles.com

Lafert North America
www.lafertna.com

Liebherr America
SEE OUR AD P5
1465 WOODLAND DR.
SALINE MI 48176
Phone: (734) 429-7225
Fax: (734) 429-2294
info.lgt@liebherr.com
www.liebherr.com

Lubrication Engineers
www.lelubricants.com

Metal Powder Industries Federation (MPIF)
www.mpif.org

Noria Corporation
www.noria.com

PITTLER T&S GmbH
www.pittler.de

PRAEWEMA Antriebstechnik GmbH
praewema.dvs-gruppe.com/

Thors, LLC
www.thors.com

VDI
www.vdi.de

Virgo Communications & Exhibitions Pvt Ltd.
www.virgo-comm.com

West Michigan Spline, Inc.
www.westmichiganspline.com

SERVICES

All of the suppliers listed here are broken down by category (consulting, hob sharpening, gear engineering, tool coating, machine tool repair, etc.) at *www.geartechnology.com*.

2 Channel Transmission
www.2channeltransmission.com

A&A Coatings
www.thermalspray.com

AB Dynamics
www.abd.uk.com

ATS - Advanced Technology Services
www.advancedtech.com

AX Control, Inc
www.axcontrol.com/

Acedes Gear Tools
www.acedes.co.uk

Advanced Coating Technologies
www.actechnol.com

Advanced Heat Treat Corp.
www.ahtcorp.com

Airflow Sciences Corporation
www.airflowsciences.com/

Aksan Steel Forging
www.aksanforging.com

American Broach & Machine Co.
www.americanbroach.com

Ampere Metal Finishing
www.amperemetal.com

Andec Mfg. Ltd.
www.andec.ca

Apex Broaching Systems
www.apexbroach.com

Artemis Vision
artemisvision.com

BG&S Peening and Consulting LLC
www.peening-consultants.com

Balanstar Corp
www.balanstar.com

Banyan Global Technologies LLC
www.banyangt.com

Barber-Colman, Div of Bourn & Koch
www.bourn-koch.com

Becker GearMeisters, Inc.
www.maagmachines.com

Best Technology Inc.
www.besttechnologyinc.com

Beyta Gear Service
www.beytagear.com

Blackbox Technologies
www.blackboxtech.in

Bourn & Koch Inc.
SEE OUR AD P7
2500 KISHWAUKEE STREET
ROCKFORD IL 61104
Phone: (815) 965-4013
Fax: (815) 965-0019
sales@bourn-koch.com
www.bourn-koch.com

Broach Masters / Universal Gear Co.
www.broachmasters.com

Broaching Technologies, LLC
keyway-spline-broaching.com

Bruce Cox Engineering Corporation
www.bcoxengineering.com/

Buehler - An ITW Company
www.buehler.com

C & B Machinery
www.cbmachinery.com

CNC Center
www.cnccenter.com

CNC Design Pty Ltd
www.cncdesign.com

Capital Tool Industries
www.capital-tool.com

Carbide Tool Services, Inc.
www.carbidetool.com/

Carl Zeiss Industrial Metrology LLC
www.zeiss.com/metrology

Cincinnati Gearing Systems Inc.
5757 MARIEMONT AVE
CINCINNATI OH 45227
Phone: 5135278600
Fax: 5135278635
gearsales@cst-c.com
www.cincinnatigearingsystems.com
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Curtiss-Wright Surface Technologies
www.cwst.com

DVS Technology America, Inc.
44099 PLYMOUTH OAKS BLVD.
PLYMOUTH MI 48170
Phone: (734) 656-2073
Fax: (734) 656-2091
ralf-georg.eitel@dvs-technology.com
www.dvs-technology.com
SEE OUR AD P3

Daubert Cromwell
www.daubertcromwell.com

Delta Inspection
www.deltainspect.com

Diametal AG
www.diametal.ch

Diehl Engineering Company, Inc. PS
www.diehlengineering.com

Dixitech CNC
www.dixitechcnc.com

Drive Systems Technology, Inc.
www.gear-doc.com

EMAG L.L.C.
38800 GRAND RIVER AVE.
FARMINGTON HILLS MI 48335
Phone: (248) 477-7440
Fax: (248) 477-7784
abakun@emag.com
www.emag.com
SEE OUR AD P33

Eagle Tool Company Inc.
www.eaglebroach.com

Eaglemaster Inc.
www.eaglemasterinc.com/

East-Lind Heat Treat, Inc.
www.eastlind.com

ElectroHeat Induction
www.electroheatinduction.com

Electronics Inc.
www.electronics-inc.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Abrasives
www.engineeredabrasives.com

Estudio Piña
www.estudiopina.com

Excel Gear
www.excelgear.com

FPM Heat Treating
www.fpmht.com

FVA GmbH
LYONER STRASSE 18
FRANKFURT / MAIN HESSEN 60528
GERMANY
Phone: +49 69 6603-1663
Fax: +49 69 6603-2663
info@fva-service.de
www.fva-service.de
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Forst Technologie GmbH & Co. KG
www.forst-online.de

Framo Morat, Inc.
www.framo-morat.com

Frenco GmbH
www.frenco.de

Friedrich Gloor Ltd.
www.gloorag.ch

Furnaces, Ovens & Baths, Inc.
www.fobinc.com

GMN USA LLC
www.gmnusa.com

GMTA German Machine Tools of America
www.gmtamerica.com

GWJ Technology GmbH
www.gwj.de

Gehring L.P.
www.gehring.de

General Magnaplate
www.magnaplate.com

Gibbs Gears Precision Engineers
www.gibbsgears.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P25, 81

Gleason Cutting Tools Corporation
1351 WINDSOR RD.
LOVES PARK IL 61111
Phone: (815) 877-8900
Fax: (815) 877-0264
gctc@gleason.com
www.gleason.com
SEE OUR AD P25, 81

Gleason Metrology Systems
300 PROGRESS ROAD
DAYTON OH 45449
Phone: (937) 859-8273
Fax: (937) 859-4452
gleason-metrology@gleason.com
www.gleason.com
SEE OUR AD P25, 81

Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P25, 81

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
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Global Physical Asset Management
global-pam.com/

GoHz Inc.
www.gohz.com

Great Lakes Gear Technologies, Inc.
www.greatlakesgeartech.com

Greg Allen Company
www.gallenco.com

Grindal Company
www.grindal.com

Hansford Sensors
www.hansfordsensors.com/us/

Helios Gear Products
heliosgearproducts.com

The Herring Group Inc.
www.heat-treat-doctor.com

HobSource Inc.
834 E. RAND RD,
SUITE 2
MOUNT PROSPECT IL 60056
Phone: (847) 398-8320
Fax: (847) 398-8326
sales@hobsource.com
www.hobsource.com
SEE OUR AD P62

Hydrotex
www.hydrotexlube.com

IHI Hauzer Techno Coating B.V.
www.hauzer.nl

IHI Ionbond Inc.
ionbond.com

IMPCO Microfinishng
www.impco.com

Index Technologies Inc.
5755 CANAL ROAD
VALLEY VIEW OHIO 44125
Phone: 216 642 5900
Fax: 216 642 8837
galllen@gallenco.com
www.indextechnologiesinc.com/
SEE OUR AD P64

Industrial Hard Carbon LLC
industrialhardcarbon.com

Industrial Metal Finishing, Inc.
www.indmetfin.com

Innovative Analytical Solutions
www.steelanalyzer.com

Involute Gear & Machine Company
46449 CONTINENTAL DRIVE
CHESTERFIELD MI 48047
Phone: (586) 329-3755
Fax: (586) 329-3965
rodney.soenen@involutegearmachine.com
www.involutegearmachine.com
SEE OUR AD INSIDE BACK COVER

Ion Vacuum (IVAC) Technologies Corp.
www.ivactech.com

Jesse Garant Metrology Center
jgarantmc.com

K+S Services, Inc.
www.k-and-s.com

Kapp Technologies
www.kapp-niles.com

Kinematics Manufacturing, Inc.
www.kinematicsmfg.com

Kingsford Broach & Tool Inc.
www.kingsfordbroach.com

KlingelnbergAmerica Inc.
118 E. MICHIGAN AVENUE
SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD OUTSIDE BACK COVER

Koro Sharpening Service
www.koroind.com

Lafert North America
www.lafertna.com

Lalson Tools Corporation
www.lalsoncuttingtools.com

Laser Tools Co.
www.lasertoolsco.com

Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
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Lomar Machine & Tool Co.
lomar.com/products-equipment/rack-pinion/

Longevity Coatings
www.longevitycoatings.com

MATsolutions
www.matsolutions.com

MESYS AG
www.mesys.ag

MRO Electric and Supply
www.mroelectric.com/

MTI Systems, Inc.
www.mtisystems.com

Machine Tool Builders
www.machinetoolbuilders.com

Machine Tool Solutions, Inc.
machtoolinc.com

Magnetic Inspection Laboratory
www.milinc.com

Maguire Technologies
www.maguiretech.com

Mahr Inc.
www.mahr.com

Masternet Ltd.
www.masternetltd.com

Matrix Precision Co. Ltd.
www.matrix-machine.tw

Metallized Carbon Corporation
www.metcar.com

Metallurgical Processing, Inc.
www.mpimetaltreating.com

Micro Surface Corp.
www.microsurfacecorp.com

MicroTek Finishing
mmptechnology.com

Milburn Engineering, Inc.
www.milburnengineering.com

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
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Mitsubishi Materials USA
www.mmus.com

Mitutoyo America Corporation
www.mitutoyo.com

The Modal Shop
www.modalshop.com

Motor & Gear Engineering, Inc.
www.motorgearengineer.com

New England Gear
www.newenglandgear.com

Nichiei Company, Ltd.
www.nichiei-ind.com

Noria Corporation
www.noria.com

Oerlikon Balzers - PPD Division
www.oerlikon.com

Oerlikon Balzers USA
www.oerlikon.com/balzers/us

Orbitless Drives Inc.
www.orbitless.com

PITTLER T&S GmbH
www.pittler.de

PRAEWEMA Antriebstechnik GmbH
praewema.dvs-gruppe.com/

Paramount Enterprises
parentnashik.com/brand/

Peening Technologies
www.hydro-honing.com

Perry Technology Corporation
www.perrygear.com

Phoenix Tool & Thread Grinding
phoenixthreadgrinding.com

Pinpoint Laser Systems
pinpointlaser.com

Precision Spindle & Accessories Inc.
www.precisionspindleinc.com

Precision Surfacing Solutions
www.pss-atd.com/

Proto Manufacturing
12350 UNIVERSAL DRIVE
TAYLOR MICHIGAN 48180
Phone: 1 (313) 965-2900
Fax: 1 (734) 946-0974
info@protoxrd.com
www.protoxrd.com
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Quality Reducer Service, Inc
www.qualityreducer.com

REM Surface Engineering
www.remchem.com

Rewitec GmbH
www.rewitec.com

Riley Gear Corporation
www.rileygear.com

Riverside Spline & Gear
www.splineandgear.com

Romax Technology
www.romaxtech.com

S.S. Tools
www.sstools.net

SMT
CHARTWELL HOUSE
67-69 HOUNDS GATE
NOTTINGHAM NOTTINGHAMSHIRE NG1 6BB
UNITED KINGDOM
Phone: +44 (0) 115 941 9839
Fax: +44 (0) 115 958 1583
info@smartmt.com
www.smartmt.com
SEE OUR AD P27

SWD Inc.
www.swdinc.com

Samputensili S.p.A.
STAR SU LLC
5200 PRAIRIE STONE PARKWAY
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.samputensili.com
SEE OUR AD IFC-P1, 63

Sandvik Coromant
www.sandvik.coromant.com

Seco/Warwick Europe S.A.
www.secowarwick.com

Sedlock Companies
www.sedlockcompanies.com

Six Star
www.sixstar.com.tw

Slone Gear International, Inc.
www.slonegear.com

Somers Forge
www.somersforge.com

Star Cutter Co.
23461 INDUSTRIAL PARK DRIVE
FARMINGTON HILLS MI 48335
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@starcutter.com
www.starcutter.com
SEE OUR AD IFC-P1, 63

Star SU LLC
5200 PRAIRIE STONE PARKWAY
SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-P1, 63

Stone Tucker Instruments Inc.
www.stone-tucker.com

Stresstech Oy
www.stresstech.com

Surface Finishing Equipment Co.
www.sfecindia.net

Titanium Coating Services Inc.
www.pvdamerica.com

TopGun Consulting LLC
www.topgunconsulting.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

USA Borescopes
www.USABorescopes.com

Ultramatic Equipment Co.
ultramatic-equipment.com

United Tool Supply
851 OHIO PIKE
CINCINNATI OH 45245
Phone: (513) 752-6000
Fax: (513) 752-5599
info@united-tool.com
www.united-tool.com
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United Tool Supply Ltd.
www.unitedtoolsupply.com

VaporKote, Inc.
www.vaporkote.com

Victrex Gear Solutions
www.victrex.com/en/gears

Viking Equipment Finance
www.vikingequipmentfinance.com/manufacturing/

WMZ - Werkzeugmaschinenbau Ziegenhain GmbH
www.wmz-gmbh.de

WPC Treatment Co., Inc.
www.wpctreatment.com

Welter Group
www.welter-lahr.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Willrich Precision Instrument Company
willrich.com

Work Out Ind. Com. Imp. e Exp. de Maq. ltda
www.workout.com.br/index-en

Yager Gear Enterprise Co. Ltd.
www.yagergear.com

SOFTWARE

All of the suppliers listed here are broken down by category (custom software, gear design software, shop management software, etc.) at *www.geartechnology.com.*

1Factory
www.1factory.com

A.G. Davis - AA Gage
www.agdavis.com

AB Dynamics
www.abd.uk.com

AKGears, LLC
www.akgears.com

ATS - Advanced Technology Services
www.advancedtech.com

Acme Manufacturing Co.
www.acmemfg.com

Andec Mfg. Ltd.
www.andec.ca

Artis Division of Marposs
www.artis.de

Ash Gear & Supply
www.ashgear.com

Blackbox Technologies
www.blackboxtech.in

Bourn & Koch Inc.
2500 KISHWAUKEE STREET
ROCKFORD IL 61104
Phone: (815) 965-4013
Fax: (815) 965-0019
sales@bourn-koch.com
www.bourn-koch.com
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Broach Masters / Universal Gear Co.
www.broachmasters.com

