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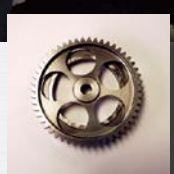

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October—Heat Treating
November—Cutting Tools
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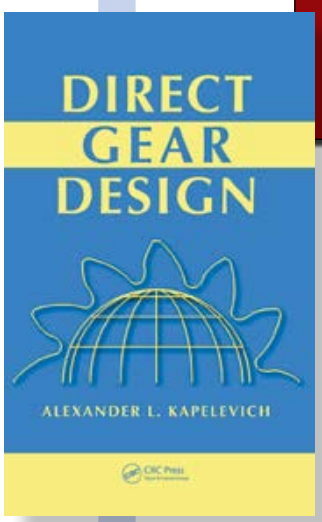

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RANDALL PUBLICATIONS LLC
1840 JARVIS AVENUE
ELK GROVE VILLAGE, IL 60007

(847) 437-6604
FAX: (847) 437-6618

EDITORIAL
Publisher & Editor-in-Chief
Michael Goldstein
publisher@geartechnology.com

Associate Publisher & Managing Editor
Randy Stott
wrs@geartechnology.com

Senior Editor
Jack McGuinn
jmcguinn@geartechnology.com

Senior Editor
Matthew Jaster
mjaster@geartechnology.com

Editorial Consultant
Paul R. Goldstein

Technical Editors
William (Bill) Bradley
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Octave Labath, P.E.
Joseph Mihelick
Charles D. Schultz, P.E.
Robert E. Smith

DESIGN
Art Director
David Ropinski
dropinski@geartechnology.com

ADVERTISING
Associate Publisher & Advertising Sales Manager
Dave Friedman
dave@geartechnology.com

Materials Coordinator
Dorothy Fiandaca
dee@randallpublications.com

CIRCULATION
Circulation Manager
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Gear Expo: Mecca Mechanica

Publisher & Editor-in-Chief
Michael Goldstein

Last issue we observed a pause, or least some unevenness, in the markets served by most gear manufacturers. Despite the unsettled state of affairs, the evidence still seems clear that U.S. manufacturing — and gear manufacturing in particular —still boasts one of the healthier business environments in the world right now.

So it's an ideal time for a pilgrimage to AGMA's Fall Technical Meeting and Gear Expo, which take place in Indianapolis (see pages 28-47 for our extensive show coverage). Once again, gear manufacturers will have a unique opportunity to tap into a wealth of knowledge and experience in two formats. At the Fall Technical Meeting, you have the chance to sit in on presentations from many of the brightest minds in gearing, and to learn about the techniques, methods and technologies that constitute the gear industry's current state of the art. The Fall Technical Meeting takes place September 15–17 and includes 26 presentations in five subject-oriented sessions.

The second is of course Gear Expo itself, which takes place September 17–19 and offers an opportunity to review the machinery, tooling and services needed for gear manufacturing, as well as to make contact with some of your most important suppliers. There you will not only become familiar with these suppliers' current offerings, but it's also an easy way for you to develop or renew contacts with the salesmen, service engineers and technicians who know the most about gear manufacturing technologies. In fact, because of their experience dealing with other gear manufacturers around the world — many of whom face challenges similar to yours — these contacts can offer you valuable insight into the technologies and approaches that have been successful in other operations. They are often aware of the techniques and processes being used by companies like yours.

As in past years, Gear Expo will run concurrently with the ASM Heat Treating Society Conference and Exposition (Sept. 16–18), so you'll also have the opportunity to explore the latest in heat treating technologies as well.

We're fortunate to have had a couple of years of reasonably good to very good business. Hopefully, for many of you, this means you will have the ability to take a breather, spend some time in Indianapolis, and possibly find new opportunities or solutions that will allow you to take your manufacturing operation to the next level.

The location of the show—Indianapolis—makes it ideal for a large percentage of gear manufacturers in the United States. For most of you, a reasonable car trip through America's heartland will get you to the show.

When you visit Gear Expo, we hope you'll stop by to see us (Booth #1123). We'll be offering complimentary espresso at our booth, and we invite you to come and talk with our editors and staff. We'd like to show you how quickly and easily you can use our online articles archive to find technical information on virtually any subject related to gears. And if you're a seller of gears or geared products, we'd like to share information with you about how *Power Transmission Engineering*, our companion magazine, is continually growing and expanding in its efforts to reach your customers—the designers of geared systems and buyers of gears and gear drives—making it the perfect marketing and advertising venue for you.

No matter your place in the gear industry, Gear Expo is sure to offer plenty of opportunities for expanding your knowledge, your contacts, and your business.

I'm looking forward to seeing you in Indy.

Where Did All the Displaced Manufacturing Workers Go?

Daniel J. Meckstroth

Following is a report from The Manufacturers Alliance for Productivity and Innovation (MAPI). Founded in 1933, the alliance contributes to the competitiveness of U.S. manufacturing by providing economic research, professional development, and an independent, expert source of manufacturing information (www.mapi.net).

What happened to displaced manufacturing workers following the 2008–2009 recession? Did they find new jobs? And if so, in what industries?

The Great Recession of 2008–2009 took an enormous toll on manufacturing workers. From December 2007 to December 2009, the total number of manufacturing jobs fell by 2.3 million—a 17 percent reduction.

To put the job loss in perspective, non-manufacturing total employment declined only 5 percent in the recession.

On the upside of the cycle, the employment recovery has been similar in percent terms—i.e., 4.5 percent growth in manufacturing and 4.7 percent growth in non-manufacturing jobs. Because the decline in manufacturing employment was many times worse than in the general economy, the manufacturing jobs recovery is less complete. Manufacturing employment has increased by 519,000 jobs since December 2009 and has recovered 23 percent of the 2.3 million jobs lost in the downturn. Non-manufacturing employment, however, is 87 percent recovered for the same time frame.

Figure 1 shows the unemployment rate for all workers and for manufacturing from 2007 to the present. The unemployment rate in manufacturing was a couple tenths of a percentage point below the overall rate in 2007 and 2008, but then rose above the total for all workers. The sector's unemployment rate exceeded the falling total unemployment rate by an average 1.0 percentage point margin in 2010. The two rates converged in 2011, and by 2012 unemployment in manufacturing was consistently lower than in the general economy.

The sharper employment loss in manufacturing and the less complete jobs recovery both beg the question as to why the unemployment rate for manufacturing workers is so much lower than that of the general economy.

The Flow Determines the Level

As an example, consider that the level of a lake is determined by water inflow and outflow; the same is true with the level of employment. 2009 saw the worst of the manufacturing job reductions and is a good illustration of how quickly employment adjustments occur. That year, 2.9 percent of manufacturing workers separated from their employers each *month* (about one-third of workers quit and the other two-thirds were layoffs and discharges), and 1.9 percent of manufacturing workers were hired each month. The flows in and out were large relative to the size of the "pond." In 2009 4.17 million manufacturing workers were separated from their manufacturing jobs and 2.76 million were hired, leaving an average manufacturing jobs level of 11.8 million jobs. The outflow was 1.41 million greater than the inflow, so the employment level fell in 2009 compared with 2008. The reverse happened in 2010 through 2012, and into the early part of 2013. The inflow was slightly greater than the outflow, allowing manufacturing employment to rise.

The Re-Employment Rate

Every two years the U.S. Department of Labor collects additional information, along with the survey that determines the unemployment rate, measuring the number of workers 20 years of age and older that were displaced from a job at least once in the previous three years. The definition of a displaced worker is rather strict in order to capture workers who are involuntarily separated from a job based on the operating decisions of employers. (*Displaced workers are those workers who lost a job because a plant closed or moved, the position or shift was abolished, there was insufficient work, or because of another similar economic reason. The definition of a displaced worker does not include job loss resulting from the actions of the worker, such as quitting or being fired for work performance or disciplinary problems. While workers may have had several job displacement spells in a three-year period, the individual is counted only once in the survey; the information collected about the job loss refers to the position held for the longest time.*)

Losing a job imposes costs on individual workers. While most displaced workers are able to collect unemployment insurance payments and quick-

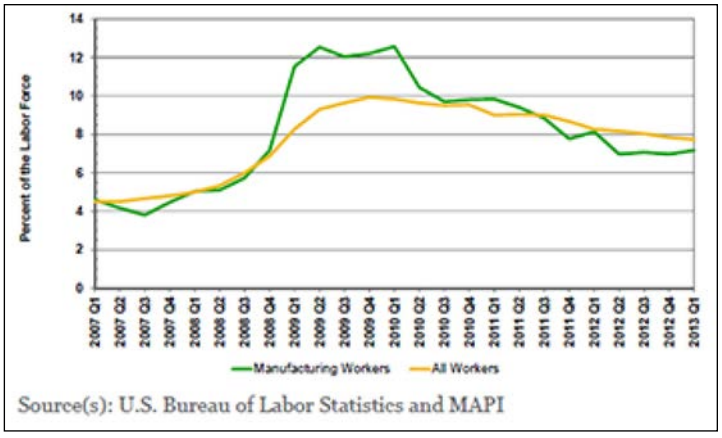


Figure 1 Unemployment rate for manufacturing workers and all workers.

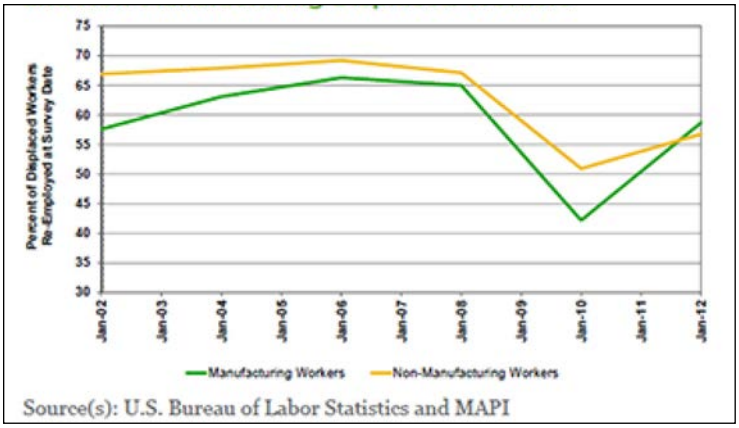


Figure 2 **Re-employment rate for manufacturing and non-manufacturing displaced workers.**

ly find another job, some segments of the displaced worker population remain unemployed for a long time; others simply stop looking for a job altogether. Figure 2 shows the percent of workers who lost a job for economic reasons over the previous three years, but who were re-employed at the time of the survey. For example, the 2009–2011 worker displacement survey estimated the number of workers who lost a job for economic reasons during the period of January 2009 through December 2011, and determined the number re-employed in January 2012. The survey found that 59 percent of manufacturing workers who were displaced from a job in the previous three years had a job by January 2012. Among workers who lost a non-manufacturing job, 57 percent were re-employed. Since 2002, manufacturing workers had consistently lower re-employment rates, but this trend changed in the most recent survey. The severe decline in construction employment and the widespread nature of the 2008–2009 recession affected many services industries that had previously been relatively immune to downturns—and drove down the non-manufacturing re-employment rate.

Table 1 **Re-employed workers who lost manufacturing jobs in the past three years by industry of job held in January 2012.**

Industry of New Job	Percent
Mining	0.6
Construction	6.2
Manufacturing	41.7
Wholesale trade	4.5
Retail trade	6.1
Transportation and warehousing	5.8
Utilities	0.4
Information	0.7
Finance and insurance	1.6
Real estate and rental and leasing	1.3
Professional and technical	6.5
Management. administrative, waste	6.6
Educational	1.8
Healthcare. social assistance	4.3
Arts, entertainment. recreation	0.6
Accommodation, food	4.0
Other services	2.9
Not specified	4.5
Total	**100.0**

What happened to the 41 percent of displaced workers in the latest survey who were not re-employed by January 2012? They either remained unemployed or were out of the labor market. That survey found that 25 percent of displaced manufacturing workers were unemployed and 16 percent stopped looking for a job and were out of the labor market.

Manufacturing Labor Resources are Re-Allocated to Other Industries

The department of labor examined those industries in which displaced manufacturing workers found re-employment. Of those workers who lost manufacturing jobs from January 2009 to December 2011, and were re-employed by January 2012, 58 percent found re-employment outside the manufacturing industry. As shown in Table 1, only 42 percent of workers who lost manufacturing jobs found another job in the sector. In other words, structural change in manufacturing re-allocated labor resources out of manufacturing and into many other sectors.

Earnings Loss as a Result of Displacement

The cost of job displacement is more than just lost wages during a job search; to many workers, it also means lower earnings at their new job when they are re-employed. Sixty-five percent of all displaced manufacturing workers who lost full-time jobs and were re-employed full-time in January 2012 earned less than at their previous job; 35 percent earned the same or more. Unfortunately, the amount of lost earnings is skewed to the low end of the spectrum. Forty percent of displaced manufacturing workers found new, full-time jobs that paid 20 percent less than their previous job; 15 percent found jobs paying 20 percent more.

Research on displaced workers' outcomes has shown that there is a very strong link between the replacement of lost earnings and tenure at the lost job. The average earnings loss from the previous job to the new job becomes larger relative to the length of tenure the worker had in the lost job. Obviously, employers pay workers in large part for loyalty and job-specific knowledge that is accumulated in the position. Because manufacturing workers are more likely to have lost a high-tenure job and are older in age, they generally experience somewhat larger wage declines than do non-manufacturing workers when they are displaced.

Daniel J. Meckstroth is vice president and chief economist and council director of the MAPI purchasing and division finance councils. He earned his BBA from Eastern Kentucky University before going on to receive a Master of Arts degree and a Ph.D. in economics, as well as a Master of Arts degree in industrial relations—all from the University of Cincinnati. Meckstroth has more than 20 years of service to MAPI, providing commentary and analysis on a wide variety of economic issues as they relate to the manufacturing sector, and is MAPI's primary spokesperson on business conditions and economic matters. He writes extensively on business practices and manufacturing activity. Prior to his tenure at MAPI, he worked 12 years for Armco (now AK Steel), a steel manufacturer. Meckstroth is a member of the National Association for Business Economics (NABE) and the National Economists Club in Washington, D.C.

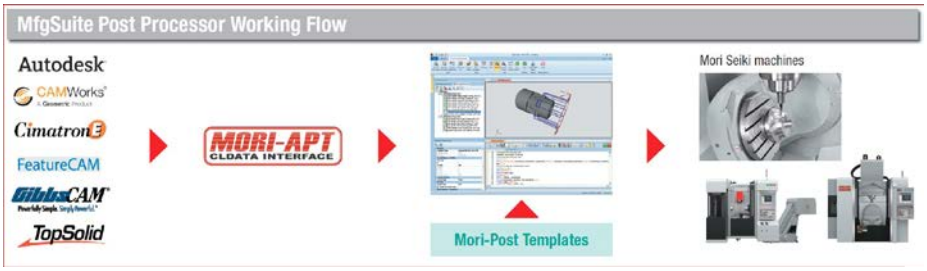
DMG/Mori Seiki

RELEASES MANUFACTURING SUITE POST PROCESSOR

DMG/Mori Seiki recently announced the release of a Mori-APT toolpath-based post processor, available September 2013. The new post processor is a part of its simple, integrated and powerful suite of applications called *Manufacturing Suite*. This universal post processor will be available for all Mori Seiki machines and will work with any CAM software that outputs toolpaths in Mori-APT standardized format. The *Manufacturing Suite Post Processor* software comes with proven post templates to output NC code for all Mori Seiki machines.

The post processor can be a bottleneck for customers—who may struggle to successfully leverage their machine-tool investment. DMG/Mori Seiki invested time and money to proactively enhance user experience by working with all major CAM vendors and to develop a template-based post processor for *MAPPS*. The result, *Mori-Post*, was released in 2007. *Mori-Post* features a generic input interface (and the Mori-APT formatted toolpath); CAM vendors can now use the generic Mori-APT input interface in their software.

The Mori-APT toolpath format is an extension of APT CLDATA standard (based on ANSI NCITS 37-1999 and ISO 4343:2000). The *Manufacturing Suite Post Processor* can import the standardized toolpath from any CAM software and generate NC code using the proven DMG/ Mori Seiki post templates.



For the process to work, customers need to acquire the Mori-APT CLDATA interface-enabled version of the CAM software from their respective CAM vendors and acquire the *Manufacturing Suite Post Processor* software from DMG/ Mori Seiki.

Traditionally, customers are required to purchase machine tools and CAM/ post processing software from different vendors, leading to discrepancies in quality, thoroughness and timely delivery. Furthermore, without quality post processors, the CAM-generated program may not run successfully on the machine tool. Now, DMG/Mori Seiki delivers the machine tool and the corresponding *Manufacturing Suite Post Processor* software, allowing customers to hit the ground running as soon as a machine lands on their shop floor. Customers can continue to use multiple CAM software solutions in conjunction with *Manufacturing Suite Post Processor* to generate NC code, now avoiding the needs to procure post processors for individual CAM software and with the added benefit of a single support contact. The Post Processor that is a part of *Manufacturing Suite* also includes additional software application modules such as, "NC Simulation" for virtual machine NC code and collision detection verification, and "Program Manager" for sending and receiving NC programs and parameters between PC and machine tools.

CAM software vendors *Autodesk*, *Cimatron*, *FeatureCAM*, *Geometric*, *GibbsCAM*, *PartMaker* and *TopSolid* have expressed an interest in working with DMG/Mori Seiki to develop interfaces to output Mori-APT CLDATA. As of the date of this press release, the following CAM products offer Mori-APT CLDATA interfaces:

Mill: *CAMWorks, CimatronE, FeatureCAM, GibbsCAM, HSMWorks, Mastercam, ParkMaker, TopSolid*

Turn: *CAMWorks, FeatureCAM, GibbsCAM*

For more information:
DMG/Mori Seiki
Phone: (847) 593-5400
www.dmgmoriseikiusa.com

Riten

OFFERS GEAR CUTTING LIVE CENTER

American gear manufacturers have traditionally used an imported center for hobbing, cutting and grinding. Many of these companies have expressed their preference for a source of American-made centers with comparable quality, lower cost, quicker delivery, and faster turnaround on repairs. Riten Industries now offers its "Raptor" series, specially-engineered live centers that are available for immediate delivery through its extensive distribution network. Concentricity is well within standard industry tolerances, and purchase costs are well below that of the imported product. Repairs are made in the United States, with turnaround times as little as two weeks. Accuracy of Raptor centers is guaranteed to ±.00005. They

Wenzel
ANNOUNCES CMM IMPROVEMENTS

Wenzel America, Ltd. is proud to announce a new series of improvements in their line of CMMs. The manual X-Cite CMM System has been overhauled with new hardware and a sleek new look that is guaranteed to impress those who are seeking a reliable CMM. The improved system, which is used for a wide variety of applications including manual part inspections of production parts and tooling and fixtures, now includes extremely high accuracy which measures by the micron, and is manufactured entirely from granite.

The newly repackaged CMM includes Manual *OpenDMIS* software with full CAD import and export with no hidden software costs. It has axis locks and fine feeds, and comes with installation and training for two people at the Wenzel training center. Prices start at $28,600 for the X-Cite 5.6.5 CMM (20" × 24" × 20") and models are available up to 7.12.5 (27.5" × 47" × 20"). All models are in stock in Michigan and the entire system is backed with a lifetime guarantee.

All X-Cite CMMs are assembled by skilled and experienced craftsmen and manufactured from metrological material to very precise tolerances.

For more information:
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Phone: (248) 295-4300
www.wenzelamerica.com

are designed with a small shell diameter to provide extra tool clearance. Models are in stock with standard and extended tracer points, in 3 and 4 Morse Taper. A 2 Morse Taper will be available in late 2013.

For more information:
Riten Industries, Inc.
Phone: (800) 338-0027
www.riten.com

Mitutoyo

DESIGNS COMPACT MEASURING SYSTEM

Mitutoyo America Corporation announces availability of the innovative, new Ko-ga-me measurement head — designed to bring full capability to applications where a compact, high-performance, 3-D CNC, 2- or 3-axis measurement system would be suitable. The Mitutoyo Ko-ga-me is small-sized, requiring only a minimal envelope (17.3" [440 mm] × 16.1" [410 mm] × 4.7" [120 mm]) and weighing 17.6 lbs. (8 kg). This makes Ko-ga-me agile and easy for a customer to mount — using either an available fixed base (wherein the workpiece moves during measurement) or using a moving-axis mounting system of the customer's own design.