Camnetics, Inc.
camnetics.com

Carl Zeiss Industrial Metrology LLC
www.zeiss.com/metrology

Community PC
www.meshingwithgears.com

DMG MORI USA
www.dmgmori-usa.com

Diametal AG
www.diametal.ch

Donner+Pfister AG
www.dpag.ch

Dontyne Systems
www.dontynesystems.com

Drake Manufacturing
www.drakemfg.com

Drive Systems Technology, Inc.
www.gear-doc.com

ESI ITI GmbH
www.simulationx.com

Eltro Services, Inc.
www.eltroservices.com

Erwin Junker Machinery, Inc.
www.junker-group.com

Estudio Piña
www.estudiopina.com

Euklid CAD/CAM AG
www.euklid-cadcam.com

Euro-Tech Corporation
www.eurotechcorp.com

Excel Gear
www.excelgear.com

FARO Technologies, Inc.
www.faro.com

FPM Heat Treating
www.fpmht.com

FVA GmbH
LYONER STRASSE 18
FRANKFURT / MAIN HESSEN 60528
GERMANY
Phone: +49 69 6603-1663
Fax: +49 69 6603-2663
info@fva-service.de
www.fva-service.de
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FastCAM Inc.
www.fastcam.com

Frenco GmbH
www.frenco.de

GWJ Technology GmbH
www.gwj.de

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
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Gleason Metrology Systems
300 PROGRESS ROAD
DAYTON OH 45449
Phone: (937) 859-8273
Fax: (937) 859-4452
gleason-metrology@gleason.com
www.gleason.com
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Great Lakes Gear Technologies, Inc.
www.greatlakesgeartech.com

Heller Machine Tools
www.heller-machinetools.com

Hexagon Industriesoftware GmbH
www.hexagon.de

Hexagon Metrology
www.hexagonmetrology.us

HiTech e Soft
www.hitechesoft.com

Involute Simulation Softwares
www.hygears.com

KISSsoft AG
ROSENGARTENSTRASSE 4
BUBIKON 8608
SWITZERLAND
Phone: 0041 (0)55 254 20 70
Fax: 0041 (0)55 254 20 71
info@KISSsoft.ag
www.KISSsoft.ag
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KISSsoft Sales and Service
8210 BUFFALO RD.
BERGEN NY 14416
Phone: +1 585 370 4339
info@KISSsoft.com
www.kisssoft.com
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Khemka Broach & Spline Gauge
www.khemkabroach.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD OUTSIDE BACK COVER

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
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Kollmorgen
www.kollmorgen.com/en-us/home/

Liebherr America
1465 WOODLAND DR.
SALINE MI 48176
Phone: (734) 429-7225
Fax: (734) 429-2294
info.lgt@liebherr.com
www.liebherr.com
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MESYS AG
www.mesys.ag

MSC Software Corp.
www.mscsoftware.com

MTI Systems, Inc.
www.mtisystems.com

Machine Tool Builders
www.machinetoolbuilders.com

Marposs Corporation
www.marposs.com

Mitutoyo America Corporation
www.mitutoyo.com

Normac, Inc.
www.normac.com

Open Mind Technologies
www.openmind-tech.com/en-us.html

Orbitless Drives Inc.
www.orbitless.com

PTG Holroyd
www.holroyd.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
SEE OUR AD P29,50,63

Pinpoint Laser Systems
pinpointlaser.com

Precision Gage Co., Inc.
www.precisiongageco.com

Prime Technologies
www.gear-testers.com

Promess Inc.
www.promessinc.com

Romax Technology
www.romaxtech.com

SMT
CHARTWELL HOUSE
67-69 HOUNDS GATE
NOTTINGHAM NOTTINGHAMSHIRE NG1 6BB
UNITED KINGDOM
Phone: +44 (0) 115 941 9839
Fax: +44 (0) 115 958 1583
info@smartmt.com
www.smartmt.com
SEE OUR AD P27

SU (Shanghai) Machine & Tools Co., Ltd.
www.samputensili.com

SWG Solutions
www.swgsolutions.com

Saazor
www.saazor.de

Sandvik Coromant
www.sandvik.coromant.com

Scientific Forming Technologies Corp.
www.deform.com

SerWeMa GmbH & Co. KG
www.serwema.de

Slone Gear International, Inc.
www.slonegear.com

Stotz Gaging Co.
www.stotz-usa.com

Stresstech Oy
www.stresstech.com

Super Systems Inc.
www.supersystems.com

Techcellence
www.broachindia.com

Thermo-Calc Software Inc.
www.thermocalc.com

Universal Technical Systems, Inc.
www.uts.com

WardJet
www.wardjet.com

Waterloo Manufacturing Software
www.waterloo-software.com

Web Gear Services Ltd.
www.webgearservices.com

Wenzel America
www.wenzelamerica.com

Wintriss Controls Group
www.wintriss.com

Yager Gear Enterprise Co. Ltd.
www.yagergear.com

Yash International
www.yashtools.com

Zontec
www.zontec-spc.com

USED MACHINERY

All of the suppliers listed here are broken down by category (auctioneers, used machiner dealers, etc.) at *www.geartechnology.com*.

AX Control, Inc
www.axcontrol.com/

Advico
www.advico.co.uk

Ajax Tocco Magnethermic
www.ajaxtocco.com

Apex Auctions Inc.
www.apexauctions.com

Blackbox Technologies
www.blackboxtech.in

Cincinnati Industrial Auctioneers
www.cia-auction.com

Corporate Assets Inc.
www.corpassets.com

Dixitech CNC
www.dixitechcnc.com

Fairfield Auctions
www.lotsurf.com

Gear Machinery Exchange
www.gearmachineryexchange.com

Gibbs Machinery Company
www.gibbsmachinery.com

GoIndustry DoveBid
www.go-dove.com

Goldstein Gear Machinery LLC
www.goldsteingearmachinery.com

Gray Machinery Company
www.graymachinery.com

Great Lakes Gear Technologies, Inc.
www.greatlakesgeartech.com

Hans-Juergen Geiger Maschinen-Vertrieb GmbH
www.geiger-germany.com

Hilco Industrial
www.hilcoind.com

Koster Industries
kosterindustries.com

MATsolutions
www.matsolutions.com

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Transmission Types in Vehicles

Attempts to eliminate mechanical drive trains in automobiles and trucks have had limited success because of cost, weight, dynamic characteristic, and efficiency of the alternative components.

If the prime mover of an automobile is a combustion engine, the torque and rpm have to be adjusted continuously to the driving condition. Manual transmissions have a high overall efficiency of 94% to 97%, however, the shifting time as well as the fact that the average driver does not assure that the transmission is in the optimal gear reduces the resulting overall transmission efficiency one percent or more.

As a matter of fact, efficiency is not a single number but always a more dimensional characteristic. In the case of automotive transmissions it has become common to identify the efficiency versus input speed and torque. There are many more environmental influences such as temperature and vibrations of surrounding structures. Figure 1 shows the efficiency characteristic of a modern axle drive unit with a hypoid gear pair. The highest efficiency values are achieved in the example (Fig. 1) in the medium- to high-torque and speed range; this characteristic is typical for gear transmissions (Ref. 1).

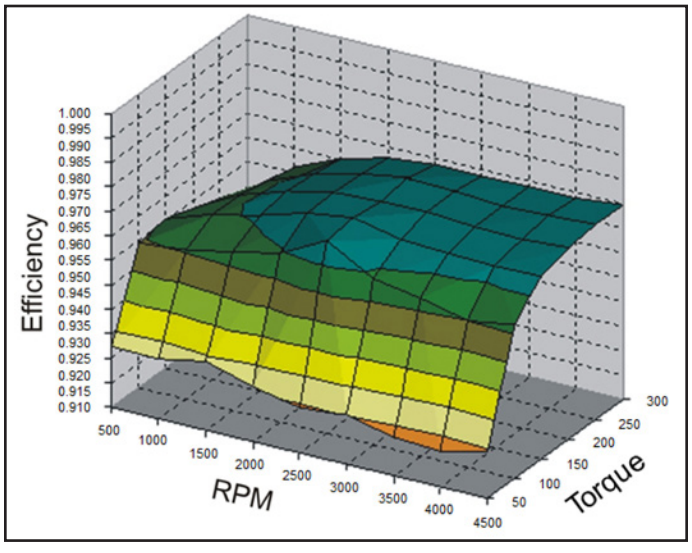

Figure 1 Hypoid efficiency versus input speed and torque.

The efficiency values mentioned in the following discussions apply always to the optimally achieved efficiency of the subject elements.

Another solution to transfer energy to two or four wheels applies individual electric motors in every wheel hub. One possible solution is the use of a combustion engine which is connected to an electrical generator. The electrical energy is transferred to the electric drives of two or four wheels with the possibility of sophisticated and fast reacting traction control.

The following sections discuss drive train and traction efficiency for different engine orientations and different driving axles. The prime mover can be a gasoline or diesel combustion engine as well as a hydrogen engine. The different concepts are combined with electrical generators and electrical motors in order to establish the different basic categories of hybrid systems. The endless possibilities of two electric motors controlling dual clutch transmissions in order to optimize the efficiency between combustion engine and electrical generator or motor in every driving condition are not the subject of this chapter, however the conclusions in this chapter regarding engine orientation and traction concept will apply to all hybrid developments discussed here.

Comparison of different transmissions. The simplified diagrams in Figure 2 — vehicle speed versus engine rpm for a medium drive acceleration from zero to 75 mph — compare mechanical or automatic shift transmissions with 4- and 6-transmission ratios with a constant variable transmission (CVT); the diagram shows engine rpm versus vehicle speed. The areas filled in green imply higher vehicle efficiency; the yellow areas imply lower efficiency. The upper two diagrams

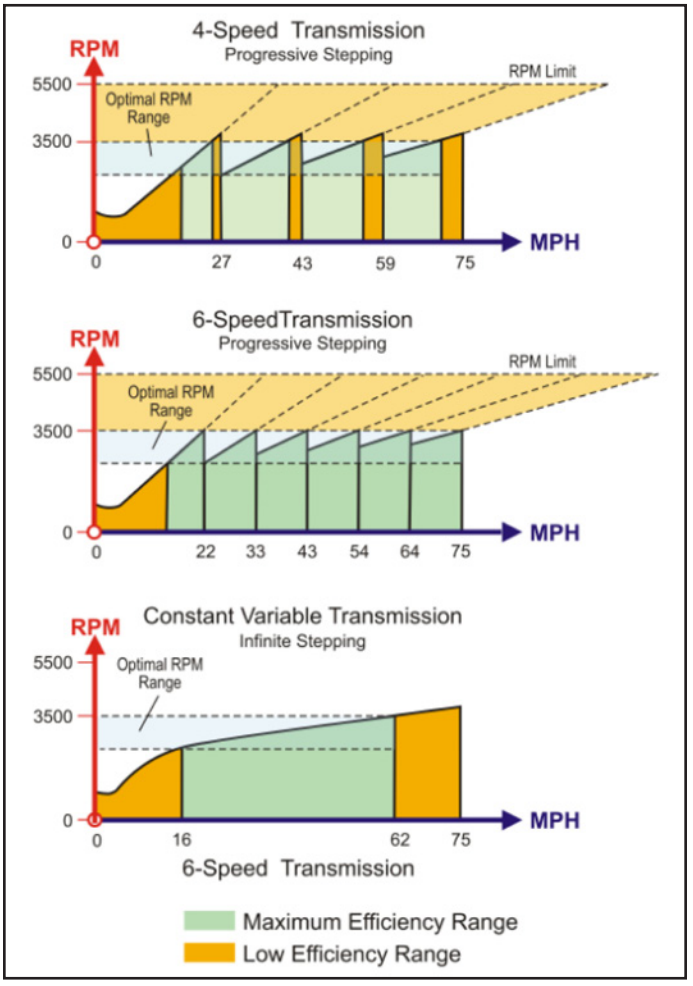

Figure 2 Efficiency ranges of different transmissions.

were developed using a progressive stepping with a decreasing stepping factor between the different gear ratios (as is typical for automotive applications). The four-speed transmission is required to run the engine above the optimal rpm range at the end of each ratio in order to cover the given speed range and minimize the less-efficient yellow areas.

The lower diagram in Figure 2 shows rpm versus vehicle speed for a CVT. The graph has a constant slope beginning at 22 mph. This slope assures that the engine rpm increases during vehicle acceleration, which in turn keeps the constantly required ratio change small. Constantly high ratio changes would result in reduced efficiency due to slippage. A higher-sloped graph would reduce the operating area (green) in the high-efficiency range of the engine; a lower slope increases the required ratio change and reduces the efficiency between 0 and 22 mph.

The diagrams in Figure 2 neglect the energy waste during shifting and clutch actuation, and also assume the driver will always shift at the optimal engine rpm. The strength of modern automatic transmissions is that the optimal shifting point is derived from engine rpm, vehicle speed, load and speed change. Even the shifting execution time and characteristic is constantly optimized, depending on driving conditions. However, the torque converter and the hydraulically or electrically actuated clutches absorb additional energy, which has to be compared to the energy loss due to the shifting and clutch actuation pattern of average drivers in cities, on country roads and on highways.

The result of comparisons show that — regarding efficiency — automatic transmissions with mechanically lockable torque converter, 6 or more speed ratios and sophisticated electronic control unit, will out-perform a mechanical 4-to-6-speed transmission operated by an average driver on highways and country roads.

CVT transmissions should solve the problem of adjusting the engine rpm optimally to the vehicle speed and torque requirement in every driving condition. The control units of CVT-equipped vehicles are programmed to optimize engine rpm and engine torque to the driving speed and driving condition. Besides those advantages, CVT-equipped vehicles present a good basis for the connection of a combustion engine with an electric motor and an electric generator. The input rpm of a CVT is in every driving condition closer to the rpm for engine efficiency and, therefore, also more constant. Lesser rpm variations will result in higher efficiency of electric power units in motor or generator mode.