Mitutoyo Ko-ga-me measuring systems are available for horizontal or vertical installation and can be used in stand-alone applications or integrated into work cells. Ko-ga-me is suitable for inspection of large or small workpieces and offers a wide range of available measurement probes including touch-trigger, optical or constant contact probing.

The Mitutoyo Ko-ga-me is available in 40 mm, 80 mm, and 120 mm stroke models and offers a resolution of 0.02 µm, a measuring accuracy from 1.5 × (3L/1000) µm, a maximum drive speed of 200 mm/s (1 axis) and has a maximum acceleration of 0.4 G (1 axis). In addition the unit supports probes including: TP200+PH6, SP25+PH6M and QVP (QuickVision Probe).

For more information:
Mitutoyo America Corporation
Phone: (888) 648-8869
www.mitutoyo.com

Norton Abrasives

LAUNCHES NORTON VITRIUM3

Norton Abrasives, a brand of Saint-Gobain, has developed and launched Norton Vitrium3, the next generation of bonded abrasives products, engineered for maximum performance and cost savings in precision grinding. An entirely new abrasives platform, Norton Vitrium3 features a patent-pending bond technology developed by the Saint-Gobain Abrasives R&D team. This bond features an exclusive chemistry that promotes excellent grain adhesion, resulting in improved product versatility across a wide range of applications. Substantial performance improvements with Norton Vitrium3 are now attainable in all Norton abrasive grains, from proprietary Norton Quantum ceramic alumina to conventional aluminum oxide.

Norton Vitrium3 has three major features and benefits over standard vitrified bonds:

1. A stronger bond construction allows superior form and corner holding for improved part quality and higher tolerances, reduced dressing time and wear, as well as the ability to meet the higher wheel speeds demanded of today's equipment.
2. An improved holding power utilizing less bond-to-abrasive ratio. This allows increased exposure of the abrasive grains for an improved cut rate and significantly less burn, while reducing power consumption and grinding forces on the part.
3. An increased porosity improves coolant flow and chip clearance to eliminate burn or other part damage, especially on today's tough-to-grind materials, such as high nickel alloys, tool steels and chrome.

"Whether the goal is to reduce total cost per part, increase throughput, or improve workpiece quality, Norton Vitrium3 is re-shaping the world of precision grinding to meet these needs," said Scott Leonard, director of product management at Norton Abrasives. "This new technology will allow significant increases in production and also introduces the possibility of grinding instead of conventional machining on some operations."

For more information:
Norton (Saint-Gobain)
Phone: (508) 795-2833
www.nortonabrasives.com

Hexagon

RELEASES OPTIV CLASSIC 443 TP

Hexagon Metrology recently announced the release of the Optiv Classic 443 tp, the newest model in the Optiv Classic series. Each unit comes touch probe-ready and includes a high-resolution CCD (charge-coupled device) camera for multi-sensor applications with micro- to nano-scale precision measurement requirements. The Classic 443 tp boasts a first term accuracy of 1.9 microns, making it suitable for the inspection of small-scale features and parts like micro-hole dies, sieves, filters, fiber optics and inkjet nozzles as well as complex, densely populated precision parts from the medical, aerospace, electronics or automotive industries. This entry level, high-capacity multi-sensor CMM (coordinate measuring machine) provides over five times the measurement volume of its smaller brother, the Optiv Classic 321GL tp. Attendees of HxGN Live, Hexagon Metrology's annual international user group meeting, previewed the new product and the Optiv Classic product line June 3 – 6 in Las Vegas, NV.

Highlights of the Classic 443 tp's innovative vision technology include calibrated lighting, a high resolution color CCD camera, and a multi-segment LED triple angle ring light to create better contrast for edge detection. The multi-sensor CMM features a 12x CNC motorized zoom for continuous adjustment of field of view and resolution, and an LED status indicator providing a quick visual check of the machine's status.

The Classic 443 tp comes standard with *PC-DMIS Vision* image processing software and optional online 3-D CAD capabilities for live programming of the machine to compare measured values to nominals. The software includes the groundbreaking MultiCapture feature which finds all 2-D characteristics in the field of view, regardless of their type, and measures them simultaneously. MultiCapture then moves the camera to the next cluster of features and measures them. This sequence continues until the inspection program is complete, and is automatically optimized by creating the most efficient path with the fewest number of stage movements. Inspection speeds increase by 50 percent or more, depending on feature size and density, which can significantly raise throughput.

"The Classic 443 tp offers increased capacity, without sacrificing accuracy, in a truly innovative multi-sensor CMM," states Dan Farnsworth, product manager for Hexagon Metrology. "The increased measurement volume makes it ideal for palletized parts and offers good accessibility to the measuring table from all sides. It is the perfect fit for high-volume measurement of small, tightly toleranced parts."

For more information:
Hexagon Metrology
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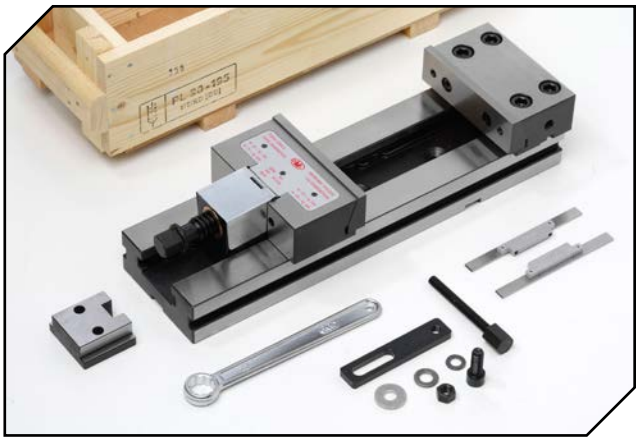
Lexair

DELIVERS WORKHOLDING SOLUTIONS



OML's MC Modular Workholding System uses fixed and movable vise jaws and patented self-locking CLAK parallels to achieve multiple clamping solutions and increased part accuracy with less set up time. Unique features on the MC vise include snap-in, self-locking middle-jaw CLAK parallels that are held in place when the vise is opened in the vertical position, making it ideal for use on tombstones. The CLAK system allows for quick-change of parallels, angular parallels, soft jaws and "V" jaws, making part changeovers and size changes quick and easy. A unique tapered-jaw design pulls the workpiece down against the parallels as the vise is closed, eliminating the need to hammer the part down.

The MC vise is designed for quick changeovers with a moveable clamping jaw that can be lifted from the base, shuttled to the next position and lowered into place for a different size workpiece. Held in place with a toggle locking mechanism, the moveable jaw unlocks from the base with a flip of the wrist. By relocating the clamp jaw close to the workpiece, the length of the clamp screw can be kept short, minimizing jaw distortion under high force.

The clamp screw can also be replaced with a hydraulic cylinder for automated operation. The MC vise accommodates jaws with rolls, GRIP jaws, aluminum jaws, middle jaws, jaws with grippers UGE, Plus 3-D jaws and floating side-ways for raw workpieces. Various jaw adapters, including one for Kurt jaws, allow the use of legacy vise accessories. Adding to their versatility, the vises are easily transported between machine tools. The 6 in. × 8 in. (150 mm × 200 mm) base with a simple clamping system weighs only 55 lbs. (25 kg).

The base length determines the vise's clamping capacity and the jaws can be used with any base configuration, providing a flexible workholding solution with minimum investment. Bases are 6 in. wide (150 mm) and available in 8 in. (200 mm), 10 in. (250 mm), and 12 in. (300 mm) lengths. An 8 in. (200 mm) × 12 in. (300 mm) base is also available, as well as two extended length MC-XL models, with lengths of 21.5 in. (545 mm) and 26 in. (655 mm).

All components are constructed from oversize steel profiles and are case hardened and precision ground to ensure exceptional flatness and durability. Wear parts are specially treated for a surface hardness of 50/60 HRC, and all non-ground surfaces are burnished to protect against corrosion.

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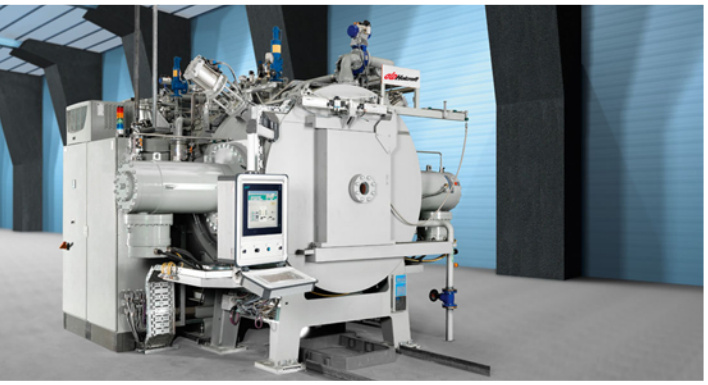


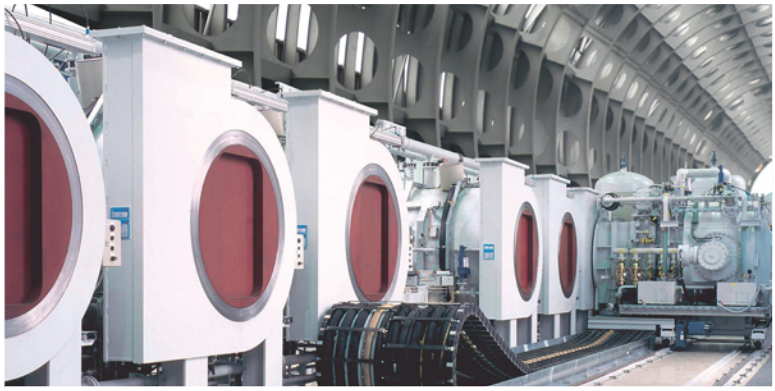
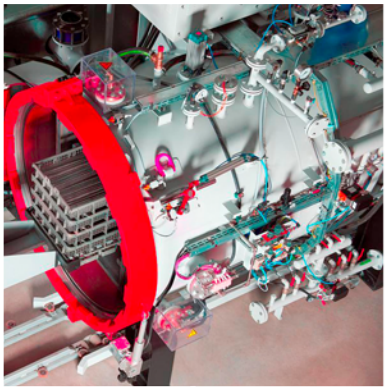

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Polygon Solutions

IMPROVES PROCESS FOR MEDICAL IMPLANT BROACHING

Innovation in orthopedic medical implants continues to improve. As a result, manufacturing processes required to make those parts are adapting. Polygon Solutions Inc. manufactures rotary broach cutting tools for the precision machining industry, and is expanding their product line to include innovative tools used for machining orthopedic implants.

The most well-known orthopedic implant is likely the bone screw. Bone screws have typically been made from materials that can resist various forms of bio-corrosion. Stainless steel and titanium have been popular metal materials. Although research continues into more organic materials and coatings, titanium is very popular, and this presents certain challenges to machining.

Machining the outside contour of the titanium screw and the threads is a turning operation, and has been addressed quite well by the tooling industry and innovative thread whirling tools. However, adding the hole for a screw driver is still challenging, and early broaching technology is constantly revisited. Once the domain of rotary broaching tools, pecking and shaping type operations are becoming more popular.

The latest advancement is to use a standard rotary broach without the rotary broaching tool holder. The broach is locked into position using a tool holder or collet, and pecked or punched into the part's pilot hole in small increments. If the chip accumulation begins to interfere with broaching, the broach can be removed, the chips drilled out, and then the broach can be brought back into the hole and broaching can resume.

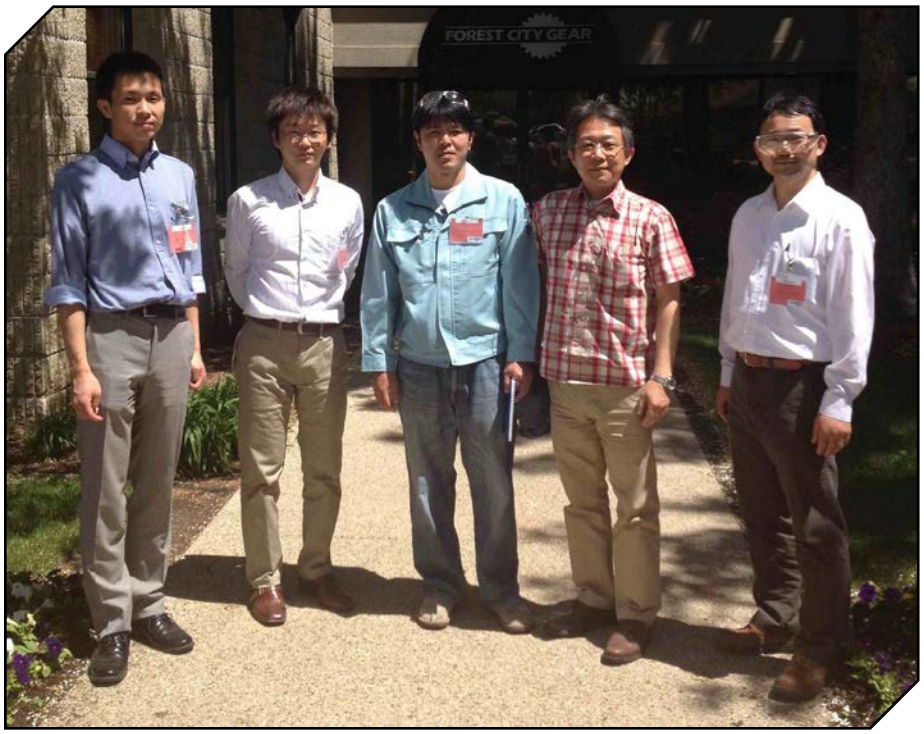
The hexagon form is still the most popular. The hexagon removes a smaller amount of material in the corners of the pilot hole than a square or hexalobular form. However, sometimes due to depth of hole, or need to broach full form without an oversize pilot hole, or large hex sizes, broaching is unsuccessful due to excessive pressure.

In this case the punch broach can form a rectangle 1/3 the hexagon form. After broaching the first rectangle, the part (or possibly the broach) can be rotated sixty degrees and broached again. After repeating one more time, a hexagon has been created without the force required to punch full form.

For more information:
Polygon Solutions Inc.
Phone: (239) 628-4800
www.polygonsolutions.com

Leading the Way in Lead Crown Correction and Inspection

Forest City Gear applies advanced gear shaping and inspection technologies to help solve difficult lead crown correction challenges half a world away. But these solutions can also benefit customers much closer to home, the company says. Here's how…



Gleason Asia Co., Ltd.'s T. Utsugi, on the far left with Forest City Gear's special guests from Japan.

Bring it on, says Forest City Gear's Fred Young.

Some might think it unusual that Gleason Asia and its customer, a Japanese aerospace parts manufacturer, would travel thousands of miles to contract with Roscoe, IL's Forest City Gear to produce prototypes of a titanium turbine part for an aerospace application. But for Young, it's all in a day's work. "We have a good reputation amongst many Japanese manufacturers as a 'can do' company," Young says. "And we're not averse to taking on challenges — even when it's something this exotic."

'Exotic' might be an understatement. This particular aerospace turbine part has an external gear with a design that calls for crowning 70 teeth. Unlike most crowns, which are generally produced on both flanks and are relatively easy to produce since they're centered symmetrically right at the mid point of the face width, this crown is asymmetrical, and with an allowable lead tolerance of just two microns (.002 mm, .000080") at the 'knee' of the crown. (Note that the crown is unusual in that it resembles an involute K chart.)

Ultimately, this Japanese manufacturer will produce these gears and perform the crowning on a new Gleason P 600 ES Gear Shaper with ES electronic guide capability, but until that machine arrives later this year, they're relying on Forest City Gear to carry the load.

Not coincidentally, Forest City Gear has years of experience running Gleason P 300 ES and P 500 ES Gear Shapers, and has long been an advocate of crowning as a highly effective way to reduce noise, and minimize misalignment problems that might exist in housings, shafts, gearboxes or bearing journals. Gears sometimes have a load differential on the two flanks as well, requiring a modification of the involute to compensate. Crowning also reduces lead problems in the gears themselves, which, over time, can cause the gears to wear unevenly and even bind because of eccentricities and position errors. (The crowning or barreling of the teeth naturally localizes contact bearing in the center of the teeth rather than toward the edge where the teeth would be more subject to stress.) While gear manufacturers have known about the benefits of crowning for some time and have often created the desired crown while hobbing or, more commonly, post-hobbing (or shaping) with a *shaving* operation, Forest City Gear has championed the use of its Gleason ES Shapers for this work, because both the crowning and cutting can be done simultaneously, thus eliminating the time and cost of an additional shaving operation.

And there are other benefits as well. According to Gleason Senior Product Manager John Lange, who is well versed in gear shaping technology, there might be only one or two gear jobbers in the world that could perform this particular operation, meet these accuracy requirements, and verify the results in its own gear inspection lab right on-site. "Crowning both flanks simultaneously is relatively common and can be done even on shapers that rely on a traditional modified back-off cam to create the desired shape," says Lange. "But these cams can cost upwards of $5,000 and take 4–6 weeks to design and produce." Furthermore, Lange says, the asymmetrical nature of this crown and the required accuracies would make it virtually impossible to produce unless the machine has an electronic guide such as the one equipped on the Gleason ES Shaper.

Gleason's ES electronic guide technology uses software and CNC programming to replace mechanical components like a special crown modified backoff cam.

The cutter's rotational motion can be programmed, as the cutter passes through the part, to make a left-hand helix angle, and then a right-hand helix angle, which together create the desired crown shape along the face width of the

tooth flank. Both teeth are cut simultaneously without a crowned surface, but on the flank requiring the crown enough stock is left to then finish just the crowned flank in a final pass. (Note in the pictured lead chart that the left flank is not modified — only the right flank.)

As one might imagine, the project was not without its challenges, recalls Young. "We realized early on that we hadn't asked for enough parts to dial in the machine without running the risk of scrapping a $20,000 or $30,000 titanium part, so we made our own test parts out of softer, less expensive steel to use before we cut the actual titanium parts," he says. "Our gear inspection lab was also challenged with the inspection criteria — 70 teeth, 100 percent evaluation of the two micron tolerance band on the crowned lead — and many process variables such as the two different material types and even the effects of removing the coating from the shaper cutter at some point to improve quality."

Where quality takes shape. "When I show others the crowning inspection results and ask them how we achieved this two-micron tolerance, they naturally conclude that the teeth have been finish ground," Gleason's Lange says. "They're amazed when they find out it's all done on the ES Gear Shaper."

Credit Forest City Gear's Quality Manager Amy Sovina and her team for their role in employing Forest City Gear's gear inspection assets to help make the project a success. According to Sovina, Forest City Gear's Klingelnberg P65 CNC Analytical Gear Checker was key to speeding the complete evaluation of this part and its particularly challenging lead crown.

As far as tackling the most challenging gear production jobs, Young wouldn't change a thing. "It stretches us as a company, and makes all of us better, each and every time we take on a project like this that we've never seen before," concludes Young. "More companies should be doing lead crown correction like this. We know just the place."

For more information:
www.forestcitygear.com

Forest City Gear's investment in analytical gear inspection equipment played a critical role in the success of this particularly challenging lead crown correction project

Wanted: Custom-Made Machine Tools

Quality, productivity, service and support required

Matthew Jaster, Senior Editor

Liebherr's LC500 will be demonstrated during Gear Expo 2013 (courtesy of Liebherr).

Is the customer always right? Is this phrase as relevant today as it was when it was championed as a slogan for Marshall Field's in Chicago or London's Selfridges store in the early 20th century? Nobody on the planet is right 100 percent of the time, are they? It doesn't matter what they're buying. In reality, the phrase *if we don't take care of our customers, someone else will*, seems to make much more sense.

The machine tool industry is as competitive as ever. New machine technologies, materials, coatings and software upgrades are changing the way gears are being manufactured. Companies like Gleason, Liebherr, Kapp/Niles and DMG/Mori Seiki spend plenty of time and resources on R&D to develop the best products for the gear market. More importantly, these companies engage with (and listen to) customer requests.

What can be done to make their products better? How can they increase quality? How important is service and support? With these questions in mind, it seems appropriate that both the upcoming EMO and Gear Expo trade shows offer machine tool manufacturers an opportunity to reach out to their customer bases and find out what they actually *want* and *need* heading into 2014. If you take care of your customers, nine times out of ten, they'll take care of you.

Gleason is expanding its inspection systems with the 300GMS (courtesy of Gleason).

Gleason Maintains Continuous Improvement Philosophy

Known for developing, manufacturing and selling machines for all aspects of the gear industry, Gleason Corporation has spent 2013 demonstrating their latest gear capabilities including new metrology solutions, profile grinding options, power skiving technology and the newest version of *GAMA* software (*GAMA 3.0*). The company plans to introduce the 300GMS, the latest addition to its GMS Series, at Gear Expo 2013.

Alan R. Finegan, director, marketing at Gleason Corporation, believes that suppliers of gear technologies are facing the same challenges of other manufacturers in 2013. "Customers demand and expect superior productivity, quality, on-time delivery and responsiveness with a lower total cost of ownership. Those suppliers who can meet those demands on the global stage will be the winners," Finegan said. "In terms of machine tool production, the United States has fallen to 7th in the world but is still 4th in consumption of machine tools behind only China, Germany and Japan, so it is still a significant market. For Gleason, the U.S. market has been fairly healthy during the post-recession years as customers continue to invest in manufacturing technology."

According to Finegan, the latest trends that will impact the gear industry the most include greater growth in emerging markets, alternative energy, design concepts to conserve energy (8-9-10-speed transmissions, CVTs, etc.), additive manufacturing, new materials and new coatings. "The list could go on and on. We monitor the end-users of gears, the applications, the broader global trends, etc. on an on-going basis, and determine if and how those changes and trends impact the products and services we provide."

Gleason's goals and priorities are not limited to machine tools, but relate as well to providing total solutions to the market. "We will continue to develop machines, processes and tools that provide our customers with a competitive edge and do so by providing the highest

level of service and overall value in the market," Finegan said.

Service and support, for example, are playing an increasing role in the competitiveness of machine tool sales. "Customers want to know how well we can support them over their product's life, and we know we must differentiate ourselves to win customer confidence. How? With a global, connected, continually trained workforce supported by robust processes, strategies and systems to rapidly respond to customer needs. Gleason has purposefully invested over the past five years to maintain a continuous improvement philosophy to be the best at what we do and to continually adjust to ever-changing market demands. Our business metrics trend our improvements, but more importantly customer feedback has been very positive."

The dialogue between customer and supplier is vital in the gear industry today. "We routinely receive requests from customers for specific functions, features and capabilities," Finegan said. "But our R&D efforts include investment not only in machine tool technology, but in gear and process technology. Aside from specific requests, however, it is important to continuously monitor the broader trends in manufacturing that are occurring in our end markets and to respond accordingly."

Trends that include the multifunctional platform, a logical extension of a trend in the broader metalworking market, according to Finegan.

"Technology has allowed machine producers to respond to market needs for reduced costs and higher quality. Gleason has responded with Agilus, our own multi-functional platform, as well as adding integrated chamfering and deburring, on-machine inspection and other features to some of our products," Finegan said. "While more conventional gear manufacturing equipment will continue to dominate, the multifunctional machine concept has its place in the gear industry, and is especially applicable to certain part configurations and sizes, and certain production volumes."

Liebherr R&D Efforts Pay Off

Liebherr Gear Technology Inc. announced a new partnership earlier this year with Wenzel America to exclusively represent the GearTec product line in the United States and Canada. Additionally, many of the company's new technologies and solutions will debut at EMO Hannover and Gear Expo 2013 thanks to an emphasis on R&D during the latest economic slowdown.

"For this market, I think the slowdown after two very successful years has been a real challenge," said Peter Wiedemann, president of Liebherr Gear Technology, Inc. "After the crisis in 2009, the U.S. industry really overwhelmed the suppliers with orders and now machinery and equipment is slowing down significantly. It's the same in Europe and in China as well. The very slow market needs to bounce back. Fortunately, we put a lot of effort into R&D during this time and

The LC500 is available in both automatic and manual operation modes (courtesy of Liebherr).

we have plenty of new products and technologies to show at EMO. The economic slowdown helped us in a certain way because it gave us time to focus on internal process optimization. Our lead times needed improvement as well as our throughput. We also focused more on the high level of customization of our machine tools. All of this goes hand-in-hand."

Custom requests and advanced machining solutions have really made it difficult to sell standard machines anymore in the gear industry, according to Alois Mundt, managing director at Liebherr Verzahntechnik GmbH. "Many of our technologies and solutions (60 percent) come directly from our customers," Mundt said. "It takes a tremendous effort from everyone involved to design our machine tools. Selling standard machines would help us move forward as a company, but it would not help our customers. Our priority is to show them how we can make a gear faster, cheaper and at a much higher quality."

"A good example of addressing the needs of our customers has to do with integrating our own gear cutting machines with our automation capabilities," added Wiedemann. "Many customers want to run these machines during night shifts so we have to integrate measuring, ensure corrections are done automatically, etc. It presents a whole new set of challenges. When our customers have specific requests it forces us to go to the next level to make our machine tools smarter."

In addition to automation, Liebherr has increased its service and support capabilities to ease customer requests. "Machine tools are very expensive. They have to work 24/7 and service has to be available if something goes wrong. You need a strong presence in the market to ensure that your customers are getting everything they need when they need it. With the variety of products that Liebherr offers, service and support can be a challenge," Mundt said, "but we've done a great job adapting to the global marketplace."

"We've implemented remote diagnosis from our Saline, Michigan location, for example. This gives us greater flexibility in this market. The time difference becomes less a factor," Wiedemann added. "Now we can dial-in and resolve any issues right after a machine is delivered. This can be minor repairs, training questions or just standard control issues that frequently come up."

"We've been doing these remote diagnostics from Germany since 1989," said Mundt. "But in 2011, we began to focus on the North and South American markets and realized there was a need to increase our service and support efforts."

While the industry continues to evolve into multifunctional machining technologies, Liebherr is focusing its efforts on modular setups that have worked so well within the automotive industry. "There are obviously limitations for these multifunctional machines outside of special parts," Mundt said. "Our philosophy is to keep it as simple as possible. With automation and separate machine units working together there is absolutely no contact with people between the various gear processes. We're trying to accomplish the same thing that has been so successful with engine lines. Automation in combination with aligned dedicated machines is the direction we feel this is going."

Star SU Expands Integration Solutions

Star SU will feature a video presentation of the Samputensili G250 Vertical CNC Grinder (for automotive and high production applications at Gear Expo 2013. David Goodfellow, president, Star SU LLC, hopes to achieve "a balance of providing awareness of the latest products and technology at Gear Expo along with making an impact at EMO Hannover during the same week."

Customer requests play a large role in the solutions Star SU and its partners provide. "The company regularly receives requests to integrate other processes on machines including gaging, chamfering/deburring, drilling, etc."

Goodfellow sees a trend in increased productivity and quality requirements in the gear industry and plans to expand Star SU's role as an integration solutions expert for machine tools, including workpiece holding, perishable tooling, gaging and automation —which go beyond selling a stand-alone machine. "We've aligned with excellent partners and solutions providers to be able

The Samputensili G 250 has been developed for very low cycle times and for top-quality and efficient mass production of gears (courtesy of Star SU).

to support total integrated systems," he added.

Today Star SU is enjoying the opportunities available in the domestic automotive market. "North America is still performing well especially in the automotive sector where vehicle production has continued to increase," Goodfellow said.

Support is one area that is providing challenges for Star SU in 2013.

"We are challenged to supply a broader range of support activities within customer facilities," Goodfellow said. "We're managing this by extending full product and manufacturing support activities with Star SU onsite engineers."

Star SU is looking forward to both EMO and Gear Expo and the opportunities these trade shows provide to the machine tool market; EMO for its depth and global reach and Gear Expo for its emphasis on gear manufacturing. "The single biggest advantage of Gear Expo is that this focused trade show carries with it a focused customer base," Goodfellow said.

Kapp/Niles Shorten Lead Times

The Kapp Group offers gear machines, tools and processes for the special requirements of its customer base. Highlights at this year's Gear Expo include the Kapp/Niles ZE series with advancements in abrasive technology and grinding speeds. Additionally, R&P Metrology, a company now represented by Kapp in the United States, will show the RPC PM 750/1000 portable gear inspection machine. "This technology has never been shown in North America before," said Bill Miller, vice president sales, Kapp Technologies.

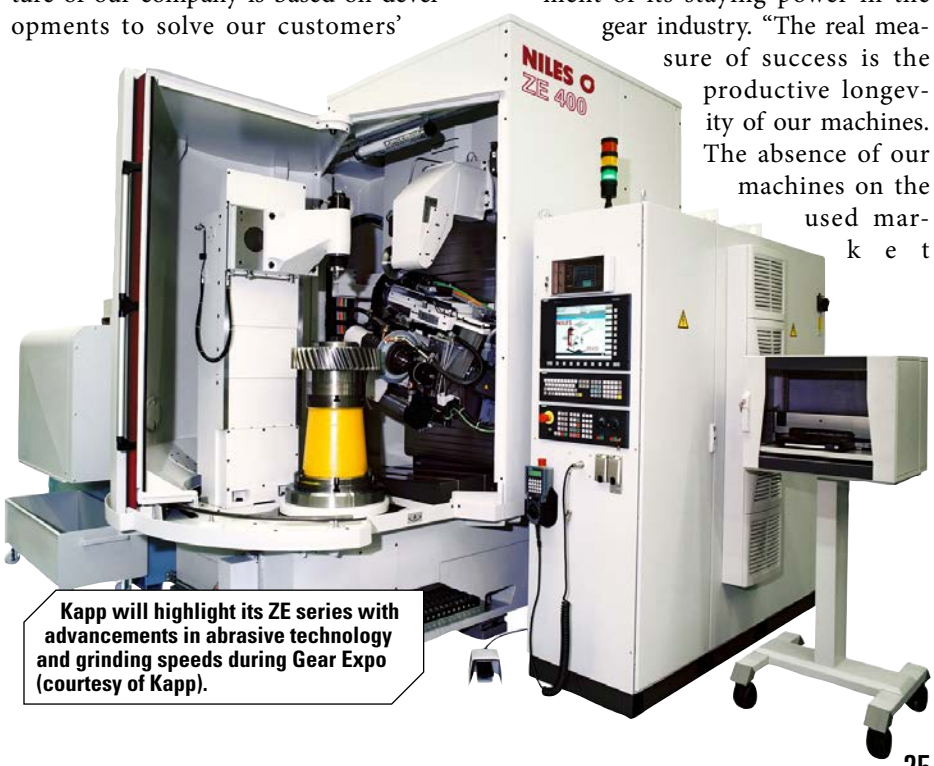
In 2013, Kapp Niles continues to grow organically by adding capabilities to its machines and services. "We offer the broadest range of grinding machines in the market and serve a diverse group of market segments," Miller said. "The culture of our company is based on developments to solve our customers' unique challenges. Our product development team seeks to anticipate new challenges to be ready when the opportunity arises."

According to Miller, the North American market exhibits a consistent demand for innovation as well as value-based machines. "Markets outside North America consume the lion's share of machinery; however there is more volatility in regional demand," he added.

Challenges in 2013 include delivery requirements. "To this end, we make consolidated forecasts in order to fill the pipeline with machines and shorten lead times for our customer-partners. This has proved to be very successful for us," Miller said.

Kapp has been following gear machine integration since the early days. "Multifunctional machines are not new. The technologies of CNC, live spindles and automatic tool changers have been progressing for 30 years. Computing power, application-specific software, and flexible clamping system development further increase the market. Our experts must be knowledgeable about the diverse processes on these machines to grow the market even more. And in order to leverage resources, cooperation between companies is necessary," said Miller.

The long term service and support Kapp/Niles provides is another element of its staying power in the gear industry. "The real measure of success is the productive longevity of our machines. The absence of our machines on the used market



Kapp will highlight its ZE series with advancements in abrasive technology and grinding speeds during Gear Expo (courtesy of Kapp).

and the high value placed on those that are available, is an indicator of this. We have a customer that has been running a Kapp VIG machine for around thirty years who said he would not trade in his Kapp for any machine on the market, even a newer model. The cycle-times continue to impress him, and except for regular maintenance the machine never needs servicing."

Moving forward, Kapp/Niles will continue to grow organically by adding capabilities to its line of machine tools. "We offer the broadest range of grinding machines in the market, and serve a very diverse group of market segments," added Miller. "Serving all market segments equally well continues to be our priority."

DMG/Mori Seiki Increases Market Presence

If you weren't sure DMG/Mori Seiki had more than a passing interest in the gear manufacturing industry, the company held its record-breaking Innovation Days (Hoffman Estates, Illinois in May 2013) with an entire day dedicated to gears. By expanding their portfolio of gear technologies, DMG/Mori Seiki continues to acquire more business in the gear market.

DMG/Mori Seiki Manager, Advanced Solution Development Nitin Chaphalkar, and Nicklas Byland, InvoMilling project manager at Sandvik Coromant, presented the InvoMilling process during the show. InvoMilling is a machining technique that allows faster, more efficient production of spur and helical gears in multitask machines and machining centers. The new technology was a highlight for many attendees as the need for flexible manufacturing increases, according to show organizers.

"DMG originally focused on large gears that were complex and difficult to do," said Chaphalkar. "With InvoMilling as well as our DMG *gearMILL* software, we're able to show our customers that our machines are capable of doing many different things. It's a two-way process, a customer tells us what they'd like to see in a machine tool and then we try to solve the problem. Once they see they can make different types of gears on one of our machines, they begin to ask about additional gear types and sizes."

Some recent developments from DMG/Mori Seiki include worm gear grinding using CBN wheels and a hybrid process that combines hobbing and InvoMilling on the NT5400. "With InvoMilling, you're getting a much nicer surface finish and the hobbing process offers significantly improved cycle times. This process combines the best characteristics of both solutions and gives the customer versatility," said Chaphalkar.

So where can the multifunctional machine tool offer the greatest advantage to the gear customer? "I think the universal gear cutting machine is one area that offers huge advantages in the gear industry," said Chaphalkar. "This is where customer reactions really come into play. Instead of being locked into a traditional solution, this universal machine can be optimized and customized to fit your individual needs. Here you can make a part with a gear and not just the gear itself. The customer doesn't need to install three machines to make a single part, it's basically one and done. As our tooling, software and machines continue to advance, so will our capabilities in the gear market."

Gear measurement is one area that DMG/Mori Seiki is continuing to examine with leaders in the inspection industry. "Gear measurement is a huge challenge in 2013. There are significant benefits for the larger parts if we don't have to take them out of the machine for measurements. We're aggressively working with inspection companies to come up with advanced solutions that will give our machine tools even more flexibility," said Chaphalkar.

Another area that is getting much attention in 2013 is training both internally and externally. "We're putting together an intensive training program to support our employees and our customers. We'll be rolling out some new training initiatives in the near future. Many of these techniques will be applied toward the gear industry," said Chaphalkar.

In the future, DMG/Mori Seiki will continue to develop new solutions and custom machine tools where they are needed. "This gives our customers more control over the equipment they're investing in," Chaphalkar said. "The integration of operations can significantly impact the workflow and it can reduce the overall time a part spends on the factory floor. We're really starting to see the impact this can have on our customers within the gear industry."

DMG/Mori Seiki's Innovation Days featured an entire day dedicated to gear manufacturing (photo by David Ropinski).

For more information:

DMG/Mori Seiki
Phone: (847) 593-5400
www.dmgmoriseikiusa.com

Gleason Corporation
Phone: (585) 473-1000
www.gleason.com

Kapp Technologies
Phone: (303) 447-1130
www.kapp-niles.com

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Crash Course on New Technology

AGMA Reflects on Gear Expo 2013

Matthew Jaster, Senior Editor

It's nice to see old friends. It's also advantageous to make new ones. Gear Expo has always been a family reunion of sorts, but it's first and foremost an opportunity to show off the latest and greatest technologies that are impacting the gear industry today. With this in mind, *Gear Technology* recently spoke with those responsible for putting the Fall Technical Meeting (FTM) and Gear Expo 2013 together in Indianapolis. We learned that the show is growing, technology is playing a larger role and that education is vital to Gear Expo's success.

"While there are plenty of advantages to attending Gear Expo, I think it always comes back to the new technologies and new gear applications," says Joe Franklin, AGMA president. "This is an opportunity to improve what you do with your business."

Within a five-day period, visitors to Indianapolis have an opportunity to hear the latest technical presentations at the FTM, browse the Gear Expo and ASM Heat Treat exhibit halls and attend short courses taught by leading gear industry professionals like Ray Drago and Robert Errichello.

"Gear Expo 2013 features a broader range of exhibitors covering the entire gear manufacturing process," says Jenny Blackford, AGMA director of marketing and communications. "There are also a good number of gear manufacturers who are there to talk with gear buyers. It's a great mixture. We're happy to report that the 2013 show is about 20 percent larger than the 2011 show in Cincinnati, in fact, it's the largest Gear Expo since 2001."

FTM Kicks Off Festivities

The great thing about the years that the FTM coincides with Gear Expo is the educational opportunities throughout the week. "They don't end with the FTM," says Charlie Fischer, AGMA vice president/technical division. "Joe and Jenny have helped put together an education program that continues during the show. Whether you've been in the industry for 20 years or you're just now getting involved, there's a variety of topics and presentations available."

Fischer enjoyed a great response for the FTM call for papers this year and is excited to deliver a variety of technical presentations on spline design, heat treat distortion, an update on new machine tool technology and bearing and gear failure analysis to name a few.

"These are the kind of practical papers our industry likes to see," Fischer says. "Hopefully, we're sending people home with information they can use as soon as they get back to the office."

Additionally, this year's FTM will be broken down into five segments including heat treating, gear manufacturing, gear design, failure analysis and gear drive components. "We welcome attendees to sign up or participate in a single session if they're only interested in certain areas or want information on a particular paper," Fischer adds.

The FTM/Gear Expo event is also pivotal in providing opportunities for up and coming gear engineers. "This has to be one of our priorities moving forward," Fischer says.

Franklin agrees. "We're seeing a huge influx of young engineers in the gear community. Two years ago in Cincinnati, one of the industry's old hands came up to me and said 'Am I in the right place? I don't recognize anybody.' Of course, it's an overstatement, but we're noticing that the gear industry is doing a nice job bringing in younger engineers and sending them to technical and professional events like Gear Expo. This is a good sign for the future and it's important for those already established in the industry to get to know the new talent coming in."

What's New in Indianapolis?

Although Gear Expo is returning to the Indiana Convention Center, the 2013 trade show will look nothing like it did in 2009. "We're utilizing a new section of the convention center. The layout is different and the move brings us a little closer to the restaurant and entertainment district," Blackford says. "Those that attended the 2009 show in Indianapolis will have an entirely new experience in 2013."

Technology is also playing a larger role in 2013 for AGMA. "We're releasing our first mobile app in August, the Gear Expo app. It will be available to Android, iPhone and iPad users and will basically put the show program into the pockets of attendees," Blackford adds. "We're still offering the regular show program, but this mobile app will let you search for a particular exhibitor or product, customize your Expo schedule and let you digitally map what you'd like to accomplish and who you'd like to see."

Social media also has an increased presence at the show. "Twitter updates will be available on digital interactive displays throughout the show," Blackford adds. Free Wi-Fi will make it easier for visitors to utilize the Gear Expo app and connect with exhibitors and attendees via social media. "With options like this, we feel it will be that much easier to network and increase interaction between visitors and exhibitors."

Once again Gear Expo will be co-located with the ASM Heat Treating Society Conference and Exhibition. In fact, plans are already in place to partner up for the 2015 show. "This has been a very successful collaboration so far and we'd like to continue to work with the ASM in the future," Blackford says.