The argument for more driving fun in case of an engine sound that is synchronized to the gear shifting periods is subjective and relative. An airplane jet engine is considered smooth, powerful and impressive in its sound, yet it goes through similar sound pattern like the engine of a CVT-equipped vehicle.

Most constant variable transmissions today are still based on the principle of two tapered pairs of disks. The pair on the input shaft increases its distance while the pair on the output shaft reduces the distance (or vice versa) in order to keep the length of the transmission element (special-designed chain belt) constantly tight while the ratio changes (Fig. 3), left image (Ref. 2). The high-contact pressure and constant periodic material deformation of disks and belt chain, as well as the angular movements of the chain elements under high tension, lead to additional energy loss and material fatigue

The right image in Figure 3 is a planetary transmission which can be utilized as a power collector from a combustion engine and an electric motor, while the electric motor also changes the ratio between input and output. In the case of a high ratio between electric motor and carrier, it is possible to utilize the electric motor between negative and positive rpms only in order to change the ratio between input and output shaft.

Figure 4 shows a principle based on two slim cones which are oriented against each other with respect to their taper. The cones have a constant clearance gap between them that is used to connect the cones locally with a transmission ring. A very small force, applied slightly off-center and opposite to the contact zone between driving cone, ring, and driven cone, will actuate a longitudinal movement of the ring which causes a step-less change of the transmission ratio. All surfaces are hardened and

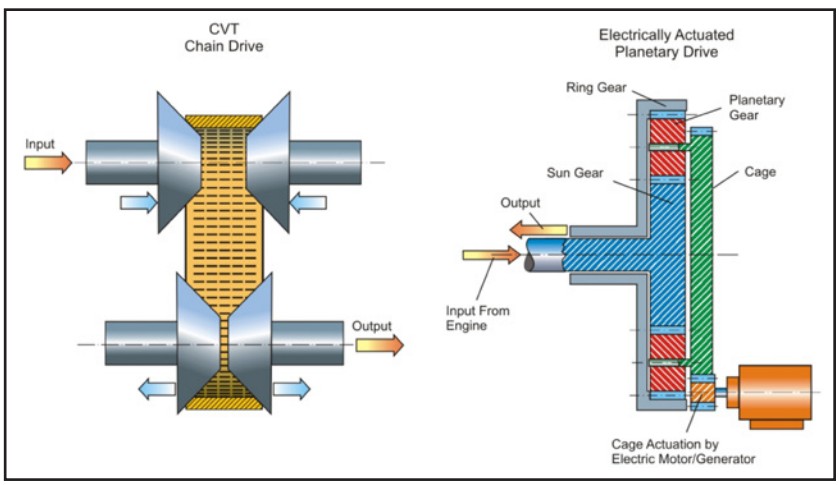

Figure 3 CVT chain drive and planetary split-torque CVT.

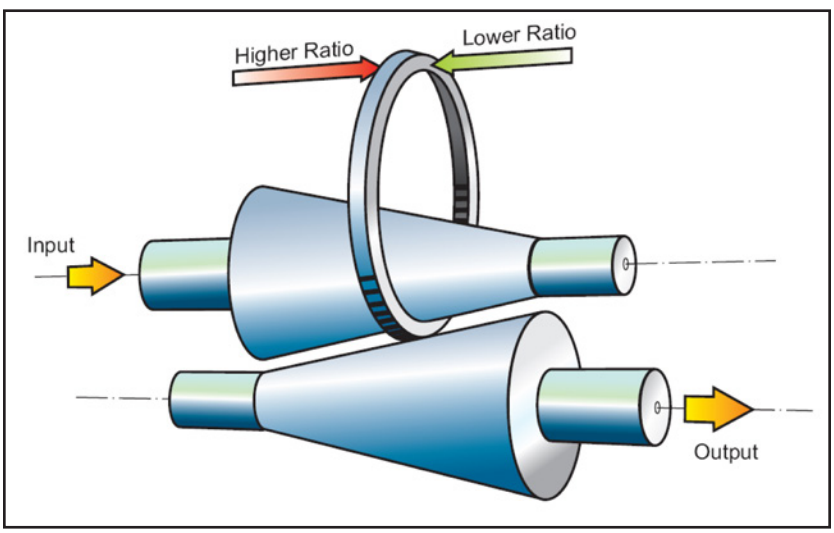

Figure 4 CVT with friction cones.

have a defined surface micro structure. The center distance of the two cones in connection with the radial wall thickness of the transmission ring provides the friction for the required torque transmission.

All friction-based CVT developments work at every constant driving speed on a lower efficiency level than shift or automatic transmissions using involute gear tooth contact as transmission elements. The advantages of CVTs can off-set the efficiency loss due to friction (versus involute gear transmission) in certain driving conditions. However, particularly hybrid vehicle concepts which benefit from the CVT transmission ratio change, depend on the highest possible efficiency of all transmission elements, which is not optimally given for transmissions with a friction-based ratio adjustment.

Electrical wheel hub motors. A combustion engine is connected by a clutch with an electrical generator; Figure 5 shows a principal sketch of such a concept. A second, smaller electrical generator/motor is permanently connected with the engine and functions as a starter motor, as well as a generator in engine operating conditions which turned out to reduce the performance of the large main generator. Four pancake-shaped wheel hub units act as electric motors to supply torque and speed directly to the wheels (Ref. 3). The same units can act as generators in coast and brake conditions in order to regenerate electrical energy from the kinetic energy of the vehicle in order to recharge the battery. In spite of the simplified sketch in Figure 4, the wheel hub units are integrated into the inside of the rim which brings the obstacle of elevated temperatures of up to 300°F being transferred into the rims and tires. This system still cannot completely eliminate a friction brake for critical deceleration maneuvers.

The result is a reduction of available space in the center of the wheels and a high, un-sprung mass. High masses rigidly connected to the wheels reduce the quality of the vehicle dynamics and lower the safety of a vehicle similar to beam style rear axles. They also constantly require additional energy to "bounce" this weight up and down in order to connect the vehicle with the road and compensate for imperfections in the pavement. High un-sprung masses require considerable amounts of energy for the up and down acceleration, which is converted into heat in the tires, the springs and the shock absorbers.

However, not only is the complexity of such a system very high which results in high manufacturing costs of those vehicles, but the overall efficiency is rather low. The total system efficiency is calculated as the product of single efficiencies of units connected in line:

- Combustion engine (38%)
- Electrical generator (82%)
- Electronic power control units (85%)
- Wheel hub drive units (82%)
- Storage, transmission and transformation of electrical power (92%)
- Un-sprung mass (98%)
- Traction factor, wheel-road (96%)
- Efficiency improvement due to hybrid function (X)

$$\eta_{total} = 0.38 \cdot 0.82 \cdot 0.85 \cdot 0.82 \cdot 0.92 \cdot 0.98 \cdot 0.96 \cdot X = 0.188X$$

The efficiency numbers above and in the following sections are of course only rough approximations. However, in the comparison of the different drive concepts, the same numbers are used consistently, which makes the result of the comparison relatively objective. The total reflects only the energy loss between engine and tires — including the traction efficiency. Air resistance, gravity, inertia and centrifugal force influences which depend on the vehicle's body design and weight are not considered in the main body of this chapter and only mentioned briefly in the conclusion in order to allow a comprehensive recommendation for a future-oriented vehicle design. Lost energy due to braking and coasting is also not part of the total efficiency calculation, but is considered to some extent in the hybrid factor X,which is above 1.0 and reflects the regeneration of some, otherwise lost energy.

The system in Figure 5 includes all elements of a hybrid system. The overall efficiency of a hybrid system according to Figure 5 will not have an improved total efficiency, although regenerative energy from the wheel hub generators (motors) can be recycled through the battery. The constant conversion between mechanical energy and electrical energy, the storage of electrical energy, and the low efficiency of the individual wheel hub motor/generator units, take away some of the big advantages a hybrid vehicle concept has. The function that makes hybrid vehicles attractive regarding fuel consumption is the regeneration, storage and re-use of energy which is converted from kinetic energy into heat during brake action and coast driving conditions in conventional vehicles. Successful regeneration, storage and re-use of energy require a high efficiency in all components, as well as a high efficiency in the overall concept.

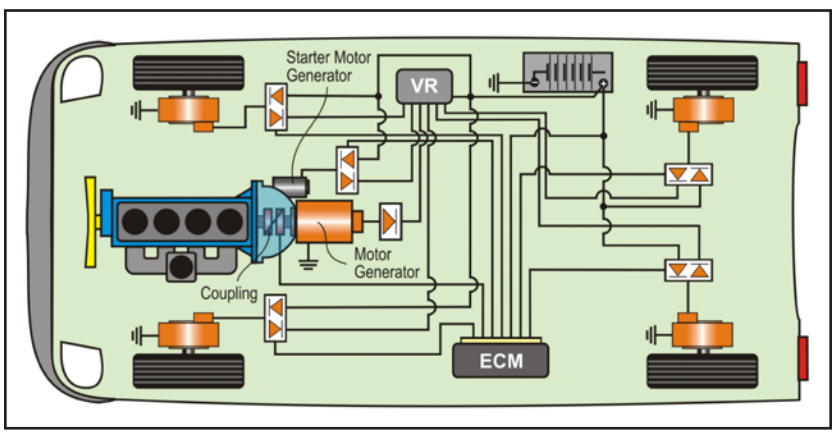

Figure 5 Individual 4-wheel-hub electrical drives,

Front-wheel drive, conventional & hybrid. The comparison of the efficiency of front-wheel-driven versus rear-wheel-drive vehicles delivers an unexpected result for many vehicle owners. Front-wheel drive vehicles with so called "East-West"-oriented engines use a helical gear set behind the shift or automatic transmission as final drive reduction with a speed reduction of about three.

The two output shafts of front-wheel-drive transmissions are connected to a first constant velocity joint (CV-joint), a drive shaft and a second CV-joint. The first CV- joints are specified to compensate the up and down movements of the front end of the vehicle. The second CV-joints are specified to allow for steering action of the front

wheels and in addition also to compensate the up and down movements of the front end (Fig. 6).

One disadvantage of such a system is the concentration of the entire drive train together with the prime mover in a tight space. The second disadvantage is an unfavorable center of gravity of front-wheel-drive vehicles, which have a driving dynamic that is not optimal and gives the driver less control over the vehicle in dangerous situations, compared to rear-wheel-drive or all-wheel-drive vehicles.

Beyond all this, there is a considerable energy loss in the second CV-joints due to the steering action. Even driving around slight highway bends reduces the efficiency below the level of rear wheel drive vehicles.

There is only one condition where front wheel drive has a concrete advantage over rear wheel drive. It is the instance to get a vehicle to move after a full stop on snow or ice. Even sophisticated traction control systems cannot eliminate this shortcoming of rear wheel drive vehicles which has its cause in the low weight above the rear axle. However, an additional weight of 35 to 50kg (77 to 110 lbs) in the trunk of a rear wheel drive car will eliminate the traction deficit which occurs in particular in the winter time.

The overall efficiency of a front wheel drive vehicle consists of the following single efficiency of engine and drive train components:

- Combustion engine (38%)
- Transmission (94%)
- Final front drive (98%)
- Inner CV joints (99%)
- Outer CV joints (steering, 95%)
- Traction factor, wheel-road (93%)
- Efficiency improvement due to hybrid function (X)

$$\eta_{total} = 0.38 \cdot 0.94 \cdot 0.98 \cdot 0.99 \cdot 0.95 \cdot 0.93 \cdot X = 0.306X$$

One possible version of a front wheel drive hybrid, shown in Figure 6 uses a central electric motor/generator which is connected to a transmission and a combustion engine. The combustion engine and electric motor share the required power to drive the vehicle in cases of acceleration. In driving conditions of deceleration or downhill driving, the electrical unit acts as a generator and charges the battery. The transmission in most of today's front wheel drive hybrids works with constant variable ratio (CVT). This concept definitely accomplishes higher efficiency than conventional front wheel driven cars, however, the weight concentration on the front axle is even higher and the energy loss in the outer CV joints caused by the higher steering forces does not present the optimal solution regarding efficiency, traction, handling and safety.

A solution of a four-wheel-driven vehicle is shown (Fig. 7). The concept is based on the front-wheel-drive hybrid concept shown in Figure 6. It uses one central electric motor in the rear, which uses a cylindrical gear or chain reduction in order to rotate the drive shafts. The rear axle motor can also act as generator in cases of vehicle deceleration. The engine connected generator charges a battery to provide enough electrical energy to feed the rear axle motor. The transmission allows for a disconnection of the engine and the front axle, while the electric motor is still mechanically connected with the front axle and can act as a generator in cases of deceleration.

A common concept today is a four-wheel-drive vehicle with an "east-west" engine and a power take off unit (PTU) that drives a propeller shaft and a rear axle. Figure 8 shows the basic drive train arrangement of such a four-wheel-drive vehicle, derived from the most common front-wheel-drive concept. The power split between front and rear axle is commonly 60% (front) and 40% (rear). A power take off unit is mounted (mostly as an add-on) to the side with the longer drive shaft. All the power

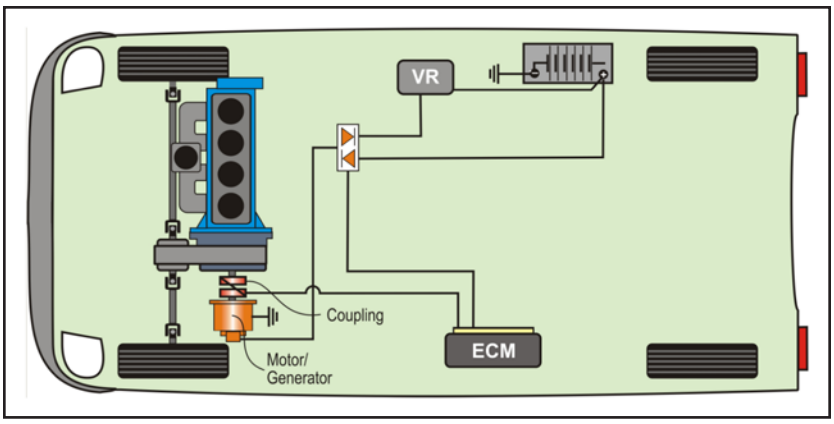

Figure 6 Front-wheel-drive hybrid vehicle scheme.