The joint education course between AGMA and ASM that was well attended in 2011 also returns in 2013. "This course is on gear materials in the morning and heat treatment in the afternoon with three instructors from AGMA and three instructors from ASM," Blackford says.

There will be a total of 24 presentations at the Solutions Center, running each day from 9:30 until an hour before the show ends. Highlights include an economic forecast, international trade and a session on 3-D technology.

"3-D printing is an interesting topic," says Franklin. "We're not sure exactly where the technology is going and what role it might play in our industry. Some people are interested and others aren't convinced it's going to have an impact. We believe, however, that it's important enough to at least put someone on the stage to talk about it. Our job is to represent all the new technologies and solutions and put them out there if we can."

If you only have one day to come to Indianapolis, Blackford suggests Tuesday, September 17 might be the best bang for your buck.

"You have a great opportunity on Tuesday to pick and choose from a variety of events. You can attend a session or two of the FTM in the morning and spend half the day on the exhibit floor. If you're relatively new to the gear industry, the Training School for Gear Manufacturing takes place on Tuesday as well as the popular economic forecast keynote."

Year in and year out, AGMA plans its various events based on the feedback it receives from its members and the industry as a whole. "We listen to all suggestions, criticisms and ideas. We try to incorporate these into our events," says Franklin. "It's gratifying for us to see the broad, wide-spread support for Gear Expo year after year."

"Gear Expo 2013 features a broader range of exhibitors covering the entire gear manufacturing process. There are also a good number of gear manufacturers who are there to talk with gear buyers. It's a great mixture. We're happy to report that the 2013 show is about 20 percent larger than the 2011 show in Cincinnati, in fact, it's the largest Gear Expo since 2001."

Jenny Blackford, AGMA

The Gear Industry Outlook

With access to market forecasters, its own members and other gear industry leaders, AGMA is a great resource to gage the current state of the industry as Gear Expo 2013 draws closer.

"If you're not making automobiles or aerospace components, your business has probably slowed down a bit recently," Franklin says. "Europe is facing a lot of economic difficulties. The demand in China is not there for gear products like it used to be. Most of the action for 2013 and 2014 will be in the United States. While the market forecasters we've talked to suggest the gear industry will be down a couple of percentage points in 2013, they believe 2014 should be a year of recovery."

With international exhibitors from Europe, China, Japan, India and Australia, attendees will have a unique opportunity at Gear Expo to get some feedback on the global gear market. All in all, gear manufacturing is following the same trends and forecasts as manufacturing in general.

To make the trip to Indianapolis as productive as possible, Franklin goes back to his comments on technology and education. "Visitors will conduct buying and selling on the show floor, but Gear Expo is really all about learning what's new in the industry. Even if you can't apply some of these things today, you may find something useful that you can implement a year or two from now. This is the real reason to attend. You'll be hard-pressed to find as much new technology (specific to the gear industry) in such a short period of time."

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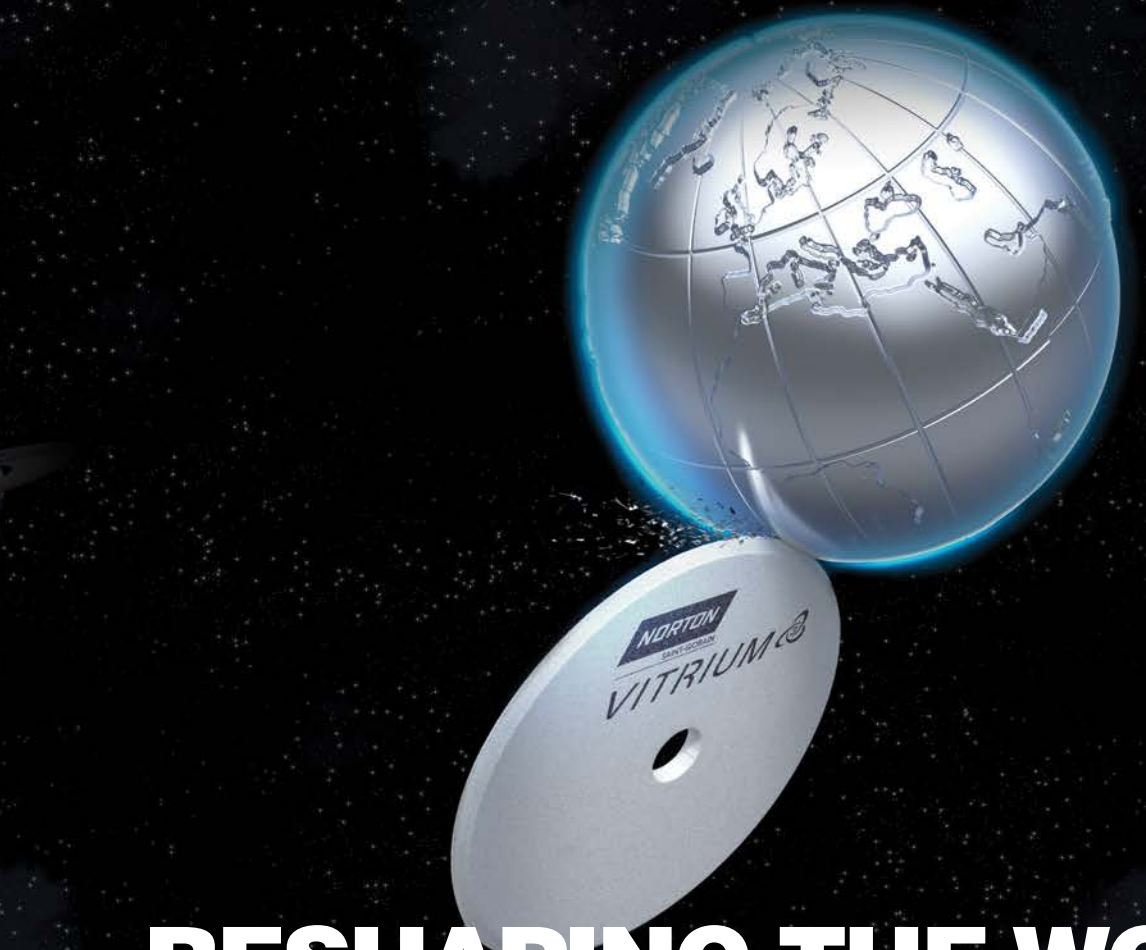

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Gear Expo 2013
An Oscar-Worthy Indy Production

Jack McGuinn, Senior Editor

Show Dates

Tuesday 9:00 am–6:00 pm
Networking Reception: 5:00 pm–6:00 pm

Wednesday 9:00 am–5:00 pm
Thursday 9:00 am–4:00 pm

WHERE
Indiana Convention Center
100 S. Capitol Avenue
Indianapolis, IN 46225
Phone: (317) 262-3400
(Note that a weather-proof pedestrian connector allows guests to walk from the Indiana Convention Center to 12 premium hotels including the Westin, Hyatt, Marriott, Conrad, Omni, Crowne Plaza at Union Station, Embassy Suites and JW Marriott.)

Gear Expo 2013 Schedule

Saturday, September 14
Registration Open 10:00 am – 5:00 pm

Sunday, September 15
Fall Technical Meeting 7:00 am – 5:00 pm
Registration Open 7:00 am – 5:00 pm

Monday, September 16
Fall Technical Meeting 7:00 am – 5:00 pm
Registration Open 7:30 am – 6:00 pm

Tuesday, September 17
Fall Technical Meeting 7:00 am – 5:00 pm
Registration Open 7:30 am – 6:00 pm
Training School for Gear Manufacturing 8:00 am – 12 noon
Where Do I Start? The Preliminary Gear Design Thought Process 8:00 am – 4:00 pm
Exhibit Hall Open 9:00 am – 6:00 pm
Why Bearings Fail 1:00 pm – 5:00 pm
Networking Reception 5:00 pm – 6:00 pm

Wednesday, September 18
Registration Open 7:30 am – 5:00 pm
How to Organize and Manage a Failure Investigation 8:00 am – 4:00 pm
Exhibit Hall Open 9:00 am – 5:00 pm

Thursday, September 19
Registration Open 7:30 am – 4:00 pm
Inspection Criteria for Gearboxes 8:00 am – 4:00 pm
Materials Selection and Heat Treatment of Gears 8:00 am – 4:30 pm
Exhibit Hall Open 9:00 am – 4:00 pm

We are well into an odd-number year, so it must be just about time for another Gear Expo. Indeed, the big show—Gear Expo 2013—kicks off in Indianapolis at 9:00 a.m. Tuesday, September 17, wrapping up Thursday the 19th at 4:00 p.m. And whether you are exhibiting or attending, the bottom line is you are going—a good thing for you, your company and the tightly knit U.S. gear industry.

This is a *gear* show; *produced* by gear people; *for* gear people—gear people representative of just about every facet of the gear industry. In fact, the show is so exceedingly gear-intensive and industry-relevant that notice is arguably paid more to those companies choosing to stay home, rather than to the participants.

If your company is exhibiting at this year's show it means that there must be something worth exhibiting, right? So let's talk to some exhibitors and see what they plan on exhibiting and, more to the point—*selling*—at this year's Expo. But beyond the dollars-and-cents considerations we'll explore some show-related issues as well.

"We will demonstrate Power Skiving technology on our 100PS machine," says Gleason Corp.'s director of marketing, Alan R. Finegan. "(It) offers productivity benefits in terms of cost per piece and provides a cost-effective alternative to gear shaping and in many cases other soft-machining processes such as hobbing and broaching. (*Ed.'s Note*: *In addition to this story, check out Matt Jaster's article on* Page 22 *for more on Gleason and other exhibiting-company show offerings.*)

"Liebherr will introduce an extended Platform 2 hobber –the LC 500 CNC Gear Hobbing machine, with new hob head for an increased module capacity on the well-known Liebherr platform 2 machines (LC 200, LC 300, LC 380, and LC 500)," says Scott Yoders, VP sales, Liebherr Gear Technology. "Hobbing gears up to module 12 in one cut can now be fully-realized with the introduction of a new hob head—m FK 2.3—that delivers 27 kW spindle power and accommodates hobbing or gashing tools up to 220 mm diameter."

"We will also introduce to the market the brand new WENZEL WGT 280 machine; a more compact version of the proven and successful WGT400,

for gear inspection of smaller workpiece applications. This CNC gear inspection machine is targeted for the automotive market, and for our gear-shops who may not need to inspect workpeices beyond 280 mm diameter."

"Drake will promote its Model GS: TE 200 external thread grinder with a robot load pallet system," says James Vosmik, Drake Manufacturing president. This model is widely used in automotive applications for steering worm gears." (*Drake is exhibiting in booth* #311 *with its gear systems reps, Koepfer America, LLC.*)

"Star SU LLC will feature the Samputensili G250 Vertical CNC Grinder (for automotive and high production applications) with a video presentation at Gear Expo," says Mark Parillo, marketing director for Star SU LLC.

"The inventor of continuous generating gear grinding, Reishauer AG of Wallisellen, Switzerland will demonstrate the RZ 260," says Dennis Richmond, Reishauer Corp. vice president. "This machine sets the standard for gear grinding machines in this size range. The concept is based on the extremely successful RZ 150 series with several hundred machines installed in plants worldwide. The RZ 260 has not only been increased in size, all relevant components have been adapted to handle higher loads and forces which occur when grinding larger gears. Gears with an outside diameter of 260 mm and modules up to 5 mm can be ground with highest reliability in the well-known Reishauer quality."

> "On-line trade shows will never replace the sensory feel, smell, and taste of having that product in your hand or asking the manufacturer specific questions about a particular application"
>
> Dennis Richmond, Reishauer

With so much impressive hardware available, distinguishing yourself from your competitors seemingly becomes more difficult at every turn. Old School due diligence is still required, of course; but, with each passing year, less traditional approaches to marketing are gaining more acceptance.

"Star SU implemented a social media strategy over the last year," Parillo says. "Trade show promotion—before, during and post-show—should no longer be looked at as nice to have, but as a necessity. Expect Star SU to communicate what our booth features, product news, and the pulse of the booth throughout AGMA on Facebook (*www.facebook.com/starsullc*) and Twitter (*www.twitter.com/starsullc*).

On a related point—what with all the online marketing and promotion capabilities (webinars, Skype, etc.) now available and increasingly pervasive, one wonders if the trade show is an endangered species.

Richmond believes that "Trade shows will always be relevant. When you're looking for a product—whether it be a car, machine tool, open gearing or pots and pans—on-line trade shows will never replace the sensory feel, smell, and taste of having that product in your hand or asking the manufacturer specific questions about a particular application."

"We are definitely in the digital age," Parillo acknowledges, "but there needs to be a balance of interactive tools and

From Reishauer AG of Wallisellen, Switzerland—the RZ 260 Gear Grinding Machine (courtesy Reishauer).

having the ability for your customers to get up-close-and- personal with our machines. Personally, I believe the show management teams at the shows we participate in have done a fantastic job of recognizing a younger audience and the emphasis the exhibitors are placing on the use of digital tools. Technology aside, trade shows will continue to present a tremendous opportunity to network and reinvigorate relationships."

Gleason's Finegan points out that "People have been predicting for several years that technology will hasten the demise of trade shows. And yet trade shows survive and have even grown in some industries. Technology will continue to provide new opportunities with respect to how we market and present ourselves and thus change the nature of shows, but the face-to-face and hands-on aspects of shows will always have appeal."

Expo venue—or location—has often been the source of some pre- and post-show observations. Not so much this year, however. Indianapolis appears to be a consensus favorite.

"From a geographical perspective, Indianapolis is a desirable location as it's within easy driving distance of Illinois, Michigan, Ohio and Wisconsin, where a majority of gear manufacturers are located," Richmond says. "The city offers a diverse variety of dining establishments and hotel accommodations within easy walking distance of the convention center."

> "Technology aside, trade shows will continue to present a tremendous opportunity to network and reinvigorate relationships."
>
> Mark Parillo, Star SU LLC

"In the heart of the manufacturing sector, Indianapolis is an excellent choice—a great city and location for this year's show," Parillo concurs.

And, Indy is a "good location for Gear Expo," Finegan believes.

"In the heart of the manufacturing sector, Indianapolis is an excellent choice—a great city and location for this year's show."
Mark Parillo, Star SU LLC

What do exhibiting companies expect/hope to gain or accomplish at Gear Expo? It helps to understand that the emphasis here is on exhibiting—not closing. While not at all unheard of, selling off the floor is not a typical occurrence. So what *do* companies look for? Here's a sampling:

"(To) showcase our technology and demonstrate to the gear manufacturing community that Reishauer is the "industry standard" when it comes to productivity, quality and lowest-cost-per- piece," Richmond says.

Parillo hopes that Star SU will "achieve a balance of providing awareness of our latest products and technology with our domestic customers at Gear Expo, along with making an impact at EMO during the same week."

"To introduce the gear market to these new machine types: LC 500 and WGT 280," says Yoders. "We are delighted to be displaying this new gear inspection machine in our booth this year, highlighting our partnership with Wenzel, which began in March 2013."

And at Drake, "(To) visit with current customers; meet new prospects and promote the Drake brand," says Vosmik. "(To) connect with recent graduates entering the job market and explore new machine tool technology."

For more information:

Drake Machinery (with)
Koepfer America LLC (booth 311)
4371 North Leavitt Road
Warren, OH 44485
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Fax: (330) 847-6323
drakemfg.com

The Gleason Corporation (booth 423)
1000 University Avenue
P.O. Box 22970
Rochester, NY 14692-2970
Phone: (585) 473-1000)
Fax: (585) 461-4348
gleason-works@gleason.com

Liebherr Gear Technology Inc. (booth 510)
1465 Woodland Drive
Saline, MI 48176-1259
Phone: (734) 429-7225
Fax: (734) 429-2294
info.lgt@liebherr.com
www.liebherr.us

Reishauer Corporation (booth 1041)
1525 Holmes Road
Elgin, IL 60123
Phone: (847) 888-3828
Fax: (847) 888-0343
www.reishauer.com
usa@reishauer.com

Star SU LLC (booth 901)
5200 Prairie Stone Parkway, Suite 100
Hoffman Estates, IL 60192
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Fax: (847) 649-0112
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AGMA 2013 Fall Technical Meeting

The AGMA 2013 Fall Technical Meeting (FTM) provides an opportunity for you to receive the latest research in the field, network with your peers and learn about the latest methods and cutting-edge technologies in use in the gearing industry today.

Registration for the FTM includes a free pass to Gear Expo 2013. Registration is available through the AGMA website at *www.agma.org*.

Early Bird Pricing (through August 16)
AGMA member $835
Nonmember $1,185

Regular Pricing (after August 16)
AGMA member $935
Nonmember $1,285

Single Session Pricing
AGMA member $275
Nonmember $395

This year's FTM will feature 26 papers, presented in five sessions:

Session I — Gear Manufacturing
Sunday, September 15
1:00 p.m. – 5:00 p.m.

Power Skiving of Cylindrical Gears with Bevel Gear Cutting Machines

Dr. Hermann Stadtfeld, Gleason Corporation

Performance and Technological Potential of Gears Ground by Dressable CBN Tools

Dr. Klaus Finkenwirth and Dr. Andreas Mehr, Liebherr-Verzahntechnik GmbH, and Dr. Fritz Klocke and Jan Reimann, RWTH Aachen University

Analysis of Gear Root Forms: A Review of Designs, Standards and Manufacturing Methods for Root Forms in Gears

Dr. Gregory Hyatt, Nitin Chaphalkar, Orrin Kleinhenz DMG/Mori Seiki USA Inc.

Best Practices for Gearbox Assembly and Disassembly

Jodi Bello, Chief Engineer, David Brown USA Inc.

Precision Shaped Grains Turn the Concept of Gear Grinding Upside Down

Walter Graf, 3M

Session II — Gear Design Issues
Monday, September 16
8:00 a.m. – 12:00 p.m.

High Gear Ratio Differential Planetary Drives' Analysis and Design

Alexander L. Kapelevich, AKGears, LLC

Finite Element Analysis of a Floating Planetary Ring Gear with External Splines

Dr. Vanyo Kirov and Dr. Yun Wang, Caterpillar Global Mining, LLC

AGMA 2013 Fall Technical Meeting (continued)

Application and Improvement of Face Load Factor Determination Based on AGMA 927 (Accurate and Fast Algorithm for Load Distribution Calculation, for Gear Pair and Planetary Systems, Including Duty Cycle Analysis)

Dr. Ulrich Kissling, KISSsoft AG

Investigations on Tooth Root Bending Stress of Case Hardened Gears in the Range of High Cycle Fatigue

Dr. B.R. Höhn, Dr. K. Stahl, Dr. T. Tobie, Dr. N. Bretl, and S. Schurer, Gear Research Centre (FZG)

Calculation of the Tooth Root Load Carrying Capacity of Beveloid Gears

Dr. Jannik Henser, Dr. Christian Brecher and Dr. Markus Brumm, RWTH Aachen Univrsity (WZL)

Striving for High Load Capacity and Low Noise Excitation in Gear Design

Dr. K. Stahl, Dr. M. Otto and M. Zimmer, Gear Research Centre (FZG)

Session III — Failure Analysis and Inspection
Monday, September 16
1:30 p.m. – 5:30 p.m.

Practical Considerations for the Use of Double Flank Testing for the Manufacturing Control of Gearing

Ernie Reiter, Web Gear Services Ltd. and Fred Eberle, HiLex Automotive Center

Gear Failure Analysis and Lessons Learned in Aircraft High-Lift Actuation

Anngwo Wang, Seth Gitnes, Lotfi El-Bayoumy and Jonathan Davies, Moog Inc. Aircraft Group

Metallurgical Investigation of "Tiger Stripes" on a Carburized High Speed Pinion

M. Li, Lufkin Industries, Inc., P. Terry, P. Terry & Associates, and R. Eckert, Northwest Laboratories, Inc.

White Structure Flaking in Rolling Bearings for Wind Turbine Gearboxes

Hideyuki Uyama and Hiroki Yamada, NSK Ltd.