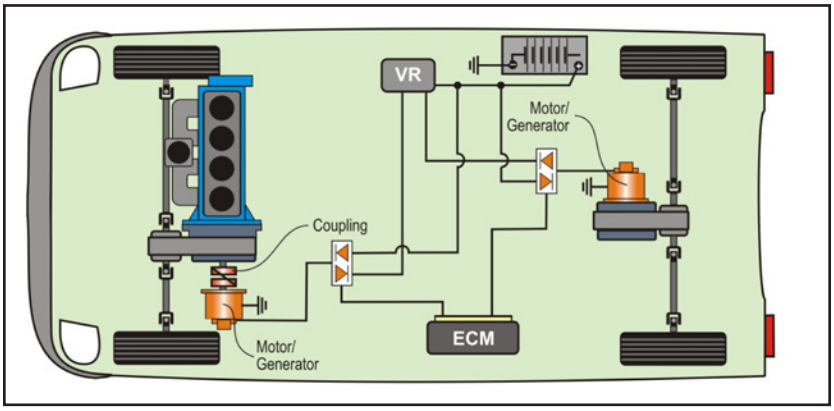

Figure 7 Four-wheel-drive hybrid vehicle, derived from front wheel drive.

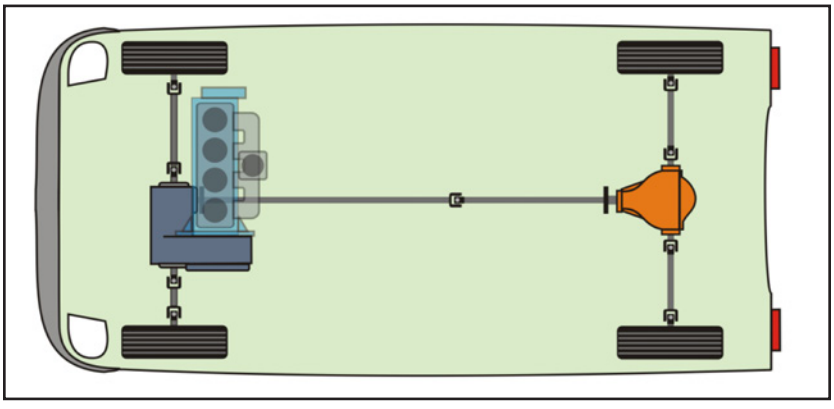

Figure 8 Four-wheel-drive, derived from front wheel drive.

passes through the transmission — including the final drive gears — before a part is split off by the PTU and redirected by 90°.

The PTU is also a speed increaser, where the ring gear drives the pinion. This is commonly done in order to keep the torque in the propeller shaft lower than required on the drive shafts. The rear axle reduces the speed by the same factor that the PTU had used for increasing the speed. This is done in order to achieve the correct torque and rpm for the rear drive shafts. The procedure of speed increase in gear trains is less efficient than speed reduction. The following efficiency calculation considers this fact, but it only applies this to 40% of the vehicle's energy consumption.

The approximate efficiency of such a system is:

- Combustion engine (38%)
- Transmission (94%)
- Final front and PTU drive, (98%)
- Front and rear, Inner CV joints (99%)
- Front outer CV joints (steering, 95%)
- Rear, outer CV joints (40% power, 99.6%)
- PTU (gear drives pinion, 40% energy, 96.5%)
- Hardy disks (40% power, 99.4%)
- Universal joint (40% power, 99.6%)
- Rear axle, 40% power (98%)
- Traction factor, wheel-road (96%)
- Efficiency improvement due to hybrid function (X)

$$\eta_{total} = 0.38 \cdot 0.94 \cdot 0.98 \cdot 0.99 \cdot 0.95 \cdot 0.996 \cdot 0.965 \cdot 0.994 \cdot 0.996 \cdot 0.98 \cdot 0.96$$
$$\eta_{total} = 0.295$$

Rear-wheel-drive — conventional and hybrid. Modern rear-wheel-drive technology is becoming more popular. Premium class compact cars, sedans, and luxury vehicles benefit from rear-wheel-drive because of the optimal weight distribution with a center of gravity behind the front axle. This allows those vehicles safe maneuvering in critical driving conditions. The advantage of excellent control and high safety are combined with high fuel economy of rear-wheel-drive vehicles.

The overall efficiency of the system shown (Fig. 9), besides the factor X, which is not applicable, is the highest of all the different solutions discussed:

- Combustion engine (38%) Transmission (94.5%)
- Hardy disks (98.8%)
- Universal joint (99%)
- Rear axle (97.5%)
- Inner CV joints (99%)
- Outer CV joints (99%)
- Traction factor, wheel-road (95%)

$$\eta_{total} = 0.38 \cdot 0.945 \cdot 0.988 \cdot 0.99 \cdot 0.975 \cdot 0.99 \cdot 0.99 \cdot 0.95 = 0.319$$

The vehicle manufacturing cost, related to the drive train components, is comparable to front-wheel-drive vehicles. Serviceability of the system (Fig. 9) is better and the service and repair statistics show that the drive train from the transmission to the rear wheels causes little or no issues during the life of a vehicle. This is quite different in front-wheel-drive vehicles.

Fuel economy is based not only on engine and drive train efficiency, but also on traction and slippage of the wheels that transmit the driving force to the road. The driving force F (Fig. 10) is always present, except in the case of coasting without any engine brake action. F multiplied with the height of the center of gravity causes a moment, clockwise about the center of gravity G, which in turn gives an additional normal force to the rear axle and takes away normal force from the front axle. This means, in the presence of a driving force, the traction will be enhanced in the case of rear-wheel-drive and reduced in the case of a front-wheel-drive.

Front-wheel-drive vehicles have very high front tire wear because the main brake load, steering forces and driving force act on the same two wheels. The driving force applied to the rear wheels will distribute the different forces better between the four wheels and, as explained before,

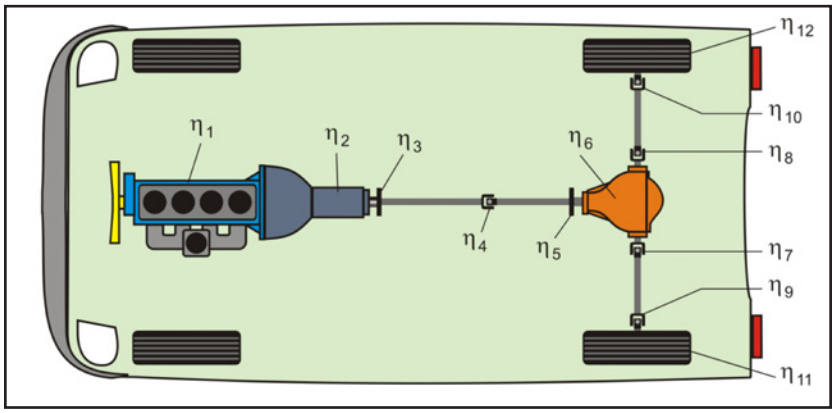

Figure 9 Modern rear-wheel-drive concept.

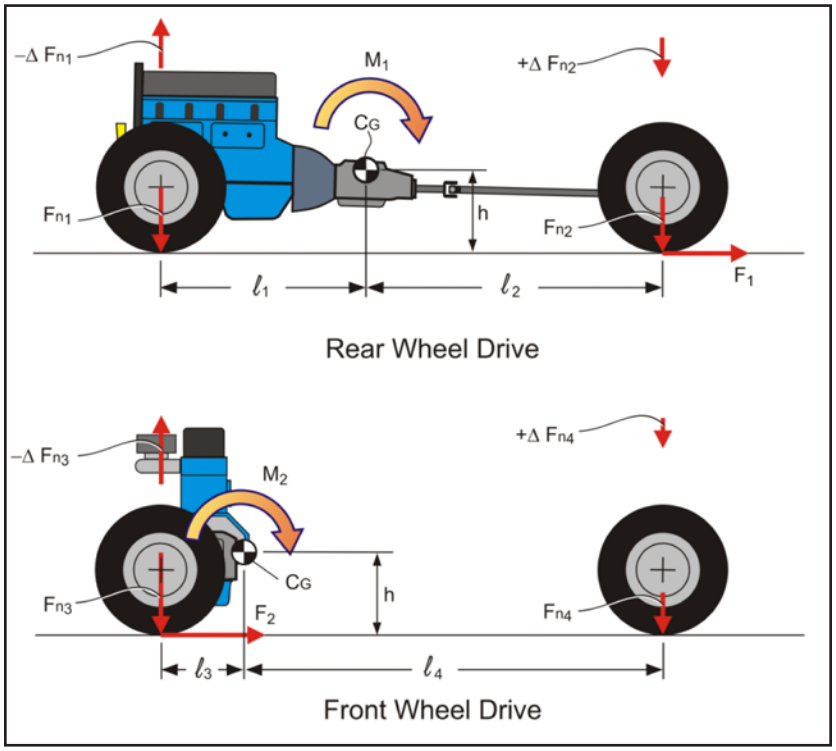

Figure 10 Center of gravity and force diagram for longitudinal and "east-west" engine orientation.

enhance the traction which is expressed as efficiency factor between tires and road. In this chapter, the traction efficiency factors used in connection to the different concepts are:

- Front-wheel-drive: $\eta_{traction} = 93\%$
- Rear-wheel-drive: $\eta_{traction} = 95\%$
- Four-wheel-drive: $\eta_{traction} = 96\%$

The concept in Figure 11 uses a longitudinally oriented engine which is connected via transmission and clutch with an electric generator. The generator is connected with the propeller shaft and charges electrical energy to the battery. In cases of downhill driving or deceleration the generator receives mechanical energy through the propeller shaft from the rear axle. The generator acts as an electrical motor in cases of acceleration and shares the required power to drive the vehicle with the combustion engine.

The overall efficiency of the rear-wheel-driven hybrid vehicle consists of the following single efficiency of engine and drive train components:

- Combustion engine (38%)
- Transmission (94.5%)
- Hardy disks (98.8%)
- Universal joint (99%)
- Rear axle (97.5%)
- Inner CV joints (99%)
- Outer CV joints (99%)
- Traction factor, wheel-road (95%)
- Efficiency improvement due to hybrid function (X)

$$\eta_{total} = 0.38 \cdot 0.945 \cdot 0.988 \cdot 0.99 \cdot 0.975 \cdot 0.99 \cdot 0.99 \cdot 0.95 \cdot X = 0.319X$$

The four-wheel-drive concept (Fig. 12) has, in addition to the rear-wheel-drive concept in Figure 11, a transfer case with a propeller shaft which is connected to a front axle unit. The common split of power is 40% to the front and 60% to the rear. The hybrid function is identical to the rear-wheel-drive version.

The overall efficiency of the four-wheel-driven hybrid vehicle consists of the following single efficiency of engine and drive train components:

- Combustion engine (38%)
- Transmission (94.5%)
- Rear&front, inner CV joints (99%)
- Front, outer CV joints, 40% energy split (steering, 97.5%)
- Rear propeller shaft hardy disks, 60% rear energy split (99.1%)
- Rear propeller shaft universal joint, 60% rear energy split (99.4%)
- Two front propeller shaft universal joints, 40% energy split (99.2%)
- Rear&front axle (96%)
- Rear, outer CV joints, 60% rear energy split (99.4%)
- Traction factor, wheel-road (96%)
- Efficiency improvement due to hybrid function (X)

$$\eta_{total} = 0.38 \cdot 0.945 \cdot 0.99 \cdot 0.975 \cdot 0.991 \cdot 0.994 \cdot 0.992 \cdot 0.96 \cdot 0.994 \cdot 0.96 \cdot X$$
$$\eta_{total} = 0.310X$$

Modern four-wheel-drive systems with torque vectoring achieve improved efficiency due to the reduction of mechanical energy loss, but also deliver breathtaking traction and cornering abilities (Ref. 4).

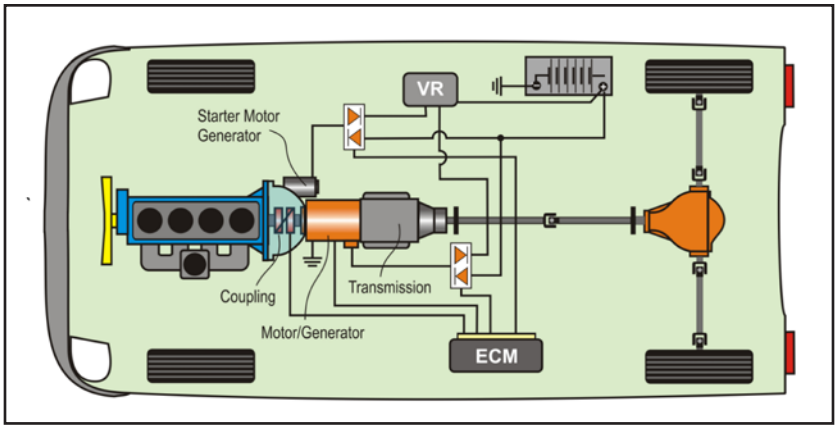

Figure 11 Rear-wheel-drive hybrid concept.

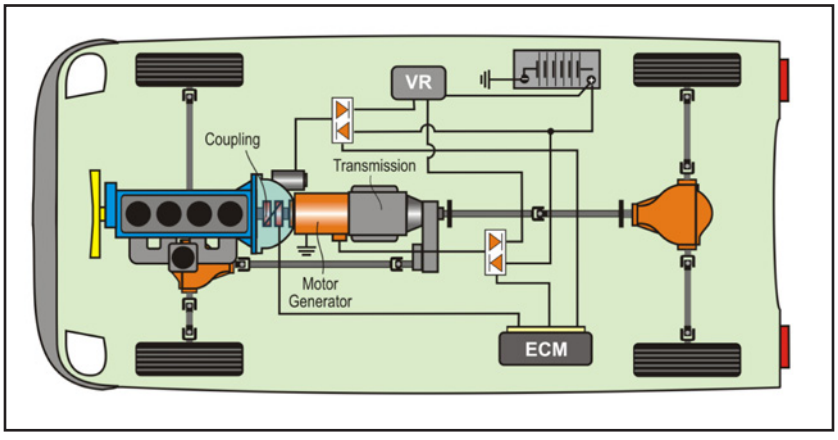

Figure 12 Four-wheel-drive hybrid concept, derived from rear wheel drive.