The Anatomy of a Lubrication Erosion Failure — Causation, Initiation, Progression and Prevention

Raymond J. Drago and Roy J. Cunningham, Drive Systems Technology, Inc. and Chad Smith, Chalmers & Kubeck

Session IV — Gear Drive Components
Tuesday, September 17
8:00 a.m. – 12:00 p.m.

Dynamic Simulations of Radial Lip Seals Flowability in an Industrial Gearbox

Michel Organisciak, Rossana Iervolino, Mickael Sansalone, Stellario Barbera, SKF Engineering and Research Centre, and Alex Paykin, SKF Sealing Solutions

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AGMA 2013 Fall Technical Meeting (continued)

Gear Lubrication – Long Term Protection for Wind Turbines

Steve Mazzola, Kluber Lubrication North America LP, Dr. Michael Hochmann, and Juian Wald, Kluber Lubrication Munchen SE & Co.

Gear Resonance Analysis and Experimental Verification Using Rapid Prototyped Gears

Scott R. Davidson and Jeffrey D. Hayes, The Boeing Company, Philadelphia

Influence of Gear Loads on Spline Couplings

Dr. Carlos H. Wink and Marcelo Nakandakari, Eaton Corporation – Vehicle Group

How to Spec a Mill Gear

Frank C. Uherek, Rexnord Industries LLC

Investigations of Bearing Failures Associated with White Etching Areas (WEAs) in Wind Turbine Gearboxes

Robert Budny, Clipper Windpower, Robert Errichello, Geartech, and Rainer Eckert, Northwest Laboratories

Session V — Materials and Heat Treatment
Tuesday, September 17
1:00 p.m. – 5:00 p.m.

Heat Treatment of Big Gear Components

Gerhard Reese, Härterei Reese Bochum GmbH

Ductile Iron for Open Gearing — A Current Perspective

Fabrice Wavelet, Ferry Capitain and Michel Pasquier, CMD

Innovative Induction Hardening Process for Improved Fatigue Performance of External Spur Gear

Dr. Zhichao (Charlie) Li, Deformation Control Technology, Inc.

Controlling Distortion in Heat Treatment through Press Quenching

Art Reardon, Gleason Corporation

Vacuum Carburizing Large Gears

Nels Plough, Stack Metallurgical Services, Inc.

Registration for the 2013 AGMA Fall Technical Meeting is available via the Gear Expo website at *www.gearexpo.com*

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Randy Stott, Managing Editor

Heat Treat 2013
27th ASM Heat Treating Society Conference and Exposition
September 16-18, 2013
Indiana Convention Center, Indianapolis
www.asminternational.org/content/Events/heattreat

The ASM Heat Treating Society Conference and Exposition is once again co-located with AGMA's Gear Expo. This year's show celebrates the 100th anniversary of the ASM Heat Treating Society, which began as the Steel Treaters Club in Detroit.

In addition to a comprehensive technical program, the conference will include three special "Heat Treating Master Series" sessions that will focus on heat treating pioneers whose research transformed heat treating technology. The sessions will include lectures by current experts in the heat treating field on the contributions and impact of past heat treating giants Walter Jominy, Marcus Grossmann and Edwin Northrup.

The technical program runs from September 16-18, but the exhibition hall is open only Tuesday, September 17 (9 a.m. until 6 p.m.) and Wednesday, September 18 (9 a.m. until 5 p.m.). Note that the Gear Expo portion of the exhibition hall is open one additional day— Thursday, September 19.

For more information, visit *www.asminternational.org/content/Events/heattreat.*

"I'm bullish on the gear industry," says Geoffrey Somary, president and CEO of Ipsen USA.

Gear Technology caught up with Somary at the recent Powdermet 2013 show in Chicago, where Somary described his company's technology and how it fits well with the current trends in gear manufacturing.

"The trend from 6-speed to 8-speed and now even 9-speed transmissions requires more compact gears capable of higher torque loads," Somary said in a follow-up e-mail. "In many cases, older heat treating equipment is no longer capable of delivering on such demanding specifications. Also, smaller, more compact gears enable the use of different improved technologies that were previously cost prohibitive. Therefore, advancement in automatic transmission technology has created new demand for heat treating equipment worldwide."

Those trends in automobile transmissions have a number of heat treat suppliers looking forward to this year's combined ASM heat treating show and Gear Expo. In particular, companies specializing in certain technologies — namely vacuum carburizing and induction hardening — seem especially interested in the possibilities opened up by these gear manufacturing trends.

"Vacuum carburizing, alternately called low pressure carburizing (LPC), will become more prevalent due to the smaller gear cross sections," Somary says. "One of the drawbacks to LPC has been the difficulty of gas quenching larger gear cross sections. Now that cross sections are smaller, LPC and the gas quenching of gears has become more affordable."

The latest technology in vacuum furnaces allows for ergonomic design and easy integration into the workflow of a manufacturing operation, as seen here with the ModulTherm concept from ALD-Holcroft. (courtesy ALD-Holcroft).

Bill Gornicki, VP sales and marketing for ALD-Holcroft, echoes the increased emphasis on vacuum carburizing for automotive transmissions. "ALD-Holcroft has benefited in the new automotive transmission trend toward vacuum carburizing. These 8+ speed transmissions with many more gears have benefited from more uniform case hardening in vacuum carburizing in conjunction with our distortion control capabilities in high pressure gas quenching."

John Gottschalk, director of engineered products for Surface Combustion, agrees that the automobile industry is driving trends in heat treating equipment. "Due to the increase in global motor vehicle production, output from small part producers has ramped up significantly, leading to increased demand for our equipment designs."

Smaller sized gears are also well suited to induction hardening, says Dr. Valery Rudnev, director of science and technology for Inductoheat, commenting that although most transmission gears are still carburized, virtually every manufacturer is using induction hardening for at least some of those gears.

"With the recent improvements, inventions and breakthroughs associated with induction heat treating—such as development of new medium- and high-frequency inverters with amazing capabilities—the range of induction for gear hardening applications is expand-

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Gear Grinding Technology

ing with a steadily increasing pace, and increasing numbers of gear manufacturers are turning to using induction gear hardening."

When discussing automotive gears, all of the suppliers agree that one of the most important demands made by manufacturers is better and better control of gear distortion.

"The biggest demand is to try to avoid post heat treat operations," Rudnev says, adding that that's an area where induction hardening shines. Because processes like contour hardening can take one second or less per part, there isn't a lot of time for distortion to occur.

Rudnev adds that a number of technology improvements are significantly changing the applicability of induction hardening for an increasing range of part geometries. In particular, technologies such as simultaneous dual-frequency induction hardening allow for greater control over the hardening process.

But there is also substantial R&D work underway, Rudnev says. Most induction heat treating equipment providers are looking for ways to expand the versatility and capability of the inverters that provide the frequency control and power supply. In fact, Rudnev says, within 5-10 years, we may see induction heat treating equipment that will allow for processing a part with three or even four simultaneous frequencies, opening up even more part geometries for possible induction heat treating.

As power supplies continue to improve, induction heat treating is becoming applicable to a much wider range of gears. Shown here is Inductoheat's Statipower IFP inverter, which will be on display for the first time at Heat Treat 2013 (courtesy Inductoheat).

For now, Inductoheat will be displaying for the first time ever its Statipower IFP (independent frequency and power control) inverter at the show. This new technology allows process flexibility by allowing independently adjustable frequencies (5-40 kHz) and power (10-360 kW) via a CNC program. In the past, such a range of options would have required multiple power supplies, each with a very limited range of adjustment.

"This concept substantially expands heat treat equipment capabilities for processing parts by programming power and/or frequency changes on the fly, optimizing hardening of gears of different modules with various tooth geometries," Rudnev says.

Controlling distortion is also one of the promises of vacuum carburizing.

"Most new automotive transmission programs are steering toward LPC (low pressure vacuum carburizing)," says Gornicki. "It is highly repeatable, extremely uniform, offers better fatigue resistance, and in conjunction with convection heating and high pressure gas quenching, post heat treat grind can often be eliminated."

Ipsen's Somary agrees. "Manufacturers are demanding tighter tolerances and greater uniformity from part to part. This has led builders of heat treating equipment to bring new innovations, sensors and software to market that can deliver on these tighter specifications."

Gornicki points out that the trend toward lower carbon emissions in manufacturing has steered the automotive transmission manufacturers toward vacuum processing. "With virtually no carbon emissions compared to atmosphere processing, vacuum is most certainly on the rise."

Similarly, Inductoheat is touting the environmental friendliness of its heat treating processes, according to Rudnev.. "In the last three to five years, there is an increasingly strong demand for environmentally friendly and energy-efficient technologies." Rudnev counts induction heat treating among these technologies because it "puts the energy where it is needed, when it is needed."

Another key emphasis of these heat treating suppliers seems to be helping to integrate heat treating into a leaner overall manufacturing environment. They're doing so by creating technologies that can be more easily integrated on the manufacturing floor (as opposed to a separate heat treating department) and which help reduce work-in-process.

"Our ModulTherm concept enables heat treating to be placed directly into the manufacturing environment," sayd ALD-Holcroft's Gornicki. "This eliminates the typically dark, smoke laden and hot heat treat facilities (often located in the back of the building). These modern vacuum facilities are ergonomically superior to the pushers and batch atmosphere furnaces of the past."

The trend is also to increase automation of heat treating equipment. "As the present demand for gearing tends to be for automotive industry driven products, designs incorporating higher levels of automation are of increased value to our customers competing in that market," says Surface Combustion's Gottschalk.

Clearly, heat treating equipment suppliers are listening to the demands of industry, and they're working to develop technologies that improve the overall gear manufacturing process. Heat treating technology is far from stagnant. In fact, all of the sources we talked to indicated that there are significant new technologies on the horizon that will soon have a big effect on the way many gears are heat treated.

For more information:

ALD-Holcroft (booth 1723)
49630 Pontiac Trail
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(248) 668-4130
sales@ald-holcroft.com
www.ald-holcroft.com

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Engineering Questions?

SME has the answers with Knowledge Edge

Matthew Jaster, Senior Editor

The Society of Manufacturing Engineers (SME) has been gathering, validating and sharing manufacturing knowledge for more than 80 years. Traditionally, SME resources were purchased by individuals for their own personal use or by colleges and universities as textbooks. Recently, these same colleges and universities were looking for digital resources to provide to their instructors and students. Companies were requesting SME content digitally for their employees as well.

"In response to this demand, SME involved several key manufacturers and educators to help frame the idea of Knowledge Edge back in 2010," said Kris Nasiatka, senior manager-certification, books and video for Tooling U/SME. "The development of the system architecture took more than two years; additionally we digitized more than 1,100 books and chapters, over 700 videos and related clips and 10,000 *Tool and Manufacturing Engineers Handbook* series entries for the new Manufacturing Knowledge Base Wiki. Plus, we transferred over 16,000 already-digital technical papers into the system. Our original advisors provided feedback every step of the way — from system prototype to final launch of the product."

Online Advantages

With content created and validated by SME members and industry experts, the advantages of an online database from SME gives engineers, educators and the manufacturing community the greatest gift it can give in our short-attention-span society in 2013; the gift of flexibility.

"A user can access only as much as they want, when they want it (It is available 24/7). If someone needs just a chapter of a book, or only needs to see a portion of a video, they can consume just that portion. Plus, they can still access the entire original work if further information is required," Nasiatka said. "Instructors, trainers, leaders, etc…, can assign content to students and employees through playlists. If you want everyone in a class or on a team to review a common set of materials, you can organize the content and assign it to them. For example, if a plant is preparing for TPM kaizen event, you could assign videos and/or book chapters to help the team prepare, which will reduce the amount of time spent in kaizen training spent covering basic concepts and get right to the work at hand. If you're a college instructor, you can pace when students access content by assigning playlists with video, books and/or technical papers that correspond to the topic at hand or potentially push out content on a weekly basis for them to review."

As mentioned earlier, users also have access to SME's long-standing *Tool & Manufacturing Engineer's Handbook series (TMEH)*. "This nine-volume encyclopedic reference set for manufacturing has been digitized and converted into a wiki environment and is now known as *The Manufacturing Knowledge Base*. It is fully searchable. Content is being added and edited by SME members, peer-reviewed, and polished editorially before the new material is released, ensuring content is valid and accurate," added Nasiatka.

The Go-To Guide for Manufacturing and Engineering

Knowledge Edge was built *by* manufacturers and educators *for* manufacturers and educators and can be adapted to accommodate different workforce needs. "Employers may need resources to help new hires with cross training or provide opportunities for continuing education through self-paced study. Depending on job roles, employees may also need access to both legacy and contemporary resources, and want access to new releases as soon as they're available.

"For example, one company cited the case where a young engineer was looking for information on particular materials for a product developed in the 1950s still being produced today. One material was no longer available and this new engineer has to quickly identify the properties of each material involved as well as how the material properties change and react as part of an alloy. They turned to SME for both the legacy information and contemporary resources. Plus, with Knowledge Edge, once new books, videos, technical papers, and wiki content are completed, they're added as available resources in the system so subscribers have immediate access to new sources of information, job aids and training content," said Nasiatka.

Just like Tooling U online classes, Knowledge Edge content is now mapped to various manufacturing competencies, according to Nasiatka. "Subscribers can review these competency maps and select all or just a few of the Knowledge Edge resources that support that competency development. They can push the resources out through playlists and formalize the informal learning process. The competency mapping is another resource to help educators and manufacturers develop the skilled workforce in demand today."

What's next for Knowledge Edge?

"Our current focus is to continue to evolve the user experience by adding new capabilities, including enhancements to search, cloning playlists and more. We are actively collecting feedback from users of Knowledge Edge for new features and functions they would like incorporated and including those in our continuing development efforts. We are also adding new content — each new book, video, technical paper or *Manufacturing Knowledge Base* entry is added into Knowledge Edge as the projects are completed, and made available to subscribers."

Putting Knowledge Edge together required relentless focus on the customer and translating their ideas online, said

Nasiatka. "It has required us to team differently, implement agile methods for development and testing, and utilize new technologies to bring this project to market. I am extremely proud of everyone on the project team for rallying behind a common vision, challenging convention, stretching themselves farther than they thought they could go, and for ultimately launching this new product," Nasiatka said. "We've lived through a time of incredible technological change, increasing access to resources, constant communication and the ways in which work and education happen are radically changing."

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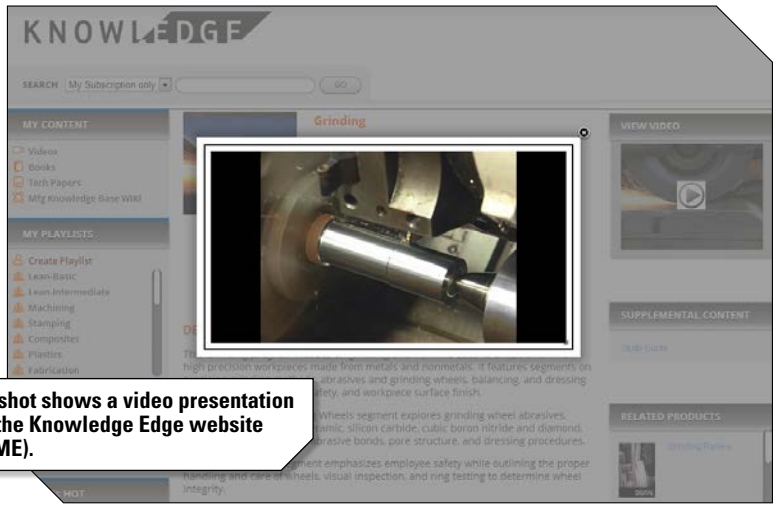
Knowledge Edge Basics

Knowledge Edge is an online service that provides access to the greatest depth of peer reviewed and validated manufacturing engineering educational material. Developed to aid on-the-job manufacturing industry employees and students engaged in higher education, it includes the following resources:



This screenshot shows a video presentation accessed on the Knowledge Edge website (courtesy of SME).

- 10,000+ Manufacturing Knowledge Base wiki entries
- 16,000+ technical papers (peer-reviewed and validated content by subject matter experts)
- 1,200+ SME books and chapters
- 700+ industrial training videos and clips
- Former nine-volume *Tool & Manufacturing Engineers Handbook*

- Useful information is provided for everyone studying and engaged in manufacturing including, technicians, management, administration, sales and marketing. Subject specific content covers manufacturing fundamentals, advanced concepts, leadership, project management and more:
  - Material removal
  - Forming and fabricating
  - Tool design/die design
  - Materials
  - Lean
  - Process design
  - Continuous improvement
  - Manufacturing management
  - Product development
  - Quality
- Core topics include:
  - Machining
  - Forming
  - Materials, finishing and coatings

  - Quality control and assembly
  - Manufacturing management
  - Design for manufacturability
  - Continuous improvement
  - Plastic part manufacturing
  - Material and part handling
- Offers tremendous resource material for:
  - Career Development
  - Understanding of Concepts and Processes
  - New Hire Training and Knowledge Refresher
  - Pre-Training Initiatives
  - Post-Training Reinforcement
- Available on demand 24/7
  - Less time searching for answers. More time building on them.
  - The exact information you need, exactly when you need it.
  - A multi-media approach for learning taught the way students learn
  - best.
  - Content is reliable — provided by subject matter experts
- Provides useful structure to educational process:
  - Individual Development
  - Formalize Informal Learning
  - Standardize Materials and Resources
  - Supplement to Tooling U Classes
- An abundance of updated reference material includes:
  - Case studies and information sharing
  - New applications
  - Research
  - Techniques
  - Processes
  - Methodologies
- Knowledge edge is a subscription-based service supporting professional development.

Trial Run

Gear Technology was given a free trial of Knowledge Edge to browse the information available. My "gears" playlist included a 22-minute *Gears and Gear Manufacturing* video that introduced primary gear terms and definitions including involute curve, base circle, pitch circle, pitch point, etc. It also gave a brief overview on the various gear forms, functions, axis positions and gear machining and was a very good starting point for anyone interested in gear manufacturing.

After downloading a PDF version of Chapter 28 of *Manufacturing Processes and Materials*, I browsed through 40-pages of material on Thread and Gear Manufacturing. It included 40 questions to help learn the material and 24 problems to solve using the information presented. Again, a great overview on some of the most commonly used processes for manufacturing threads and gears.

The database continued to impress with information on inspection, powder metals and ebooks on hobbing, shaping and shaving. As Tooling U/SME continues to update the website with more material, I'm sure the technical papers, videos and articles on gear manufacturing functions and processes will grow.

Currently, they have put together a great balance for students and new employees to gain access to a large amount of manufacturing data. The website is user-friendly and lets you bookmark and customize the most important information easily and efficiently. As a subscription-based service, Knowledge Edge offers years of SME data 24/7 and is a much needed resource in the manufacturing community online.

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JOB SHOP LEAN

Ed's Note: This is the fifth article in an eight-part "reality" series on implementing Continuous Improvement at Hoerbiger Corporation. Throughout 2013, Dr. Shahrukh Irani will report on his progress applying the job shop lean strategies he developed during his time at The Ohio State University. These lean methods focus on high-mix, low-volume, small-to-medium enterprises and can easily be applied to most gear manufacturing operations.

Dr. Shahrukh Irani, Director IE Research, Hoerbiger Corporation of America

Design of a Flexible and Lean (FLEAN) Machining Cell: Part 2 (Application)

Job shops may be ill-advised to undertake a complete reorganization into FLEAN (Flexible and Lean) cells. A FLEAN cell would (i) be flexible enough to produce any and all orders for parts that belong in a specific part family and (ii) utilize lean to the maximum extent possible to eliminate waste. For example, FLEAN cells that are implemented in job shops may not allow the perfect one-piece flow that is feasible in assembly cells. Still, due to the proximity between consecutively used machines, small batches of parts can be easily moved by hand or on wheeled carts or on short roller conveyors or using jib cranes. In fact, it is possible that the production volumes and demand stability for many part families simply could not justify dedicating equipment, tooling and personnel to producing any of those families in a stand-alone cell.

FLEAN Cells: Starting Point for Implementing Job Shop Lean

The starting point for implementing job shop lean in a high-mix, low-volume facility is to implement as many FLEAN cells as possible. In fact, management should further support continuous improvement (CI) projects to help each cell become an autonomous business unit (ABU). How? By empowering the team of employees in each cell to manage day-to-day operations and make decisions about allocation of orders to operators, deciding who gets cross-trained on which machines, etc. Those CI projects should be given top priority which seek to eliminate, or at least mitigate, all the

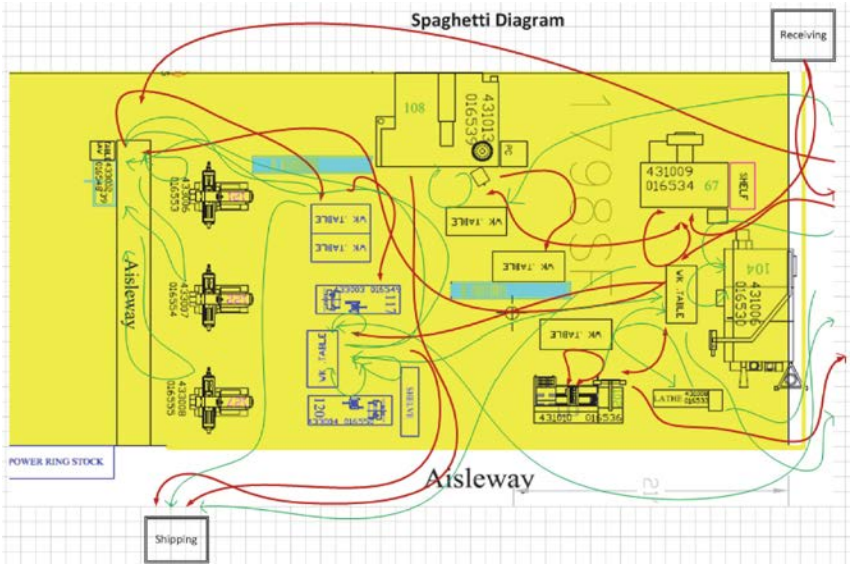

Figure 1 Material Flows in the Current Layout for the MP Cell (MPC).

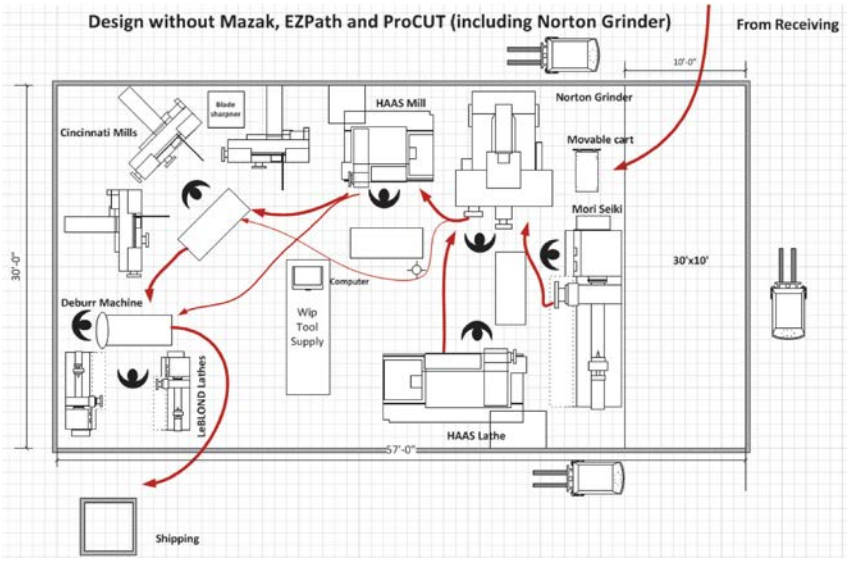

Figure 2 Material Flows in the Proposed Layout for the MP Cell (MPC).

constraints that force the cell to send its orders to external resources, both in-house or vendors, for processing. Ideally, each cell would be allowed to communicate directly with their customers on changing delivery dates, questions about part drawings or routers, etc.

Origins of FLEAN Cells and Job Shop Lean

Serck Audco Ltd. pioneered the use of group technology and cellular manufacturing as a complete manufacturing and business strategy as early as the middle of the 20th Century. During the period 1961–1967, they reported the following improvements in company performance using GT and CM from John Burbidge's book *Group Technologies in the Engineering Index*:

- **Sales:** Up by 32 percent
- **Stocks:** Down 44 percent
- **Ratio of stocks/sales:** Down from 52 percent to 22 percent
- **Manufacturing time:** Down from 12 weeks to four weeks
- **Overdue orders:** Down from six weeks to one week
- **Output per employee:** Up about 50 percent
- **Capital investment:** Cost recovered four times by stock reduction alone

Interestingly, the benefits of GT and CM reported in Burbidge's book published in 1979 are similar to those attributed these days to the Toyota Production System designed for repetitive high-volume assembly. A very recent implementation of high-mix assembly cells reported in the open literature is at Metcam Inc.'s Alpharetta, GA, facility, according to an article in the May 2013 issue of *Industrial Engineer* entitled, "Cellular Precision."

Design of a FLEAN Cell at HCA-TX

In the previous issue of *Gear Technology* magazine, we had described the theory underlying a methodology for identifying potential part families and machine groups that would constitute one or more FLEAN cells. We had chosen one of the existing five machining cells, the MP cell (MPC), to test this computer-aided methodology for implementing Job Shop Lean. We collected the routers of all the parts that were being processed in the MPC during a 5-day week to create the *PFAST* input file. Using the from-to chart produced by *PFAST* for this sample of parts and the current layout of the MPC, we produced the flow diagram shown in Figure 1. In the figure, the flows shown in red represent large values in the from-to chart, and the flows shown in green represent low values.

In this issue, we will explain how we designed a future state for the MPC whereby it would have no external resource requirements and, hopefully,

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Part No	Work Center No	Sequence No
1210954	705	1
1210954	240	2
1210954	210	3
1210954	205	4
1210954	255	5
1210954	710	6
1872434	705	1
1872434	240	2
1872434	210	3
1872434	205	4
1872434	255	5
1872434	710	6
1867043	705	1
1867043	240	2
1867043	210	3
1867043	215	4
1867043	205	5
1867043	255	6
1867043	710	7

Figure 3(a) Routings Spreadsheet in the PFAST Input File.

Part No	Description		Annual Quantity	Revenue
1210954	PISTON RING	HY113	25	25
1872434	PISTON RING	0804-00	12	12
1867043	RIDER RING	0872-00	5	5
1206113	RIDER RING	HY112	26	26
1203600	PISTON RING	HY112	4038	4038
1205489	RIDER RING	HY112	178	178
1205702	PISTON RING	HY112	110	110
1230010	PRESSURE BREAKER	HY112	4	4
1203361	PACKING RING	HY112	2,273	2273
1204876	PISTON RING	HY112	100	100
1205529	PACKING RING	HY112	1022	1022
1233569	PISTON RING	HY103	83	83
1233281	PISTON RING	HY112	247	247
1385526	SEALING RING	0309-01	845	845
1875646	PISTON RING	0703-00	8	8
1210542	PISTON RING	CL40CI	6	6

Figure 3(b) Parts Spreadsheet in the PFAST Input File.

Work Center No	Description	Area
105	PACKING DOUBLE DISC	1
110	PACKING CNC MILL	1
115	PACKING SPRINGS	1
120	PACKING MANUAL LATHE	1
125	PACKING MISCELLANEOUS	1
126	PACKING SPRINGS AND MISCELLANEOUS IN CELL	1
130	PACKING DRILL & PIN	1
135	PACKING CNC LATHE	1
145	PACKING REBORE	1
150	PACKING SLITTER	1
155	PACKING DEBURR	1
170	PACKING SEGMENT CNC LATHE	1
180	PACKING MELCHIORRE LAPPING	1
205	P/R RING SAW	1
210	P/R RING GRINDER	1
215	P/R RING MILL	1
227	P/R RING HEAT TENSION	1
240	P/R RING MANUAL LATHE	1
245	P/R RING SANDBLAST	1
305	BLANCHARD GRINDER	1
255	TACLOC/EXPANDER BENCH GRIND	1
410	POWER RING GRINDER	1
705	MATERIAL ISSUE	1
710	STOCK & STAGE	1
915	TINNIZE	1
250	P/R RING CNC LATHE	1

Figure 3(c) Workcenters Spreadsheet in the PFAST Input File.

evolve into an ABU (autonomous business unit). Figure 2 shows the new layout for the MPC that was designed, and even partially implemented, by blending:

- Outputs produced by the *PFAST* software
- Outputs produced by the *STORM* software
- Work done by an IE intern (Dhananjay Patil) who was dedicated full-time on the project and engaged daily with the employees in the cell
- Work done by our Tiger Team who partnered with the employees in the cell to implement 5S, housekeeping and ergonomics-related improvements
- Time study data provided to us by our in-house IE (Shalini Gonnabathula)

As the above list of bullets will indicate, the major take-away from this project is that computer analytics are simply an aid to implement Job Shop Lean. They are necessary but not sufficient and should enhance the effectiveness of the decisions and designs produced by the project team and the employees responsible for designing and implementing the cell.

Application of the Job Shop Lean Methodology at HCA-TX

Figure 3a shows the routings spreadsheet in the *PFAST* input file. Figure 3b displays the parts spreadsheet. Figure 3c displays the work centers spreadsheet. Together, these three spreadsheets constitute the *PFAST* Input File that is submitted to the *PFAST* (*Production Flow Analysis and Simplification Toolkit)* software developed by the Department of Integrated Systems Engineering at The Ohio State University, Columbus, OH.

Figure 4a shows the product-process matrix analysis produced by *PFAST* using the data for the sample of parts produced in the MP cell. This visual display that aggregates many different/similar routings immediately picked up a major obstacle that we would face if we chose to implement a self-sufficient new cell with no external machining resource requirements. The two part families displayed in Figure 4a correspond to parts in the MPC part family and parts from the family produced in another cell, the PRR cell (PRRC). The machines required by the PRRC part family could not be fitted into the room that housed that cell; hence, they were intermingled

in the same area with the machines that constitute the MPC.

Figure 4b shows the sequence similarity analysis of the routings for the same sample of parts. Like the product-process matrix analysis, Figure 4b is an alternative visualization of a large number of different/similar routings of parts being produced by machines in a single cell (or a large machine shop or an entire vertically-integrated factory).

Now we were ready to design an actual layout for the MPC. This required us to arrange the group of machines required to produce the part family into a U-shape, else some composite of other alphabets, such as S, Y, M or F whose shapes could "fit" the flow of the variety of routings processed by the cell. Figure 5a shows the from-to chart that *PFAST* produced using the data in the input file submitted to it. Figure 5b shows the flow diagram that *PFAST* produces to help contrast the high-volume and the low-volume flows between various machines in the cell. Essentially, Figure 5b is a visualization of Figure 5a to assist anyone who may want to manually design the cell layout.

We input the from-to chart produced by *PFAST* to *STORM*. The student version of the *STORM* software is affordable software for quick-and-dirty facility layout design. Figures 6a–c show examples of the different arrangements of the machines in the cell that could be produced simply by changing layout settings permitted by the algorithm programmed in this educational software.

But how good were these computer-generated layouts? So next we had to verify if any of these "layout skeletons" for the MPC were viable for implementation. We did this using a multi-pronged approach as follows: We met with the MPC team and asked them to walk us through the machining pathways of several active orders being processed in the cell that day. Also, we conferred with the two machine shop supervisors, Greg Oakley and Ziggy Skora, as well as our IE, Shalini Gonnabathula.

Based on these multiple inputs, we realized that whoever had identified the part family for the MPC in the past *using no software at all* had done a good job. The generic/composite routing for the MPC part family was as follows: Turn→Grind→Mill→Rebore→Drill→Insert Pins→Attach Spring. While this became the "backbone" of the cell layout, several adjustments were made to accommodate the differences among the routings that were highlighted by the Sequence Similarity Analysis of Routings shown in Figure 4b.

This is how the proposed layout in Figure 2 was designed by integrating computer analytics with established rules for precedence among different

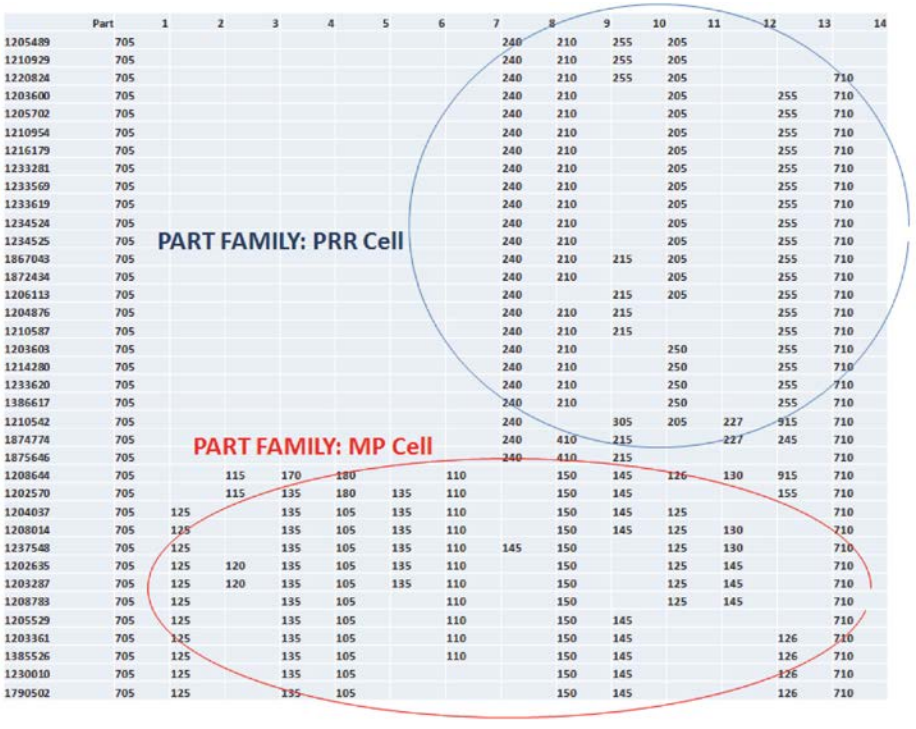

Figure 4(a) Product-Process Matrix Analysis.

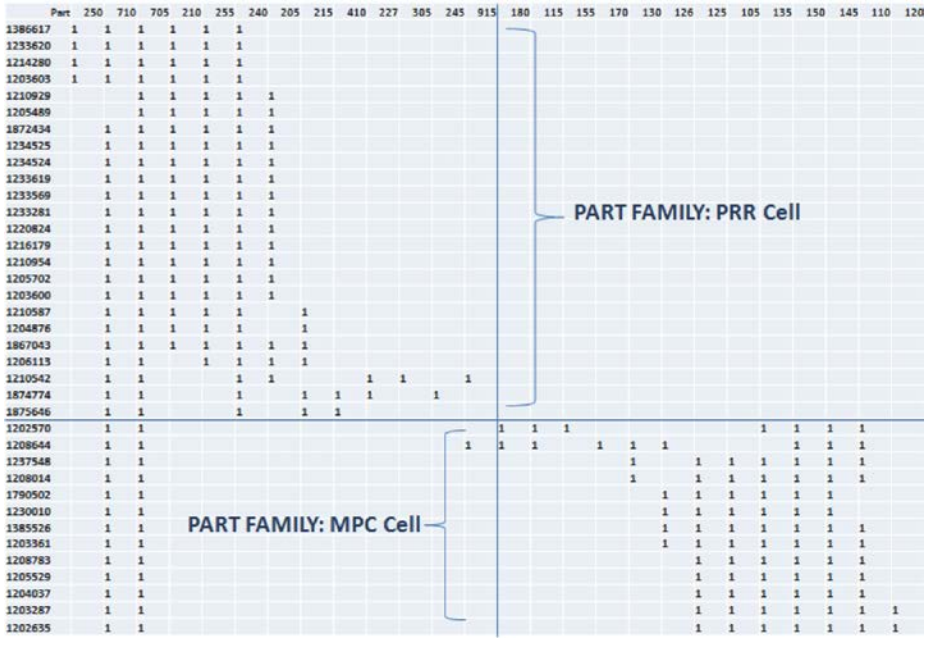

Figure 4(b) Sequence Similarity Analysis of Routings.

machining processes and employee expertise. It is unrealistic to expect (or even want) to do the computer analyses manually.

A Major Challenge that Lies Ahead

The proposed layout in Figure 2 is at best a good starting point. This was the easy part. This layout is theoretical because computer algorithms simply cannot take into consideration many constraints and operational realities. Next, we faced a major hurdle of justifying the investments in re-locating the machines already in the area, as well as moving machines currently located elsewhere into the area. John Sexton, our facilities maintenance and industrial engineering manager, estimated that the following expenses would be incurred:

- Capital Investment
  - Purchase a Norton Grinder
  - Purchase a jib crane for loading/unloading both the Mori Seiki and Haas lathes
  - Purchase new worktables, toolboxes and cabinets for all machines
- Equipment Re-Location
  - Move Mori Seiki from PRR Cell into MP Cell
  - Move Mazak VTC/Mill, ProCut Lathe and EZPath Lathe out of the MP Cell into the PRR Cell
- Facility Upgrades
  - Relocate and rewire all other machines already in the area occupied by the MPC based on the new floor plan for the cell
  - Resurface the floor

Figure 5(a) From-To Chart for the MPC Part Family.

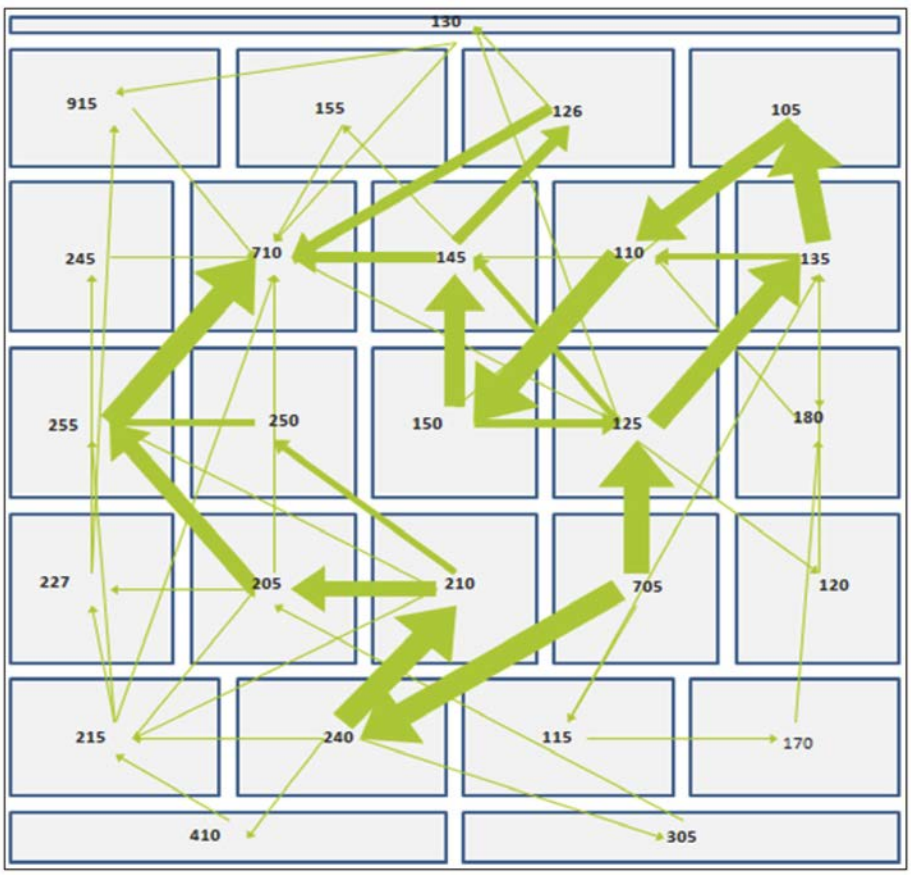

Figure 5(b) Flow Diagram to Visualize the From-To Chart.