Conclusion

The comparison of all basic drive concepts and approximate total efficiencies lead to the following efficiency ranking:

1. Rear-wheel-drive: $\eta_{total} = 31.9\%$ (+4.2%)
2. Four-wheel-drive with longitudinal engine: $\eta_{total} = 31.0\%$ (+1.3%)
3. Front-wheel-drive with "east-west" engine: $\eta_{total} = 30.6\%$ (reference 100%)
4. Four-wheel-drive with "east-west" engine: $\eta_{total} = 29.5\%$ (–3.6%)
5. Four-wheel-drive with electrical wheel hub motors: $\eta_{total} = 18.8\%$ (–38.6%)

The comparison shows that if No. 3 (the common concept for today's compact cars) is used as a reference basis (equalized to 100%), then a rear-wheel-drive vehicle with the same body style and weight will achieve 4.2% higher efficiency. Beyond this, the rear-wheel-drive vehicle will require lesser maintenance in the drive train and has a lower tire wear. An interesting aspect of the comparison is also the fact that the most economical four-wheel-drive has a longitudinal engine and even out performs a front-wheel-drive only vehicle with similar body style and same weight.

Rear-wheel-drive vehicles are perfectly suitable as compact and small cars. The classic compact vehicle shown (Fig. 13) is vintage 1966, and is still on the road today. It still has a rather low average fuel consumption of 6.76 liter/100 km (35miles/gallon), while it was mostly used for country side driving. The vehicle in Figure 13 has a curb weight of 780 kg (1,700 lbs) and is driven by a beam style rear axle. A similar vehicle with today's technology (efficiency improved combustion engine, modern 5- or 6-speed transmission and a modern, independent rear axle with traction control) would most likely achieve 6.0 to 5.3 liter/100km (40 to 45miles/gallon), even without hybrid technology.

Figure 13 Opel Kadett B, RWD, built in 1966.

A rear-wheel-drive passenger car has a good weight balance and shows better control in steering action and dynamic driving situations than comparable front-wheel-driven cars. Inefficient beam rear-axle technology and the easy assembly package of front-wheel-propelled cars led automobile manufacturers to pick the front-wheel-drive as their concept of choice for sedans of all sizes. This trend started in the 1980s and continues today. However, for about 5 years we have seen a trend to rear-wheel-driven mid-size sedans with longitudinally oriented engines and the four-wheel-drive derivatives thereof.

Figure 14 Modern RWD vehicles, BMW 1-series (top) and Dodge Charger (bottom).

Some manufacturers picked the rear-wheel-drive concept — even for their latest compact editions — and demonstrated that the "driving pleasure" and the feeling of safety in their small cars are outstanding. Figure 14 shows a compact and a midsize vehicle with rear-wheel-drive and a dominating sporty image. However, BMW demonstrated with their introduction of a 1-Series makeover in spring 2007 that the rear-wheel-drive concept is a very good basis for not only sporty, but also for very economical small vehicles. This vehicle has been called "mild hybrid" in *www.hybridcars.com* (Ref. 6). The report highlights features such as variable valve timing; electric power steering; lightweight materials; low- resistance tires; gearshift change indicator; and, most notably, an auto stop function with regenerative braking. The vehicle promises outstanding handling and excellent fuel economy between 6.0 and 5.0 liter/100 km (40 to 33miles/gallon) during highway and country side driving. At the same time, the fact that the 1-Series requires neither an additional electric motor nor a considerable capacity of batteries is an advantage to both the "total cost of ownership" and also the environment.

For more information.

Questions or comments regarding this paper?
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For 35 years, Dr. Stadtfeld has had a remarkable career within the field of bevel gear technology. Having received his Ph.D. with summa cum laude in 1987 at the Technical University in Aachen, Germany, he became the Head of Development&Engineering at Oerlikon-Bührle in Switzerland. He held a professor position at the Rochester Institute of Technology in Rochester, New York From 1992 to 1994. In 2000 as Vice President R&D he received in the name of The Gleason Works two Automotive Pace Awards—one for his high-speed dry cutting development and one for the successful development and implementation of the Universal Motion Concept (UMC). The UMC brought the conventional bevel gear geometry and its physical properties to a new level. In 2015, the Rochester Intellectual property Law Association elected Dr. Stadtfeld the "Distinguished Inventor of the Year." Between 2015–2016 CNN featured him as "Tech Hero" on a Website dedicated to technical innovators for his accomplishments regarding environmentally friendly gear manufacturing and technical advancements in gear efficiency.

Stadtfeld continues, along with his senior management position at Gleason Corporation, to mentor and advise graduate level Gleason employees, and he supervises Gleason-sponsored Master Thesis programs as professor of the Technical University of Ilmenau—thus helping to shape and ensure the future of gear technology.

Asymmetric Cylindrical Gears

Dr. Paul Langlois and Baydu Al

Introduction

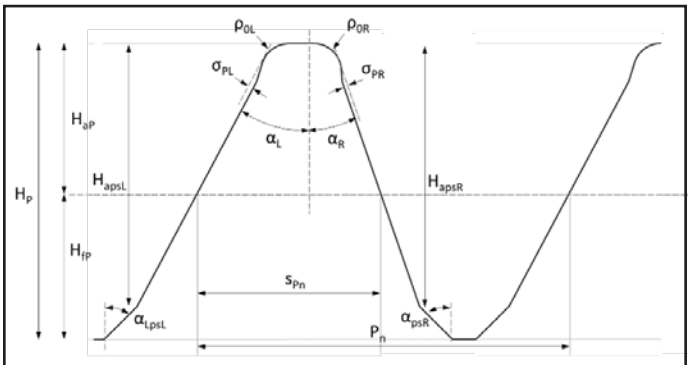
In typical applications the two flanks of a given cylindrical gear have different operating conditions with, for example, different loads and different periods of operation. This is the case for automotive gear trains where the operation is mostly unidirectional with the primary drive flanks operating for a much greater time and under greater load than the coast flanks. Asymmetric cylindrical gears using a different pressure angle on each flank can be designed to improve the performance on the drive flank at the expense of the coast. Asymmetric gears have been used for many years — especially in high-cost, low-volume applications such as wind and aerospace. Significant application and interest for asymmetric gears is now being shown within the automotive industry. With this increasing interest comes an increasing need for methods and tools to assess the relative merits of asymmetric gears, as compared to symmetric gears, and assess the impact of changes in asymmetric gear geometry. The standard rating methods for symmetric cylindrical gears are not directly applicable to asymmetric gears. In this paper we present a loaded tooth contact analysis (LTCA) method for asymmetric gears that provides an accurate and efficient design tool for analyzing and comparing designs. The presented method is implemented in SMT's *MASTA* software. We further present an example comparative study using this tool for an example automotive application.

Asymmetric Gear Geometry and Rating

Drive-side geometry. Asymmetric cylindrical gears are involute cylindrical gears with asymmetric flank profiles. In particular, the usual approach is to increase the operating pressure angle on the drive flank beyond the traditional limits of symmetric gears by using a lower pressure angle on the coast flank to maintain sufficient tip thickness. Such a design can lead to benefits that include an increased transverse contact ratio on the drive-side, leading to lower sliding and, therefore, less scuffing risk and higher efficiency. The increased pressure angle on the drive flank results in a smaller base radius, which gives a higher normal load for a given torque. However, it also leads to a larger radius of curvature at contact, potentially leading to lower contact stresses. Decreased bending stresses can also result due to a decreased bending moment on the gear tooth. Higher strength on the drive-side can lead to more compact, lower weight designs.

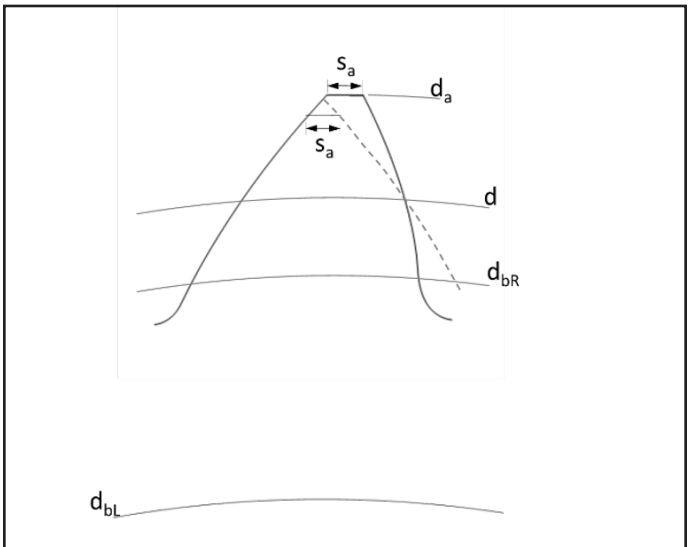
Coast-side geometry. With an increased pressure angle on the drive-side, a decreased pressure angle on the coast-side is required to maintain tip thickness. This decreased pressure angle often leads to NVH benefits for the drive-side with the increased tooth compliance. One of the biggest challenges when designing asymmetric gears for applications where operation on both flanks does occur is to limit the decrease in performance on the coast-side. In an automotive application, for example, particular attention should be paid to NVH performance in coasting conditions.

It is worth noting that for idler gears, operating on both flanks in the same operating conditions, there may be additional benefits with asymmetric gears. In a planetary system the planet gears operate on both flanks. Typically, the sun to planet mesh fails before the planet to annulus. Using a higher pressure angle on the sun-side and lower on the annulus, the lives between the meshes can be balanced.



Single Value	Defined per Flank
Normal Module	Pressure Angle
Helix Angle	Edge Radius and Protuberance
Addendum and Dedendum	Chamfer Definition

Figure 1 Asymmetric rack geometry.



Single Value	Defined per Flank
Reference Diameter	Base Diameter
Tip and Root Diameters	Tip and Root Form Diameters
	Finish Stock

Figure 2 Asymmetric gear geometry.

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Figure 1 shows the major geometry parameters for an asymmetric rack cutter, while Figure 2 shows the geometry parameters for an asymmetric gear. There are single normal module, helix angle and tip and root diameters. However, there is asymmetry in pressure angle, root geometry and chamfer geometry.

Rating. The existing cylindrical gear rating standards for the major gear failure modes of, e.g. — pitting and bending in ISO 6336 (Ref. 1) — are not directly applicable to asymmetric gears. Some authors have applied the methods of these standards with modifications (Refs. 2–5). Kapelevich, for example, has developed a rating method that utilizes the existing standards and equivalent symmetric tooth gears, with conversion factors based on FE analysis. Kapelevich has reported good results for the method, although it is not entirely satisfactory from a physical perspective, as it does not directly model the actual situation. Langheinrich (Ref. 4), on the other hand, developed an approach by modifying the equations of DIN 3990/ISO 6336. Sekar and Muthuverappan (Ref. 5) adapted the form and stress correction factors of ISO 6336 Method B for spur asymmetric gears.

In this paper we present an approach to the analysis of asymmetric gears based on a high-fidelity hybrid Hertzian and FE-based specialized gear loaded tooth contact analysis; this analysis method is described in the next section.

Loaded tooth Contact Analysis

For the assessment of asymmetric gear tooth contact conditions, including load distribution, transmission error and root and contact stresses, a hybrid Hertzian and FE based loaded tooth contact analysis method was developed based on the model presented in Langlois et. al (Ref. 6) for symmetric gears.

Hybrid hertzian and FE-based LTCA model. The developed model is a specialized gear-loaded tooth contact analysis model. The analysis is quasi-static, performed at n discrete time steps. At each time step, first the potential contact points on the gear teeth flanks in mesh are calculated. The assumption is made that deflections of the system are sufficiently small that the potential contact points and normals do not move from their theoretical no-load locations. Applied loads can bring those points into and out of contact. However, do not move those points locations. These potential contact points are calculated from the cylindrical gear theoretical contact lines under no misalignment and no micro geometry. In addition to these "nominal" potential contact points, a set of additional potential contact points are included at the tips of the gear teeth that are points which can potentially come into contact early, prematurely, due to deflections under load (Ref. 6).

Compatibility and force equilibrium conditions are set up between the sets of potential contact points.

$$U_{k1}+U_{k2}+\varepsilon_k-\alpha \geq 0$$

Where:

1, 2 Label the pinion and wheel, respectively

U_{ki} Is the elastic deformation of gear i at point k

ε_k Is the initial separation at point k

α Is the rigid body approach

$$\Sigma_k F_k = F$$

Where:

F_k Is the normal force at strip k

F Is the total applied normal force due to the applied torque

The first equation enforces that there is no penetration between the contacting points. The second enforces that the sum of calculated forces is consistent with the applied torque input.

The elastic deformations U_{ki} are a function of the forces, and so these equations must be solved iteratively for α, which is related to the transmission error, and F_k. For the calculation of the elastic deformations, the stiffness contributions are separated into two parts. For the bulk bending stiffness of the teeth and base rotation of the teeth on the gear body, an automatically generated FE model of the gear macro geometry is used. This model is easily adaptable from symmetric to asymmetric cylindrical gears simply by using the asymmetric gear geometry for this FE model. For the contact stiffness local to the contact points, the formalism of Weber (Ref. 7) is used.

Once the load distribution across the flanks has been calculated, the contact pressures are calculated as a post-calculation with a Hertzian cylinder on cylinder formalism with the radius of curvatures given by the roll distance of the contact points. Root stresses are post-calculated by applying the calculated load distribution back on to the FE model and reading the stresses in the root area of the FE model directly.

Due to this separation between the local contact stiffness and the bulk tooth bending and base rotation stiffness, the FE model required for the calculation can have a coarse mesh. The FE mesh is not being used to solve the Herztian contact, as this is solved by Weber's formalism. In contrast, to perform gear-loaded tooth contact analysis in a general FE package, a very fine mesh is required at the contact points in order to capture the local Hertzian contact deformations. As a result, the specialized gear contact model takes the order of seconds to run a load condition, while a general FE package takes orders of magnitude longer. The method therefore leads to a viable design tool where multiple loads, design parameter changes and tolerance studies can be run within the design process.