180	170	130
105		110
135		150
125		145
120		126
155		710
115		915
705		

Figure 6(a) U-shaped Layout produced by STORM.

705	115
170	180
125	135
120	105
150	110
145	155
126	130
710	915

Figure 6(b) Parallel-Line Layout produced by STORM.

115	705	
170	125	120
180	135	105
	150	110
155	145	
	126	130
	710	915

Figure 6(c) Block Layout produced by STORM.

This is just the initial list of costs that was presented to us so we could prepare a detailed cost/benefit analysis to justify investments in the implementation of the first FLEAN cell in our facility.

But We Did Not Wait To Implement the Simple Changes

Lean encourages us to make any and all improvements that cost nothing or require minimal expense. So, we decided to at least "pluck the low-hanging fruits". In the case of the MPC, the employees have worked in this cell for decades. For example, Luong Dam, who runs the three Cincinnati mills has been with the company for nearly three decades. It took little time for us to convince him that beneficial change was in the air. He worked tirelessly with the Tiger Team over a period of two weeks to raze his workcenter. There were also examples of in-house benchmarking where we tried to borrow ideas that had been successfully implemented in other cells. In another cell, the QRC, we noticed a tool storage cart that had been fabricated by one of our senior multi-talented employees, Phillip Nguyen. All that we needed to do was to request him to design and fabricate a similar fixture for the tools used on the Le Blonde lathes in the MPC. How much do you think it cost him besides his time and effort? Such is the power of lean to motivate and inspire every employee who "gets it."

Dhananjay Patil is a Masters student at the University of Texas-Arlington where he is pursuing his degree in Industrial Engineering (IE). He is currently working as an Industrial Engineering intern at Hoerbiger.

Dr. Shahrukh Irani is the Director of Industrial Engineering (IE) Research at Hoerbiger. In his current job, he has two concurrent responsibilities: (1) To undertake continuous improvement projects in partnership with employees as well as provide them OJT training relevant to those projects and (2) to facilitate the implementation of Job Shop Lean in HCA's U.S. plants.

Turbine Gearbox Inspection: Steady Work in a Shaky Wind Market

Jack McGuinn, Senior Editor

Having outlasted the worldwide Great Recession, the Global Wind Energy Council (GWEC) forecasts a constant growth in wind energy, i.e.: "increase in worldwide capacity to 460,000 MW by 2015."

Europe is a particularly robust market and remains a leading wind power leader—if not in rate of growth (wind energy is arguably a mature industry in Europe), certainly in penetration. The United Kingdom and France are good examples, with the former set to invest 100 billion pounds (> $152 billion American) in wind energy, both on and offshore, the latter progressing to a goal that 10 percent of the country's electrical consumption be wind-generated by 2020.

Here in the United States? Not so hot. According to a recent report by *North American Wind Power* (*nawindpower.com*), "The wind energy industry averted disaster by securing a one-year extension of the production tax credit (PTC) and is likely to benefit from the 'begin construction' language contained in the latest iteration of the incentive. Some companies, including GE, the world's largest wind turbine manufacturer in terms of megawatts installed in 2012, have expressed concerns about where the wind power market is headed for the remainder of 2013, as the PTC's eleventh-hour extension came too late for many firms to resurrect their development plans for this year."

That is so excruciatingly same-o, same-o that we'll leave the market analytics to the experts. We're here to talk about wind turbine gearbox inspection.

And given the highly complex nature of wind turbine gearboxes and their innards, it is little wonder that they are arguably a wind turbine's most endangered component. What heightens that danger is bearing failure. It follows, then, that turbine gearboxes require a good deal of TLC if they are to run dependably without sucking up every available dollar invested in their service warranties. It is really just another take on the old bromide — you can pay me now or you can pay me (much more) later. So a dedicated combination of planned, predictive — whatever you care to call it — maintenance and inspection is significant to gearbox life. And here's another reason that the upkeep on existing wind units is critical. As pointed out above, wind in the U.S. continues to be a relatively unpredictable market, so for sake of demonstrating that wind energy is a winning strategy for the country, it behooves the current players in the market here to ensure that those already installed wind turbines function to their designed capability.

So what's with gearboxes? Why so failure-prone? Reasons typically mentioned include quality-discrepant parts, defective material, faulty design and Mother Nature, with bearings as typically leading the pack in all categories. It has been reported that a wind turbine gearbox is replaced every five to seven years (Source: *DEWI* magazine, No. 39, August 2011). And, although according to Andy Milburn of Milburn Engineering, Inc., a gear consulting company located in Seattle, WA (*andy@milburnengineering.com*), "The typical *design* life (of a turbine) is 20 years," he adds that the real-life experience is that "most turbine manufacturers only offer warranties in the two to five year range."

And then of course there are insurance providers who quote coverage (liability, performance, etc.) rates based in large part upon—*exactly*—previous industry performance.

Toward that end, "I can only speculate that early detection of failures can significantly reduce the cost of repairs, especially if the difference is between deploying a crane to remove the gearbox or repairing it up-tower," says Don Roberts, P.E. and president of DA Roberts, LLC (*don@daroberts-llc.com*). "What has impacted the frequency of gearbox inspections most significantly

Depending on the assignment, rappelling is a valuable part of a wind turbine gearbox inspector's skillset (all photos courtesy NREL/Siemens AG).

is the warranty expiration, which usually occurs between two and five years."

What does a comprehensive wind turbine gearbox inspection require? First, understand that there are four levels of gearbox inspection:

1. Quality assurance audits during manufacturing
2. Operations and maintenance (O&M) inspections
3. Tear-down inspections at end of warranty
4. Tear-down inspections for failure analysis

Trying to address all four in the space allotted here is not possible, so let's address No. 2—O&M inspections.

Given the complexity of the assignment, you wonder how many personnel are needed for the job. Is there, for example, a gear person, a bearings person, a lube expert, etc?

"Up-tower inspections involve two trained technicians who are good with a borescope," says Roberts. "Shop inspections may involve a number of experts, depending upon the nature of

the inspection. For example, gear failure may involve a gear expert, whereas a bearing failure may involve a bearing expert. Oftentimes, in wind energy, the engineering experts are gear and bearing guys. Unique failure modes may require a specialist from a university or manufacturer. Coordination is usually performed by a consulting engineer who is lead on the project, but may not have the highest levels of expertise in each discipline."

And at Spin Trends (a division of Frontier Pro Services; *frontierpro.com*), "My teams use two men," says Darrin McCulloch, vice president. "One highly skilled technician to provide bore scope inspections while the other is present for safety requirements, although typically is also well versed with inspection methodology. Our skilled inspectors are versed with standards, creative best practices of the inspection and author their own in-depth reports."

How long does a gearbox inspection take?

"That's best answered by people doing the inspections, but in my experience it takes about four hours once you get up to speed with a particular model gearbox," Milburn allows.

Or, according to Roberts, "Eight hours for a more thorough inspection looking at all planet bearings and working with custom fixtures to access hard-to-reach locations. More detailed inspection uptower requires draining of at least some of the oil, maybe 40 liters."

As for the level of experience required to be a good gearbox inspector, it is not acquired easily. As Milburn points out, "There are two aspects to an inspection; the first is observing the condition of the components, and the second is knowing what that condition means and how serious it might impact life. The first part can be learned fairly quickly, but the second will take some time and really requires a lot of experience in failure analysis and forensics."

Anyone in manufacturing is well aware of the latest advances in condition monitoring systems and the savings they can provide. Regular inspection of potential trouble spots and addressing them when they are least expensive is huge; but how does that affect wind gearbox inspection?

"Vibration, wear particle monitoring systems and oil sample or filter element analysis are being used to help inform the scope of borescope inspections uptower," Roberts informs.

"They have also been successful in early detection of failures, making the verification inspections easier due to less collateral damage within the gearbox," says Shawn Sheng of the NREL (National Renewable Energy

A robust, up-tower gearbox inspection regimen is critical to ensure steady performance.

Laboratory)/National Wind Technology Center (*nrel.gov*).

Spin Trends began using condition monitoring in 2003 while the rest of the industry was still talking about it. Our gearbox inspectors are also CM specialists." However, McCulloch says, CM is often not enough. "Technology such as condition monitoring, oil analysis, particle counters, temperature readings—and even fault logs—do not typically provide enough insight that allows management to make $20,000 to $320,000 decisions." In those cases, McCulloch says, photo documentation of the problem is often required.

And then there is non-destructive testing (NDT). It's a technology that plays a role in turbine gearbox inspection, limited though it may be. (It's a nacelle space issue.) Indeed, while Roberts explains that, "No, (NDT) is not commonly used (up-tower)," Milburn on the other hand says "(NDT is used) not just on gearbox inspections but plays a big part when gearboxes are disassembled for repair." Or, as Charles D. Schultz, PE/chief engineer of Beyta Gear Service (*gearmanx52@gmail.com)* and a *Gear Technology* technical editor points out, "You can use spray-can crack checks and ultrasonic testing up-tower, but magna-flux (NDT) equipment won't fit up there."

Bearings have been fingered as a leading root cause for gearbox failure. But what can be done? How about lubrication, a bearing's best friend?

"There is a huge amount of research on cracked raceways on intermediate and high-speed shaft bearings that may result in changes to current standards or practices," Roberts says. "It is more common to see off-line filtration systems added to reduce the amount and size of wear particles in the gear oil. There are brief discussions on off-line filtration systems in AGMA 6006 or the new IEC/FDIS 61400-4."

"An AWEA (American Wind Energy Association) operation and maintenance (O&M) working group has released recommended practices for changing oil in wind turbines, which is part of the larger set of O&M-recommended practices, available at: *http://www.awea.org/oandm*," says Sheng.

Material choice is another element of the mix under constant scrutiny, along with its counterpart industries—heat treating, surface finishing, etc.

"There has been more focus on bearing materials, heat treatment and surface coatings, along with superfinishing surfaces of gear and bearing elements," Roberts confirms.

And according to Milburn, "One particular gearbox manufacturer has experienced a high rate of failures due to inclusions in gear steel. In general I think most wind turbine gearbox manufacturers are specifying steel that is a higher quality than what has been used for industrial gears in the past."

There is also the ever-increasing size—and load assumptions—of today's turbines to consider. How does that relatively recent development affect an inspector's work? Are the measurement and other inspection tools of today adequate to keep abreast of such growth?

"The larger size brings additional sensors and accessories to the gearbox for monitoring and lubrication," says Roberts. "Those systems have a wealth

of data that can be extracted by whoever has the monitoring contract, be it OEM, owner, or third party. The inspector does not always have access to that data, but it seems redundant, or even inappropriately matched, for the inspector to supply more sophisticated diagnostic equipment. What is needed, or would be helpful, would be a single-point diagnostic interface (read-only USB) with standardized communications protocols, similar to what the auto industry has developed. Imagine a standard that specified an essential list of data such as repair history, laboratory analysis results, significant events such as grid-loss stops, hours and production since rebuild (not turbine operating hours or production as is now typical). The inspector should be able to pull pertinent inspection snapshot information such as SCADA history for faults or temperatures, oil analysis results, condition monitoring trend lines, service history or log, etc. to a laptop or tablet by browsing or submitting a customized query to the gearbox service database.

As for Milburn, the size issue is more of a manufacturing concern.

"Size is affecting manufacturing, but so far I don't think it has had much effect on gearbox inspections," he says. "The most used tools for inspection are still human eyes, cameras and borescopes."

Another critical gearbox component is what is known as an "acoustic signature," and every gearbox has one. That signature's noise level maximum is predetermined by regulatory dictates relative to that specific installation. How is that tested in the field?

"All wind turbine gearboxes are full-load tested as part of the manufacturing process," Milburn explains. "Vibration data measured with accelerometers is gathered during the testing. Each gearbox design has acceptance and rejection criteria that determine whether the gearbox is acceptable. The results during testing and initial operation in the field are then used to develop alarm levels for when vibration is monitored during normal operation."

As for acceptable noise levels in Europe (and a few U.S. locations), they are stricter and more prevalent, as determined by population proximity.

"Sound levels are a significant issue in Europe and some parts of the U.S. where the turbines are located closer to human activity," Roberts says. "Therefore, certification testing may include noise signature, which is published with the certification documentation. Noise testing is a very rigorous process performed by certification bodies; IEC 61400–11:2002 or AWEA 9.1–2009 are examples of acoustic noise measurement and analysis stan-

dards. Testing agencies must be accredited in order to provide valid test results."

Finally, a word or two about standards for wind turbine gearboxes. Most reading this are well aware that a standard—in both its implementation and evolution—comes about at a seemingly glacial pace—especially wind turbine standards with an international scope. But what drives the evolution of a standard? That is, what changes that in turn changes the standard? Is a standard, in a sense, always evolving? The answer to the last part of the questions is yes—but not always in a good way.

"A standard is the lowest bar that can be agreed to by consensus with everyone on the committee," says Milburn, adding, "Unfortunately, it does not represent best practice, and company commercial interests can override technical issues."

Adds Schultz, "Standards change because the committee members learn new things in the field or react to ongoing problems from the field. (For example), micropitting research is a hot topic in the wind turbine field right now."

"(A standard's) evolution can be driven by failures, or, due to large representation from industry, from within to improve manufacturing," Roberts explains. "In extreme cases, industry can implement or attempt to implement self-promoting language. Size of equipment in wind energy would be a good example of what is driving changes in the standards. The operating environment, off-shore for example, may also contribute."

Technicians working in a turbine nacelle brought in-shop.

For more information:

Charles D. Schultz, president
Beytagear Service
0N230 County Farm Road
Winfield, IL 60190
Phone: (630) 209-1652
chuck@beytagear.com

Milburn Engineering
Andy Milburn, president
2024 7TH AVE. N.W.
Seattle, WA 98177
Phone: (206) 365-2818
andy@milburnengineering.com

National Renewable Energy Laboratory
901 D. Street, S.W. Suite 930
Washington, D.C. 20024-2157
Phone: (202) 488-2200
nrel.gov

DA Roberts, LLC
Don Roberts, president
4829 NE 75TH ST
Seattle, WA 98115-5207
Phone: (206) 525-6349
don@daroberts-llc.com

Spin Trends
Darrin McCulloch, vice president
1191 Watson Loop
Touchet, Washington 99360
Phone: (509) 394-2663

Girth Gear Inspection — Pre- and Post-Manufacture

Email your question—along with your name, job title and company name (if you wish to remain anonymous, no problem) to: *jmcguinn@geartechnology.com*; or submit your question by visiting *geartechnology.com*.

QUESTION

What are the ins-and-outs of quality inspection of girth gears, from both a manufacturer and buyer perspective?

Girth gear specifications: DP = 6.327.12 mm, Module = 30, Number of teeth = 208, Teeth width = 600 mm, Dim. = 6.367/4.900 × 760, Material = GS34CRMO4, Rep. = 1.3 to 13

Response No. 1 provided by HMC Inc.: There are many quality control requirements involved with girth gears. The process begins in manufacturing and continues through installation, run-off and ongoing monitoring.

Manufacturer perspective:

- During manufacturing:
  - ***Raw material: incoming checks and inspections***
    - ◊ These include, but are not limited to, material certifications with full reports from forging and plate vendors, dimensional inspection and hardness testing upon arrival, and ultrasonic inspection of the forgings.
    - ◊ Dimensional reports.
    - ◊ NDT hardness testing and verification.
  - Fabrication (welding)
    - ◊ Stress-relieving oven; digital charting (thermal reports).
    - ◊ Dimensional checks.
    - ◊ Magnetic particle testing; ultrasonic testing of welds.
    - ◊ CWI (certified welding inspector) visual checks.
  - Machining/tooth inspections
    - ◊ In-process dimensional, run-out and surface finish checks for any significant process.
    - ◊ On-board lead, pitch and profile checks on the teeth are performed.
  - Final inspection
    - ◊ During the final inspection everything is dimensionally inspected and thoroughly reviewed to make sure all items and inspections are up to the specifications.
    - ◊ Mesh test between gear and pinion (contact pattern).
- During installation and alignment:
  - Over the years, HMC has seen misalignment cases where companies get in a hurry and/or have a lack of proper supervision and instructions. The girth gear driving pinion ends up getting aligned to the reducer, causing a misalignment issue between the girth gear teeth and the driving pinion teeth (Fig. 1).
  - Proper alignment should consist of: axial and radial alignment of the girth gear to the center line of kiln/mill; center line of the driving pinion is aligned to the center line of the girth gear; center line of the reducer output shaft with coupling is aligned to the center line of the girth gear driving pinion; finally, the center line of the motor is aligned to the center line of the reducer input shaft with coupling.
- Run-off and ongoing monitoring
  - Proper oil inspection and selection
    - ◊ Oils and other lubricants are often stored in the same area. And often the numerical and alphabetical identification numbers that identify the different gear/transmission oils and the heavier, open-gearing lubricants are very similar, thus inviting employees to potentially use the wrong lubrication materials. This could prove to be a disastrous situation for the operating quality of your girth gear. Proper selection and continuous inspection of the girth gear's lubrication selection falls in parallel to both proper alignment of the gearing and start-up monitoring/inspection, as mentioned above.
    - ◊ By routinely inspecting the quality of the oil lubricating the girth gear system an effective 'double-check' on proper alignment would be created. In the event of an improper initial alignment inspection, the results from a girth gear oil sample inspection

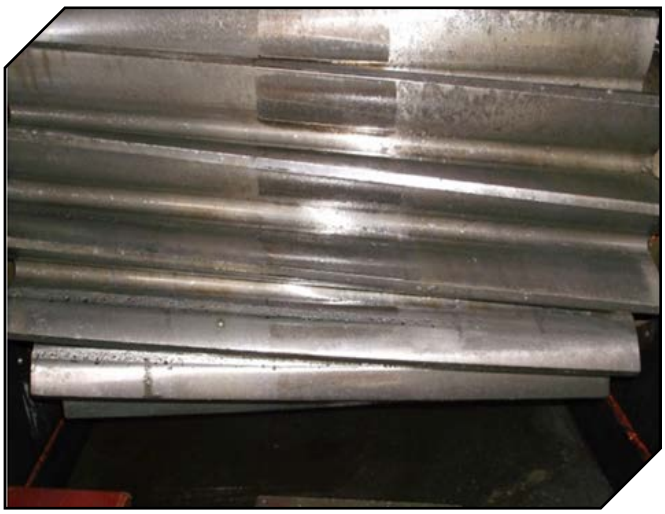

Figure 1 Example of girth gear misalignment: girth gear driving pinion end is aligned to the reducer, causing misalignment between the girth gear teeth and driving pinion teeth (courtesy HMC).

would yield metallic contents due to the meshing contact breaking down and dynamic destruction occurring.
  - ◊ Proper start-up monitoring/inspection, specifically with emphasis on temperature recording, would be a significant indicator of proper oil selection. If the incorrect oil is selected for lubrication purposes, an unusually high temperature will be observed at initial start-up; this is due to the possibility that the oil selected has a viscosity under the requirements for a girth gear set. If the viscosity is not high enough to properly lubricate the meshing set, operating temperatures will increase. As these temperatures increase, the natural viscosity properties of the lubricating oil will continue to decrease, leading to damage of the girth gear set. As can be observed, this is a double-edged sword; i.e.: an improper, low-viscosity oil selection from the beginning will lead to high operating temperatures and an even lower operating viscosity in the gear set.
- Run-off and ongoing monitoring (cont'd.)
  - ***Two functions must be performed at start-up*:**
    - ◊ Monitor contact patterns, as the pattern could change under loading.
    - ◊ Verify the gear set is lubricated properly.
  - As soon as the machine is running, verify that adequate amounts of lubrication are conveyed and dispersed evenly and completely. A good suggestion is to run mill for eight hours under no load, then increase load slowly over a 24-hour period. Check contact pattern and lubrication patterns every 2-4 hours. When partially or fully loaded, some deflection will occur; continue to check contact and lube patterns every 2-4 hours and make alignment corrections as required. Continue checking until no farther adjustments are required and all pattern checks are satisfactory.
  - Check contact pattern and lubrication patterns approximately (30) days after start-up and take a lubrication sample. Make alignment adjustments as required and change lubrication as it becomes contaminated. A periodic maintenance schedule should be developed based on specific field conditions.