Validation of the model.The specialized gear LTCA method for asymmetric gears described in the previous section was validated against a surface-to-surface contact analysis model in the general finite element software *ANSYS*. Code was written to set up the finite element model and analysis using the *ANSYS parametric design language* (*APDL*). The node positions in the FE model were defined directly from an analytical description of the geometry, including modifications to these positions for micro geometry modifications; no CAD model was used. Figure 3 shows a schematic of the *ANSYS* model set-up including the applied boundary conditions. The geometry parameters for one

Table 1 Asymmetric gear pair validation example geometry		
	Pinion	**Wheel**
Number of Teeth	27	41
Face Width (mm)	30	28
Normal Module (mm)	3	
Helix Angle (°)	0	
Centre Distance (mm)	102	
Tip Diameter (mm)	87.09	128.935
Root Diameter (mm)	74.393	116.23
Cutter Edge Radius (mm)	0.75	0.75
	Drive	**Coast**
Pressure Angle (°)	38	19
Contact Ratio	1.2578	1.7233

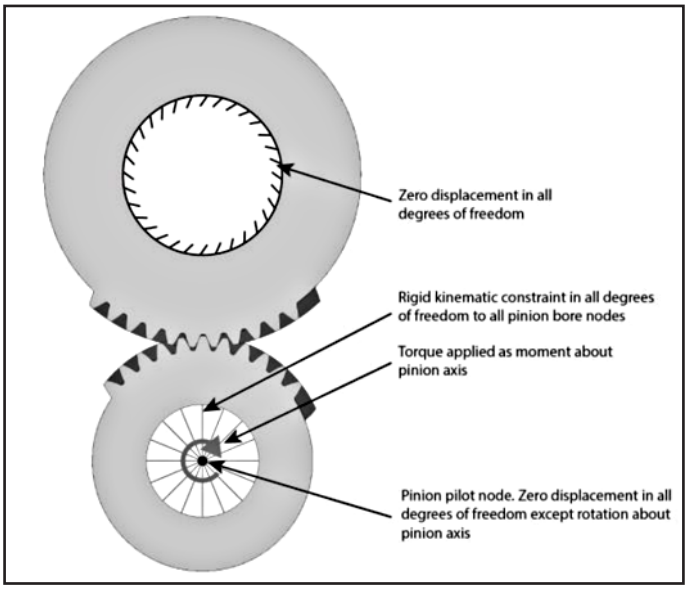

Figure 3 Schematic diagram showing the displacement and force boundary conditions applied to the FE model.

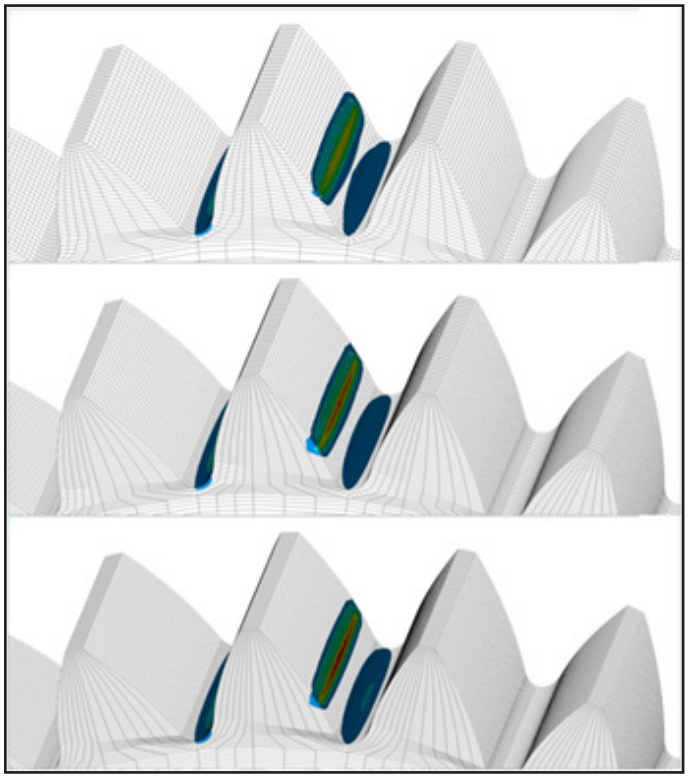

Figure 4 *ANSYS* meshes; from top to bottom — mesh 1, mesh 2, mesh 3.

of the examples used for validation is given in Table 1. This particular validation example is not an automotive example. It was chosen as it has an extreme asymmetric geometry with 38 and 19 degree pressure angles on drive- and coast-flanks, respectively, and was introduced by Kapalevich (Ref. 2). 15 µm of lead crowning and 13 µm of parabolic profile crowning were applied to the pinion; the gears are steel.

To check the accuracy of the FE model results a mesh convergence study was performed. Figure 4 shows the levels of meshes used in order to achieve convergence.

Figure 5 shows the result of one such convergence study, together with the corresponding results of the authors' model. TE is shown for the torque value for which the results were seen to be most sensitive to the FE mesh size. In this example Mesh 1 is seen to give a good prediction of mean and peak-peak TE, compared to the other meshes; however, the TE trace is not 100% smooth. Mesh 2 is seen to be smooth and gives almost identical results to Mesh 3. Similar results were seen at all loads considered — from 100 Nm–1000 Nm. A similar convergence study was performed for the results of the authors' specialized LTCA model. Excellent correlation is seen between the authors' model and *ANSYS*.

Figure 6 shows peak-peak transmission error against load, and Figure 7 shows mean transmission error against load for the authors' model and the full *ANSYS* analysis.

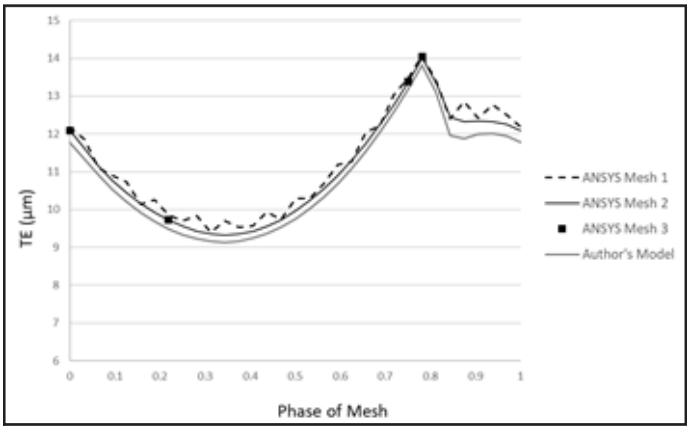

Figure 5 *ANSYS* convergence study at 100 Nm torque on drive flank; transmission error (µm).

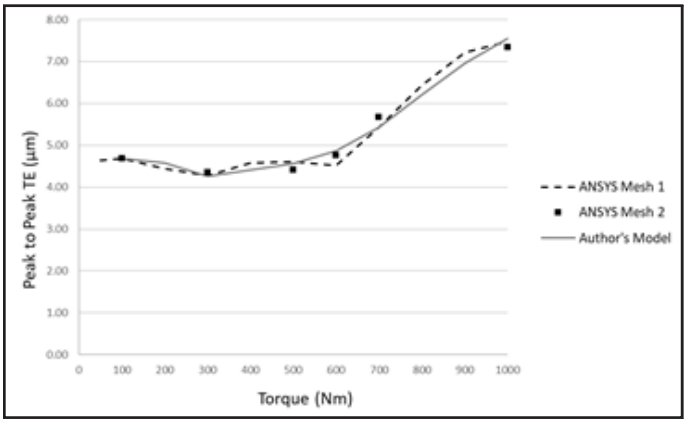

Figure 6 Comparison of authors' model and *ANSYS*; peak-peak transmission error (µm) against load.

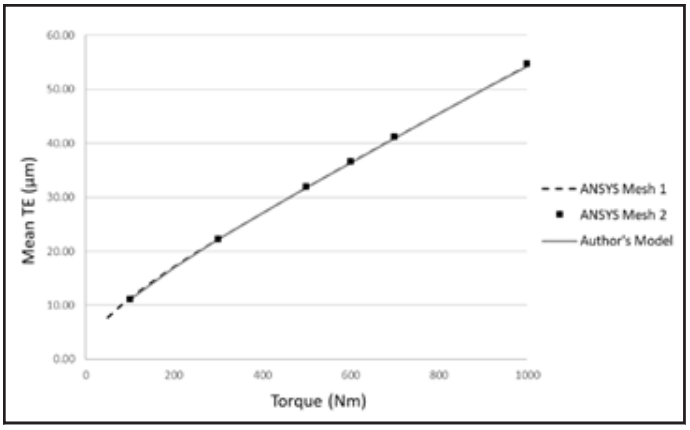

Figure 7 Comparison of authors' model and *ANSYS*; mean transmission error (µm) against load.

Figure 8 shows the results for the maximum principal root stress, in tension, for the pinion.

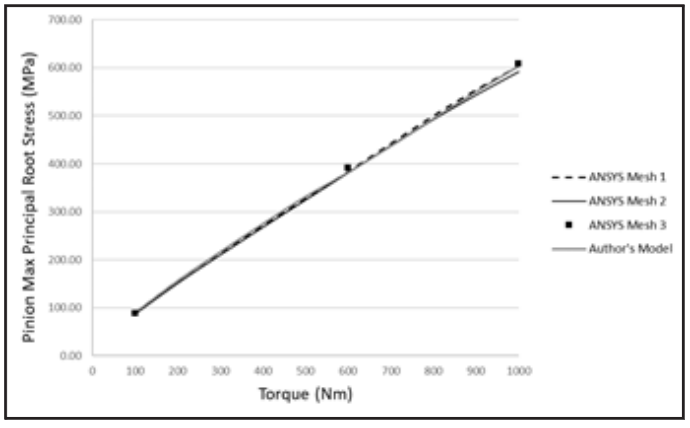

Figure 8 Shows the results for the maximum principal root stress, in tension, for the pinion.

Finally, Figure 9 shows a comparison of the maximum contact pressure. The results for maximum contact stress are taken in the region away from any severe tip contact. It is very difficult to calculate an accurate value for the stress in edge contact regions such as extended tip contact, both via full FE or specialized gear contact analysis. In such regions the actual contact stress will be a function of the details of the actual tip shape in terms of manufacture and wear under operating. It is important to identify when such contact occurs, which such models can do, and include micro geometry such as tip and root relief in designs to avoid hard tip contact.

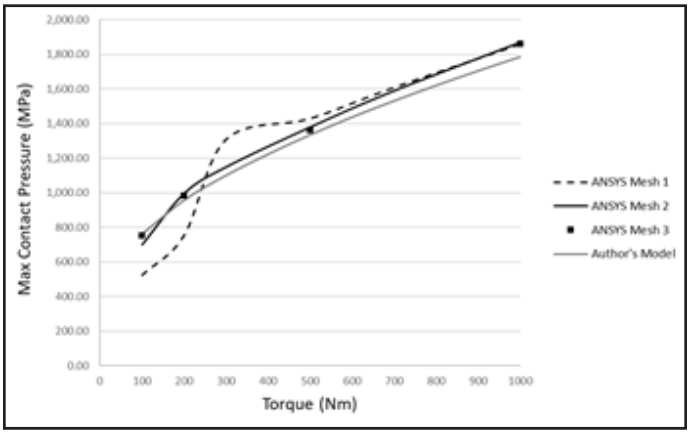

Figure 9 Comparison of authors' model and *ANSYS*; maximum contact stress (MPa) against load.

It is worth noting that the run times for the *ANSYS* model on a typical desktop with 64 GB RAM, Intel Core i7-5820K CPU were of the order of 20 minutes-per-time-step (32 time steps were run per load) for Mesh 1, 1.5 hours for Mesh 2, and 12 hours for Mesh 3. In contrast, the authors' model run times are of the order of seconds to a minute for a full load step.

Automotive example

In this section we discuss a typical automotive application where asymmetric cylindrical gears may be considered as a design option.

Gears in typical automotive applications are mostly subjected to unidirectional loading, where the drive flank operates at greater load for longer duration compared to the coast flank. This means that the drive flank dictates the torque capacity of the gears. Asymmetric gears can be designed to increase the performance of the drive flank at the expense of the coast. This can increase the overall load capacity of the gears. Due to this reason there has been increased interest in the use of asymmetric gears within the automotive industry.

The geometry parameters used in this study are given in Table 2 and shown (Fig. 10). The original, symmetric design is based on real automotive application; the asymmetric design is an optimized asymmetric alternative to the original gear set. The

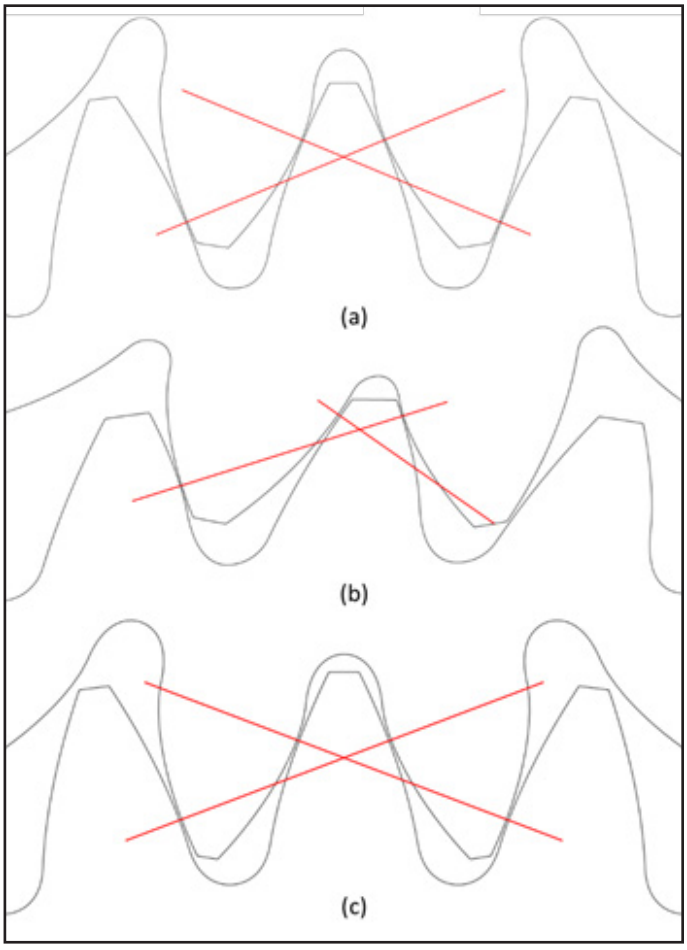

Figure 10 Comparison of tooth shapes (a) original, (b) asymmetric and (c) HCR.

Table 2 Design study example geometries

	Original		Asymmetric		HCR	
	Pinion	Wheel	Pinion	Wheel	Pinion	Wheel
Gear Ratio	2.45		2.53		2.45	
Effective Face Width (mm)	17.5					
Normal Module (mm)	2.2		2.5		2.21	
Helix Angle (°)	23		28		23	
Centre Distance (mm)	83					
Axial Contact Ratio	0.99		1.0628		1.003	
	Drive	Coast	Drive	Coast	Drive	Coast
Pressure Angle (°)	20		32	16	19	
Transverse Contact Ratio	1.7614		1.08	1.42	1.9943	

high contract ratio design (HCR) is the authors' symmetric gear optimization of the original gear set.

Even though it is possible to design asymmetric gears with high contact ratio. the option to do so was limited by the constraints for the example investigated here. One constraint was that both flanks have the same tip form diameter. This interacts with the constraint of maintaining sufficient start of active profile (SAP) to form diameter clearance. Sufficient tip thickness was also maintained for all designs.

These designs were evaluated for peak-to-peak transmission error, contact stress and root stresses using the LTCA methodology described and validated earlier in this paper.

Figure 11 shows calculated peak-to-peak transmission error for the designs detailed in Table 2. The asymmetric gear has substantially reduced transverse contact ratio, and this has an adverse impact on the transmission error. As can be seen, peak-to-peak transmission error was significantly higher on the drive flank. In the coast flank, the asymmetric gear was found to provide a lower peak-to-peak transmission error compared to the original. The best-performing design on the drive flank was the HCR, although it might be possible to achieve improved peak-to-peak transmission error behavior for asymmetric gears in certain cases, as shown by Kapelevich (Ref. 2).

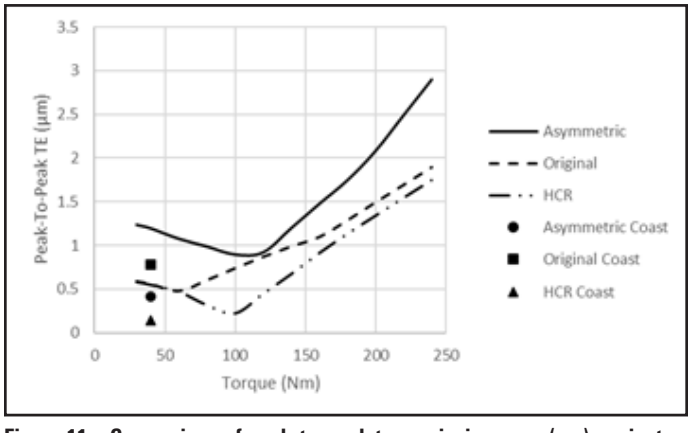

Figure 11 Comparison of peak-to-peak transmission error (µm) against load.

Figure 12 show the comparison of maximum contact stress for the three designs. For the asymmetric design, the maximum contact pressure was reduced compared to the original. This reduction is much more significant between 50 to 150 Nm than at the higher loads. However, the HCR gear resulted in lower contact stresses than the asymmetric gear at all loads; it should be noted that all of these designs have some level of tip contact present.

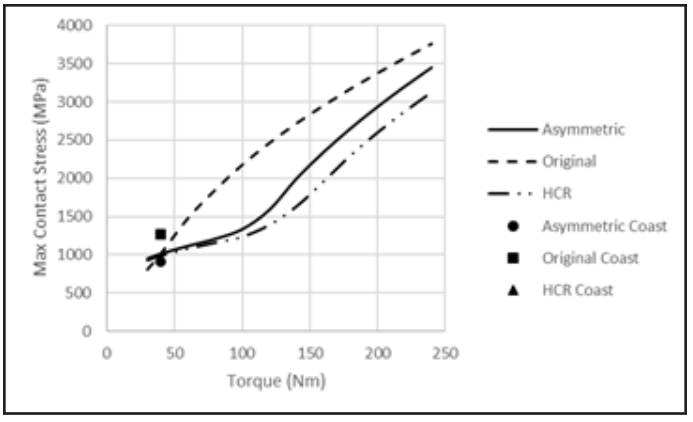

Figure 12 Comparison of maximum contact stress (MPa) against load.

Figure 13 show the comparison of maximum principal root stress, in tension, for the pinon. Using the asymmetric design, maximum tensile stress at the pinion root is reduced by approximately 10 percent in the operating range, as compared to the original design. However, it was found that the HCR gear resulted in root stresses similar to the asymmetric gear.

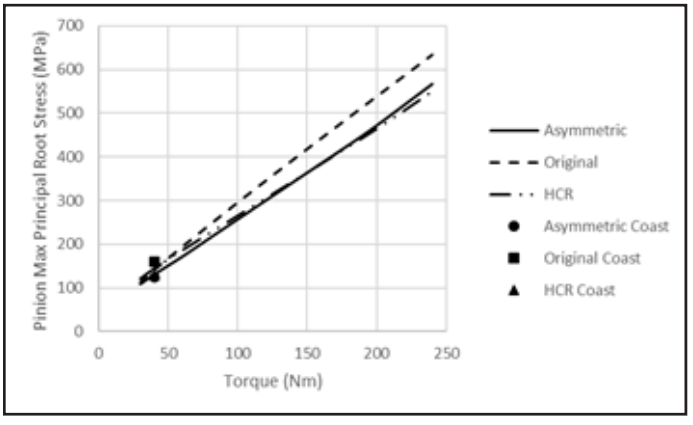

Figure 13 Comparison of pinion max principal root stress (MPa) against load.

Figure 14 shows the comparison of maximum principal root stress, in tension, for the wheel. The wheel root stresses did not improve for the asymmetric design, as compared to the original, whereas they could be improved using a HCR design.

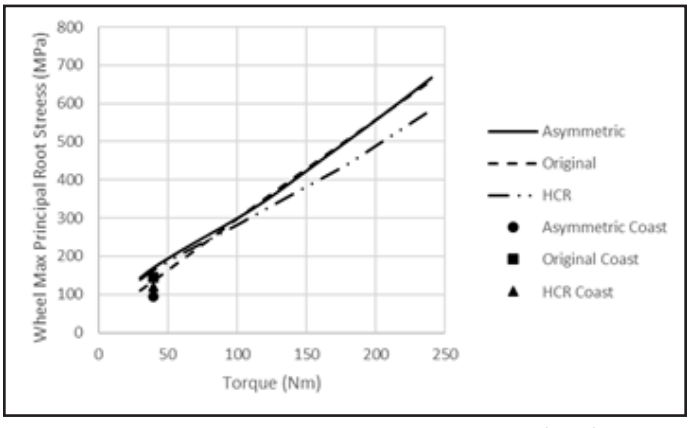

Figure 14 Comparison of wheel max principal root stress (MPa) against load.

Asymmetric gear design optimization for the given example was not very successful, although it reduced pinion root stress and contact stresses when compared to the original design. For the given constraints, it was possible to design a symmetric gear with HCR that was better than the asymmetric gear in every aspect. This indicates that although there are stated potential improvements that can be achieved with asymmetric designs, improvements are not guaranteed. A tool such as that developed by the authors is required to enable engineers to accurately and efficiently compare the advantages and disadvantages of multiple asymmetric designs between themselves and symmetric alternatives.

The designs discussed here were compared based only on transmission error, root bending stress and contact stress. Asymmetric gears might have further advantage if efficiency, scuffing and micropitting are considered. This could result due to improved radius of curvature and specific sliding due to higher pressure angle. In design settings where such criteria are important, further analysis is required. However, the efficiency effects must be investigated at the system level, as increasing the pressure angle increases the bearing loading. In addition, it is important to understand the cost repercussions of manufacturing and quality control of asymmetric gears, compared to symmetric variants.

Conclusion

Asymmetric gears have been shown in the literature to offer significant operating advantages over symmetric gears in many applications. Increased interest is being seen in the application of asymmetric gears in the automotive industry. An efficient, validated, loaded tooth contact analysis method has been presented for the assessment of symmetric and asymmetric gear load distribution, transmission error, contact and root stresses. An automotive example was presented showing that potential benefits of asymmetric gears are not necessarily achieved when compared to optimized symmetric gear designs. This highlights the benefits of a tool such as the one presented in enabling the engineer to accurately and efficiently assess multiple gear design options — both symmetric and asymmetric.

For more information.
Questions or comments regarding this paper?
Contact Paul Langlois at *Paul.Langlois@smartmt.com.*

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Dr. Paul Langlois is the Software Engineering Director at SMT. Having worked for SMT for more than 14 years, he has extensive knowledge of transmission analysis methods and their software implementation. He manages the development of SMT's software products and is a main contributor to many aspects of the technical software development. As a member of the BSI MCE/005 committee, Langlois contributes to ISO standards development for cylindrical and bevel gears.

Baydu Al is a senior software engineer — gear specialist at SMT and has been working for SMT for more than 6 years. Since joining SMT, he has been contributing to development of MASTA mainly focusing on the detailed analysis of gears. Also as a member of three BSI MCE/005 committees he is participating in different working groups of the ISO TC60 committees as a UK delegate.

Eaton

IMPLEMENTS 3D METAL PRINTING PROGRAM

Eaton has announced its Vehicle Group is implementing a new 3D metal printing program as a part of its Industry 4.0 strategy to reduce development time and improve efficiency. The first metal printer system was installed at the Kings Mountain, N.C., facility, and a global deployment of 3D polymer printing technology is slated to be completed by first-quarter 2021.

The 3D printers are being utilized to create high-quality fixtures, safety devices, automation grippers for assembly and handling, and maintenance components requiring replacement. Prototype development is following the same strategy to support faster product development trials and improve efficiency.

Improving output and efficiency

To speed up the design process, scanners are used to create 3D models of existing components. This process allows components to be reverse-engineered to better leverage 3D printing capabilities, including changing component design to use less material, the addition of different topography elements or consolidating multiple components into a single part.

As an increasing number of 3D printers are deployed across the globe, Eaton's Vehicle Group has been realizing further operational improvements including lead-time reduction and cost savings.

The 3D printing technology adds material only where it is needed and allows more advanced designs to be developed. Together, these two factors reduce the amount of post-processing operations needed while reducing material cost.

A closer look at 3D printing

The process to print metal parts and components begins with powdered metal stored in a rod and held together by wax and a polymer binder. Similar to extrusion, the metal is melted, and the 3D printer begins to add layer after layer, based on its programmed schematics.

Once the printing process is complete, the part or component is run through a chemical bath to remove most of the polymer binder. The part then goes through a furnace to remove the remaining wax and polymer, and to fuse the metal material in a high-density structure. Depending on what the printed part or component is to be used for and which material it was printed with, an additional heat treatment process can be performed to increase part strength even further.

The total lead time to get a component printed depends on several criteria, including the size and intricacy of the part. Depending on the part or component design and required tolerances, it also can undergo post-processing. The debinding operation and heat treatment are done in batches, with several different components going through these processes together while the next components are being printed. Although the printer, debinding and furnace work in an integrated loop, there is flexibility to increase the number of printers without having to duplicate either the debinding or furnace.

Going forward, the Vehicle Group's 3D printing capabilities will be used to further reduce production time and drive efficiency. Learn more about the Vehicle Group's Industry 4.0 technologies and benefits. (*www.eaton.com*)

Helios Gear Products

IMPROVES SUPPORT WITH NEW SERVICE ENGINEER

Helios Gear Products proudly announces the addition of **Jack Jaeger** in the position of service engineer. Gear manufacturers will benefit from Jaeger's experience and technical aptitude. Said Adam Gimpert, president of Helios: "Jack significantly boosts Helios's ability to support gear manufacturers with his unique ability to troubleshoot and solve technical machine problems on-the-spot. With Jack on the team, Helios continues its dedication to personal and professional customer service."

Jaeger launched his career from a background in construction and carpentry into precision gear manufacturing as a machine operator on Koepfer hobbing equipment. (This experience particularly helps Helios support its 300+ Koepfer machine installations.) His formal education includes a degree from Waukesha County Technical College as an Industrial Maintenance Technician. While in school, Jaeger earned multiple scholarships from the AGMA (American Gear Manufacturers Association) Foundation, the mikeroweWORKS Work Ethic Scholarship, and the Nuts, Bolts & Thingamajigs Foundation. Before joining the Helios team, Jaeger applied his education servicing printing press equipment.

As part of the Helios service group, Jaeger adeptly covers several duties. These include machine rebuilding, recontrolling, and reconditioning; machine installations; customer service; and mechanical troubleshooting. Jaeger joined Helios in 2018 and has already solved many machine challenges,

such as hob head rebuilds, recasting hobbing machine ways, and the mechanical reconstruction of a complete hobbing machine. Helios customers are better supported today because of Jaeger's additional experience on Koepfer, K-Repowered, KFS, and Hera machines. Said Troy Kutz, service manager for Helios: "Jack has really added value to our team, and this helps Helios service gear manufacturers better than ever. With him onboard, our customers are confident they will remain productive through thick and thin." (*heliosgearproducts.com*)

Index

NAMES NEW PRESIDENT AND CEO

Index has named **Cris Taylor** as the new president and CEO of Index Corporation, effective January 1, 2021. Taylor will be taking over for Tom Clark, who has announced his retirement at the end of 2020. Taylor will be joining the Index Group in October to ensure a seamless transition for the organization and its customers.

Taylor has over 30 years of experience in the machine tool industry, both in Europe and the United States. Having grown up in the United Kingdom, Taylor spent most of his working career in Germany. This includes 27 years at Chiron, where he held positions of increasing responsibility. He established the Chiron UK's sales and service and engineering operations, then built Chiron's used machinery division in Germany. Taylor spent five years with Chiron America in Charlotte, NC and, most recently, served for eight years as managing director of Stama, Chiron's sister company.

"Cris brings to Index Corporation international sales and service experience combined with a long career working in Germany, which will greatly benefit our operations in North America." said Clark. "When one leaves a leadership position, you always hope to transition to someone who can build on previous accomplishments and continue to grow the organization. Cris will be a great addition to the Index team."

Clark's mandate four years ago was to pursue aggressive growth within the North American market. Under his leadership, Index revitalized its distribution network, grew its service and applications capabilities, expanded the team in North America and achieved record sales in 2018 and 2019. (*www.index-usa.com*)

Klingelnberg Mexico

CELEBRATES 20-YEAR ANNIVERSARY

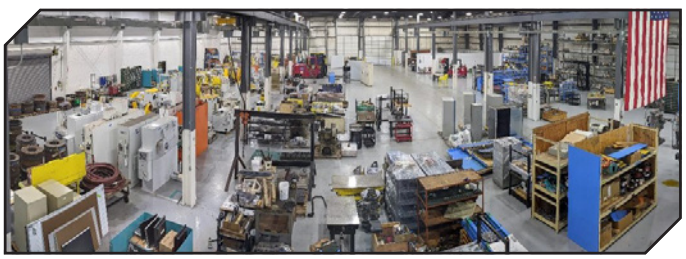
On November 1, 2020, Klingelnberg México, S.A. de C.V. celebrated a milestone anniversary. For 20 years, Klingelnberg has been offering distribution services and individual technical service at its Mexico location in Querétaro City. Since it was established in 2000, the Mexican branch office has undergone continuous development.

The Grinding Service Center, which commenced operations in 2011, is yet another component of the company's commitment to meeting the growing customer requirements locally. State-of-the-art tool adjusting and measuring devices guarantee an optimum workflow, from servicing and repairing the tool to use in the machine tool. To enable efficient, trouble-free production of drive components for our customers, Klingelnberg offers a broad portfolio in a Closed Loop process. The company is therefore able to ensure optimal grinding results for quality assurance on the shop floor.

Managing Director Adrián Hernandez extended a warm thank you to all customers, business partners, and colleagues: "I wish to thank my colleagues in particular, who have been delivering superb service to our Mexican customers from the very start." (*www.klingelnberg.com*)

C&B Machinery

MOVES TO NEW MANUFACTURING FACILITY



C&B Machinery has moved to a new manufacturing facility located in New Hudson, Michigan. The company now has more than 26,000 sq. ft. of manufacturing space to provide customers with the highest quality of precision grinding machines in today's global market. C&B Machinery designs and builds custom grinding solutions. All mechanical and controls engineering is done in-house. They can build a custom integrated grinding machine cell, update and rebuild existing machines, supply a used machine from the company's extensive inventory, or serve as an accessory and spare parts supplier for machines. (*www.cbmachinery.com*)

Big Kaiser

ANNOUNCES NEW PRESIDENT/CHIEF OPERATING OFFICER

Big Kaiser Precision Tooling has announced the promotion of **Jack Burley** to president/chief operating Officer as of January 1, 2021. Chris Kaiser, Big Kaiser president and CEO of 30 years, will take on the role of executive advisor.

"Jack has been my right hand in this company from the very beginning," said Kaiser. "He's shown his leadership in managing the sales and engineering teams and has made many significant contributions to Big Kaiser including new product designs and development. He's more than ready and deserving of this promotion."

Burley began his career with Big Kaiser more than 30 years ago and is currently vice president, sales and engineering. Burley is a U.S. Marine veteran and earned his degree in mechanical engineering from State University of New York at Alfred. As president/COO of the North American operations for Big Kaiser, Burley will continue to hold his seat on the board

of directors for Big Kaiser.

"I am very honored and excited about my new position with Big Kaiser, and truly grateful to the executive management at Big Daishowa and to Chris for placing their trust and confidence in me to lead the company," said Burley. (*www.us.bigkaiser.com*)

MHI

HIRES NEW VICE PRESIDENT OF SALES

Mitsubishi Heavy Industries America is pleased to announce and welcome **J. Scott Knoy** as the new vice president of sales for the Wixom, Michigan based Machine Tool Division. Knoy will be responsible for sales team leadership, driving revenue, strategic planning and marketing, as well as management responsibilities.

Knoy brings 26 years of experience in the gear machine and tooling industry. His career includes 12 years with the Gleason-Pfauter organization working as a regional sales manager in both the tooling and machinery sales groups and 14 years with GMTA (American-Wera) where he served as the vice president of sales, vice president and president.

"Scott has an impressive background in sales and executive management within the gear machine industry," says Atsuhiro Kawaguchi, general manager of the Mitsubishi Machine Tool Division. "Scott will aggressively lead our sales team and I believe with his leadership we will overcome this unforeseen market condition."

Knoy who resides in Howell, MI is married (Holly) and has 2 adult children (Kelsey, Karlyn). His education includes an MBA from Lawrence Technological University as well as a bachelor degree from the University of Michigan in Ann Arbor. Additionally, Knoy served as a combat engineering officer in the U.S. Army Reserve for 10 years.

He will be replacing long standing Senior Vice President Tom Kelly. Kelly began his career in the machine tool business in 1987 when he started selling Mitsubishi Machine Tools for a local dealer. Two years later, he joined Mitsubishi International Corporation (the importer for MHI). After more than ten years of local success, he approached Mitsubishi Heavy Industries America with a proposal to eliminate the existing dealer network and take over all sales and service responsibilities for North America. Tom will be retiring at the end of December, and will move with his wife Cayce to their home in North Carolina. (*www.mitsubishigearcenter.com*)

Solar Atmospheres

SOUTH CAROLINA FACILITY NUCLEAR APPROVED

Solar Atmospheres, Greenville, SC facility was recently approved to NQA-1, 10CFR50 Appendix B, and 10CFR21. These standards represent the nuclear power industry's requirements for quality operating systems within the supply chain. Additionally, the approval allows Solar to eliminate our customer's need within the Nuclear Industry to provide ongoing oversight of heat treatments.

Site Quality Manager and NQA-1 Lead Auditor Kevin Cyrulik states, "With this progression from Commercial Grade Supplier to externally approved NQA-1 Supplier, Solar continues to show its dedication and commitment to unmatched quality and product safety."

Steve Prout, Solar Atmospheres Southeast President states, "At a time when the entire manufacturing world is facing unprecedented operational challenges, Solar is thrilled to be able to support our customers with an opportunity to streamline their processes, saving them time and money."

(*www.solaratm.com*)

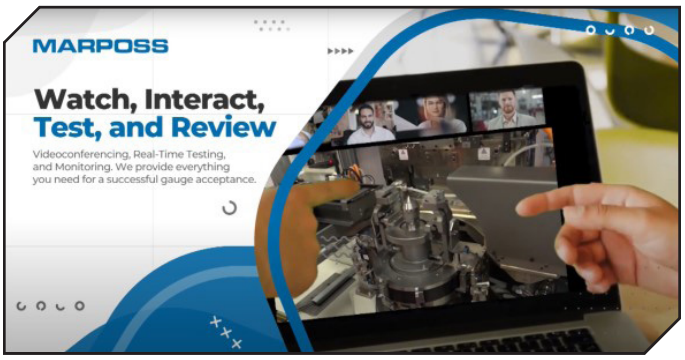
Marposs

ANNOUNCES REMOTE VIDEO CONFERENCE AND ACCEPTANCE SERVICE

Marposs has announced its real-time Remote Testing and Acceptance Service. Marposs is enabling customers to participate in live testing, review and acceptance of their machines/gauges/applications without having to travel, enabling work to continue in an efficient manner while saving time and money.

"The manufacturing industry is often criticized for a lack of modernization. With the pandemic preventing the ability to meet in-person, companies must adopt new technologies," commented Matteo Zoin, Marposs, head of marketing and new market development. "We are living in a challenging time and to stay competitive requires aggressively moving into the digital space."

Tests for North American customers are run at Marposs' Technology Labs in Auburn Hills MI, Fremont CA, or at



HQs in Europe. The sessions livestreamed through the Zoom Conference platform are supported by video cameras and wireless equipment to ensure a highly detailed and accurate experience. Customers can provide immediate feedback and any requested alterations can be made in real-time.

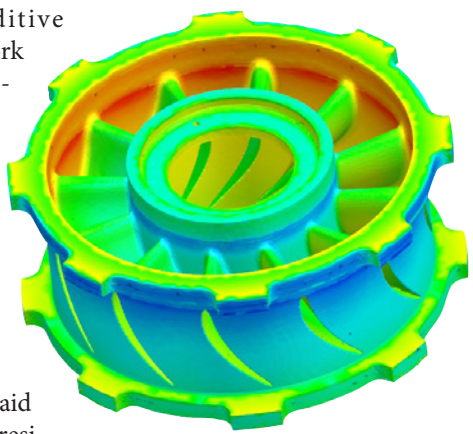
Marposs has produced a video on this service to provide potential users a better understanding of the experience. (*youtu.be/gUrSurWUNno*)

Siemens Digital Industries Software

EXPANDS ADDITIVE MANUFACTURING ECOSYSTEM

Siemens Digital Industries Software is expanding its ecosystem for industrial additive manufacturing (AM) through partnerships with Morf3D, Sintavia and Evolve Additive Solutions. Through these new partnerships, Siemens is adding support for new methods of AM production, further strengthening Siemens' end-to-end solution for industrialized additive manufacturing as part of its Xcelerator portfolio of software and services.

"Over the past year, through acquisitions and technology advancements, the launch of the new Siemens Additive Manufacturing Network and these relationships, we have continued to expand our ecosystem for additive manufacturing, which will help us enable all our customers to be successful adopting industrialized additive manufacturing," said Aaron Frankel, vice president of the AM Program for Siemens Digital Industries Software. "These key partnerships can help move us forward to enable customers not only prototype, but manufacture ground-breaking products at scale, in order to meet the demands of the current marketplace." (*www.sw.siemens.com*)



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Big Gears: Seeing is Believing

Matthew Jaster, Senior Editor

This is the timely and relevant sequel to our Nov/Dec 2018 Addendum article, "Safety Guaranteed." In the original article will looked at some incredible gear applications from the safety of our desktop computers and smartphones. Who knew we would be spending most of 2020 doing the same exact thing?

Big gear applications continue to amaze and astound engineers across the world—a perfect example of this is the kind of coverage a massive gear project video gets on Twitter or LinkedIn. It's one thing to write about these enormous components; but watching the manufacturing of these gears takes it to another level. Here are some recent examples:

Horsburgh & Scott

Horsburgh & Scott has in-house capabilities in gas carburizing, induction hardening, stress relieving and through-hardening. Many of these gear operations are discussed in the pages of Gear Technology, but it's a completely different experience to see firsthand the heat and flames needed to meet today's large gear requirements. Learn more here:

www.youtube.com/watch?v=5H0qfWrjgWA

Courtesy of HMC.

ATA Gears

ATA Gears offers intelligent mechanical power transmission solutions. These diverse applications offer improved availability, durability and safety. And the best part? The gears are animated!

www.youtube.com/watch?v=_XrSGdNJMuI

P. van der Wegen Gears

Time lapse videos are some of the best on the Internet and this time lapse video of a big gear from P. van der Wegen shows the remarkable ingenuity needed to assemble these massive components. P. van der Wegen Gears is a family-run business (4th generation) that began in 1880 as a service shop for the textile industry.

www.youtube.com/watch?v=ApqvxH2vsNs

F.L. Smidth

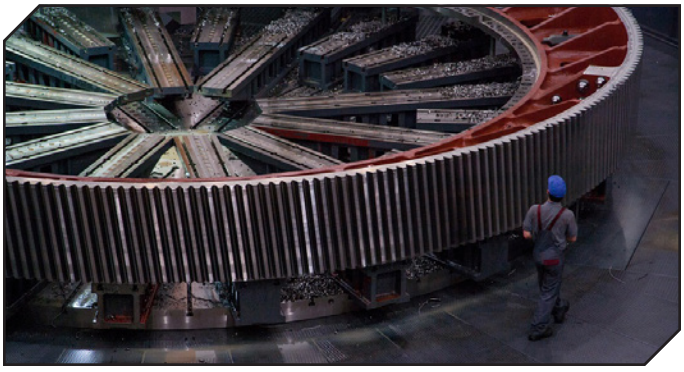
The MAAG CPU Gear unit represent the classic central drive for ball mills. With it's two-stage planetary gear arrangement it delivers high productivity for ball mills.

www.youtube.com/watch?v=wu4XPC0ESCw

Ferry Capitain

Ever wonder how these massive gear components get where they need to go? This short demo video from Ferry Capitain examines a gear mounting project in France in July 2019.

www.youtube.com/watch?v=auws5MOt4t0



Courtesy of Ferry Capitain.

X-Machines

You can't typically brag about producing the largest gear in the world because by the time you publish the news, someone is making something bigger. That doesn't stop a popular YouTube destination called X-Machines from showcasing some of the most unique and biggest gears in our industry here:

www.youtube.com/watch?v=mtV8Zu5EtUE

Girth Gear at HMC

This step-by-step video of the manufacture of a girth gear at HMC highlights the impressive ingenuity needed to complete a component like this in-house.

https://www.youtube.com/watch?v=OILZgEQHutw

While it's amazing to watch these machine tools produce enormous components, the Addendum team longs for the days when a shop visit would allow us to see some of these engineering marvels up close and personal. Hopefully by the middle of 2021, we'll be back on the road taking in the sights and sounds of the future of gear manufacturing—live and in-person!

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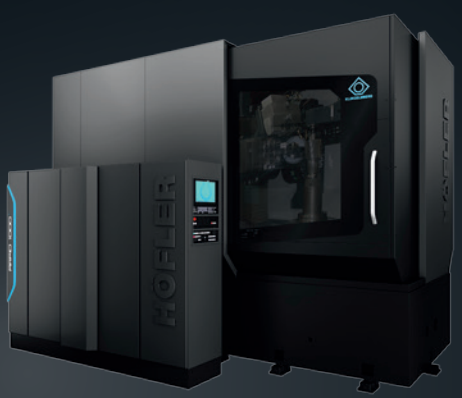

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