Customer perspective:

Generally, customers require a final inspection report that may include, but is not limited to, a mesh check (contact pattern check), material certifications, dimensional inspection, run-outs, MT and UT reports. Some customers require quality inspection test plans. Customers perform full vendor audits.

HMC responses were a team effort consisting of

Ryan Parkes, Robert J. Smith III, Josh Winiger, Greg Kermode, Bob Sullivan and Rob Ferguson

HMC Inc.
3010 S. Old U.S. Hwy. 41, Princeton, IN 47670
Phone: (866) 990–9462
www.hmcgears.com

Response No. 2 provided by Frank Uherek, Rexnord Corp.

Manufacturer perspective:

When the gear is mounted on the mill, periodic inspections are required to check alignment of the pinion and gear. This can be done by measuring temperature differences between each end of the gear face as it meshes with the pinion. In addition, the teeth should be visually examined for pitting and wear damage. Magnetic particle inspection is a useful tool to detect surface separation (cracks) in the tooth surface. ASTM E2905 discusses a new method for performing this type of inspection. Confirming that the lubricant system is dispensing the correct amount of oil or grease at the proper spray interval is also important for long gear life. Reviewing bolt torques at the split joint and mill mounting flange is also required.

Inspection steps—manufacturer side:

Given the critical service these gears perform, quality assurance is an integral part of the manufacturing process. The process begins with chemical analysis of the blank material, magnetic particle inspection of the cast blanks or fabricated rims, heat treat documentation records, and mechanical properties testing. Once the gear blank leaves the foundry or fabrication shop and is rough-machined, ultrasonic testing of the split-joint flange (where the gear is bolted together), the rim and the mounting flange to the mill is performed to ensure a sound base before cutting teeth. The hardness of the blank is also confirmed at this time. Dimensional checks are made to confirm interface dimensions. Run-out of the mounting flange, face width and outside diameter is taken to record the as-cut condition of the blank to enable the same mounting conditions on the mill as on the gear cutter. Tooth attribute inspections, such as profile and pitch, as well as tooth thickness, are recorded to confirm that the gear matches the design requirements of the engineer. A roll contact check, or fixed center contact check is also completed to confirm that the helix (lead) of the gear matches the pinion. Split joint closure is measured to confirm that the gear did not distort during the manufacturing process. Magnetic particle inspection of the finished gear teeth is typically conducted and the results reviewed by the design engineer to identify and relieve any surface indications present on the gear teeth from the raw material. The last step is to have the design engineer review all of this collected information to confirm that the finished product meets the specification and provides the client the performance they are expecting for the application.

What is required of the customer?

The client should confirm that the mill is properly installed with a well-designed foundation and the required safety and electrical controls. A periodic preventative maintenance inspection program ensures that all controls, lubricant delivery systems and power transmission components—gear drive, couplings, pillow blocks and girth gear sets—are aligned, lubricated and performing to specification.

Frank Uherek, principal engineer—mill products
Rexnord Gear Group
3001 West Canal Street, Milwaukee WI 53208
Phone: (414) 937-4523
Fax: (414) 937-4083
www.rexnord.com

An Experimental Investigation of Aerospace-Quality Gears Operating in Loss-of-Lubrication Condition

Ida Bartilotta, Enrico Ciulli, Salvatore Manconi and Elena Toson

This work establishes a baseline for aerospace spur gear behavior under oil-off conditions. The collected test results document a different oil-off time, dictated by material used.

Introduction

The ability of gearboxes to perform in a loss-of-lubrication condition is an important parameter in design criteria—particularly in aerospace applications. The heat generated by a lost lubricant is extremely high and can lead to loss of gear backlash, which in turn leads to thermal expansion, reduced hardness, plastic deformation and high frictional wear—all of which contribute to a total failure of the transmission system (Ref. 1).

The certification of large rotorcraft drive systems requires survival of a loss-of-lubrication test. The test must certify that—for at least 30 minutes after the lubrication system failure (Ref. 2)—any performance issues resulting in loss of lubricant will not prevent continued safe operation, and will maintain the torque and rotational speed prescribed by the applicant for continued flight.

Whereas calculation methods and standard criteria for predicting gear damage, e.g.—wear, scuffing, pitting and bending—are available, an analytical standard criterion for determining the capability of a transmission to achieve the required 30 minutes running in oil-off condition is not. Thus an experimental approach is required. A need for establishing a baseline for gear behavior in oil-off condition—exacerbated by the dearth of published data on prior work in this area of study—justifies the experimental work described herein.

Experimental Approach

The experimental work was carried out in two ways:

1. Four tests were conducted with gears of different geometry and materials to gain preliminary indication of the heating of the running gears and to check the capability of the test facilities to perform the test.
2. Thirty-six tests were planned using the "design of experiment" (DoE) technique to evaluate the influence of three parameters: 1) material (variable on two levels); 2) sliding speed (variable on three levels); and 3) contact pressure (variable on three levels). Each combination of these parameters was investigated twice and, indeed, 36 tests were conducted.

The tests involved (Fig. 1):

- Warm-up of the test rig and steady-state operation of the test spur gears under normal lubricating conditions; in this phase the gears were jet- lubricated with an in-mesh spray bar (Fig. 2).

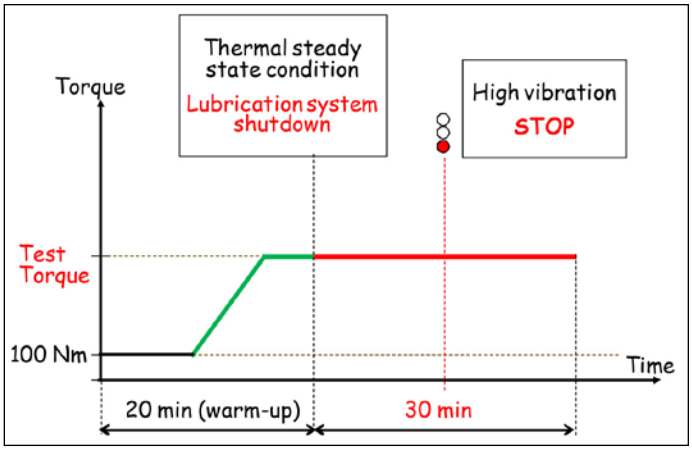

Figure 1 Test procedure.

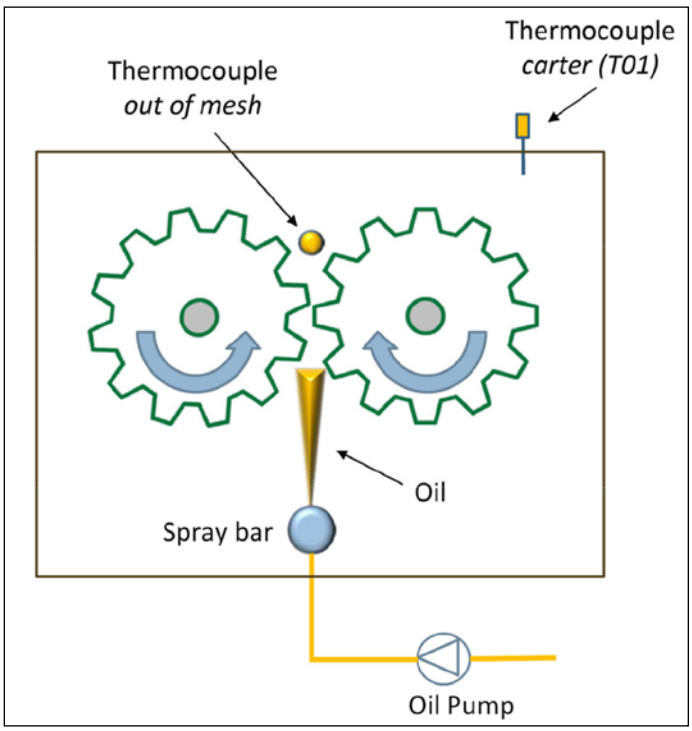

Figure 2 Gear lubrication.

Proceedings of the ASME 2012 11th Biennial Conference on Engineering Systems Design and Analysis, ESDA2012, July 2-4, 2012, Nantes, France

- Lubrication system shutdown.
- Continued operation at constant speed and constant torque on the driven gear in loss-of-lubrication condition for 30 minutes.

(Were the safety threshold of the test rig (high vibration) endangered, the test was to be stopped immediately.)

Throughout the test, the temperature—at a point very near the mesh, referred to as "temperature out of mesh"—was measured (Fig. 2.) to gain an indication of the heating of the gears. In some tests the bulk temperature of the running gear was measured. At conclusion, the gears were visually inspected and, in some cases, a metallographic observation of the teeth and a hardness measure were made. These results are reported in this paper.

Description of Test Facility

Gear rig. The experiments were carried out using a back-to-back test rig specifically designed for aerospace gear testing (Refs. 3 and 4), shown in Figure 3.

The test rig is capable of high performance; maximum rotational speed is 18,000 rpm and maximum circulating power about 1 MW.

Torque in the system is provided by an electromechanical servo-actuator that varies the axial position of a load shaft on which two helical gears are mounted. The aggregate motion of the load shaft controls the magnitude of torque in the closed-loop system (Fig. 4).

The bench is equipped with two torque meters—one on each test gear shaft—of 20 thermocouples installed on the bearing outside ring and at several points of the test and slave gearbox. An online vibration monitoring system based on four high-frequency accelerometers is used to control damage to the sample gears as well as other test rig components.

The lubrication system provides thermo-regulated, independent lubrication of the slave gearbox and test gearbox.

During initial operational mode—but before loss-of-lubrication testing—a single lubricating jet impinged on the gear teeth just prior to mesh. Oil temperature was the same in all tests. To avoid dripping of the lubricant during the oil-off phase, the spray bar was positioned under the gears (Fig.2).

Test gears. Two identical gears were used for all tests. Owing to the 1:1 gear ratio, the same tooth pairs are in mesh throughout the test. The test gears were made from two steels typical for aerospace application, and referred to here as Material A and Material B.

In order to measure the tooth bulk temperature, one of the two sample gears was equipped with a K-type thermocouple buried in the end-face (Fig. 5). The temperature signal, conditioned onboard by a purposely developed electronic amplifier, was transmitted to the acquisition units through a slip-ring (Ref. 5).

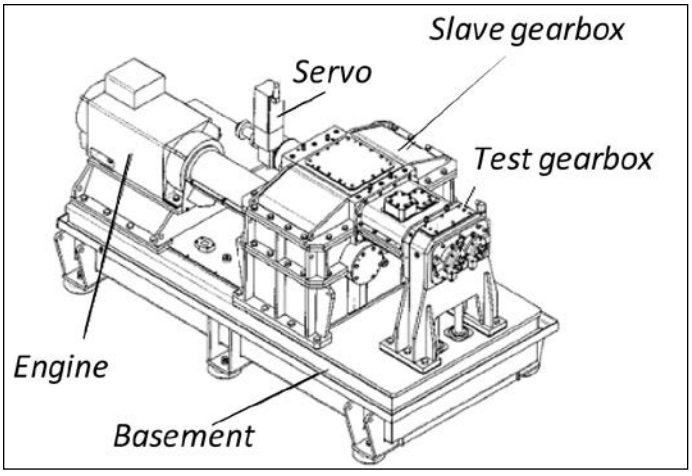

Figure 3 Test rig.

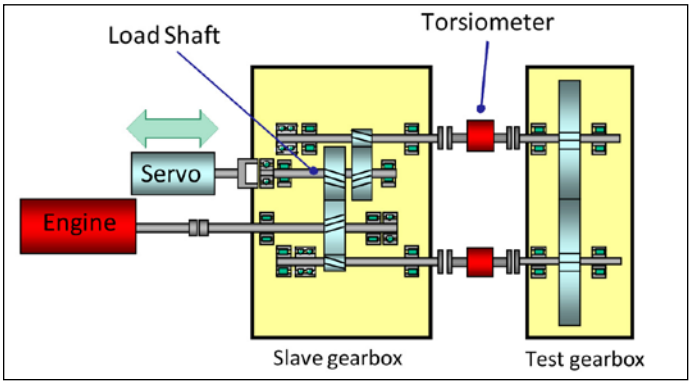

Figure 4 Test rig layout.

Figure 5 Gear equipped with thermocouple for bulk temperature measurement.

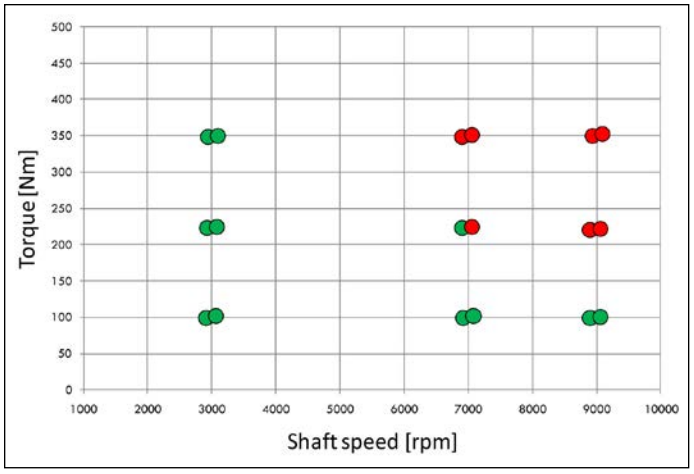

Figure 6 Test results: Material A.

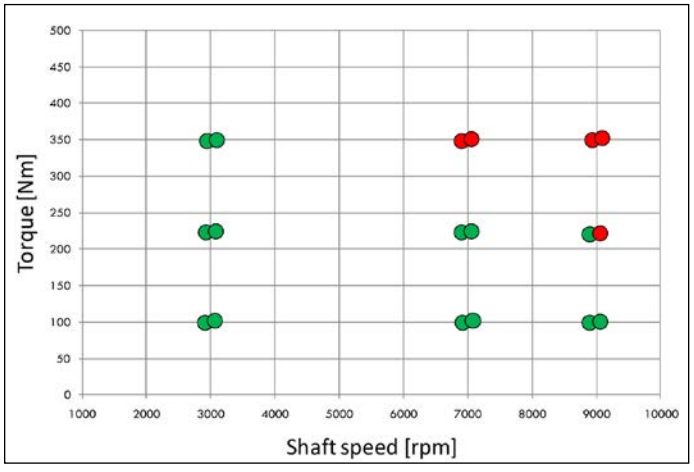

Figure 7 Test results: Material B.

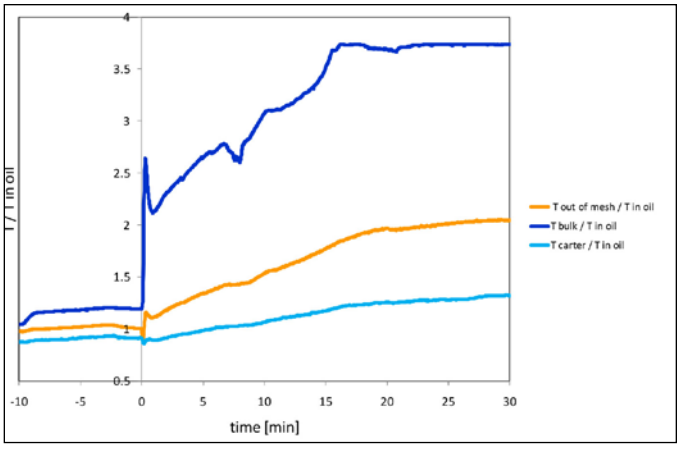

Figure 8 Loss-of-lubrication effect on bulk temperature at 350 N-m and 3,000 rpm.

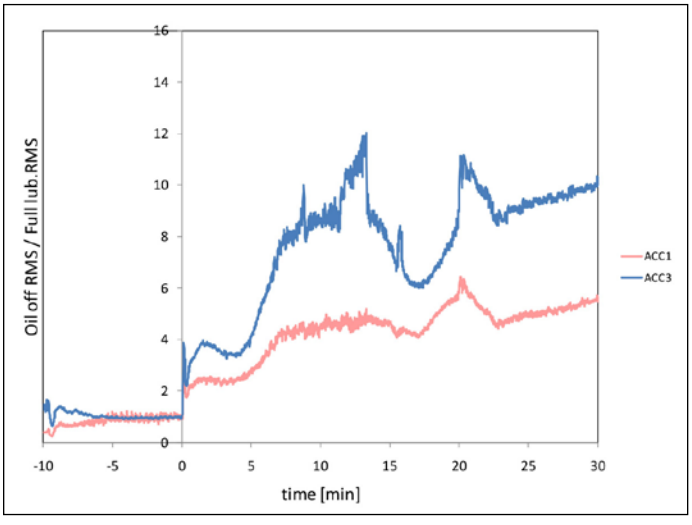

Figure 9 Loss-of-lubrication effect on RMS at 350 N-m and 3,000 rpm.

Test Results

Figures 6 and 7 show the torque and shaft speed values for the tested operating conditions. Since the gear geometry was the same in all tests, the observed torque and shaft speed levels correspond to a like number of contact pressure and sliding-speed levels.

Test conditions with an oil-off time of 30 minutes are indicated in green; conditions with the shorter oil off-time are indicated in red.

Of the 36 tests conducted, 24 met the 30 minute requirement despite the loss of lubrication; 12 tests were stopped prematurely.

All tests with an oil-off time less than 30 minutes were stopped before the required time due to a breaching of the safety threshold of the test rig (high vibration). However, in all tests the transmission was able to transfer the required power.

In Figures 8 and 9 we see the trend of the main parameters monitored during a test carried out at 350 N-m and 3,000 rpm in which bulk temperature was measured. Immediately after the lubrication shut-down, a rapid, attendant increase in bulk temperature and vibration level (RMS of the accelerometer signal) was observed.

Whereas the RMS spiked up and down several times during the test, the bulk temperature showed an initial, progressive increase; but after about 15 minutes it stabilized and remained so until the end of the test.

The out-of-mesh temperature showed a trend similar to that of the bulk temperature.

During the loss-of-lubrication phase a progressive increase in the motor current—due to the increase in the mesh power losses—was observed.

In most of the tests a variation of the load shaft position was required to keep the running torque constant to compensate for a loss of torque—due probably to the progressive and severe wear on the running gears' active surface (Ref. 6).

The data shown (Figs. 10–12) demonstrates the effect of load and speed on out-of-mesh temperature. As can be seen in comparing the reported data, the out-of-mesh temperature increased slightly with the shaft speed, but was affected more by the load. This data was collected from tests carried out with gears made from Material A, but similar results were found in tests carried out with Material B.

The out-of-mesh temperature at the end is, as expected, higher than at the beginning of the oil-off phase in all tests except the one carried out at 3,000 rpm and 100 N-m; it was conducted under less-severe operating conditions than among all those tested. In this case the temperature decreased; the same result was found for Material B.

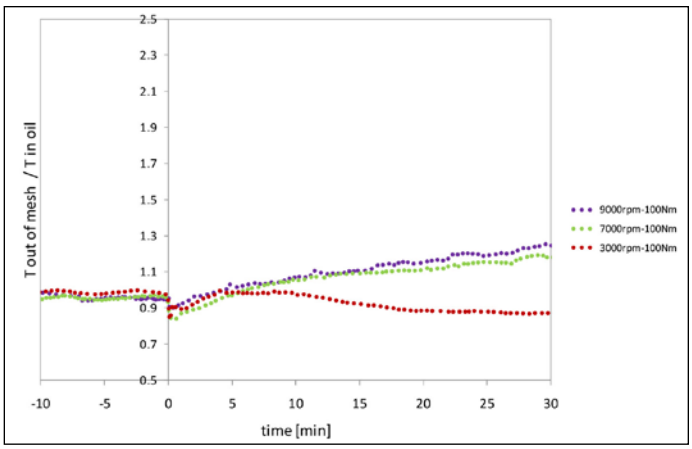

Figure 10 Loss-of-lubrication effect on temperature out of mesh at 100 N-m at various speeds.

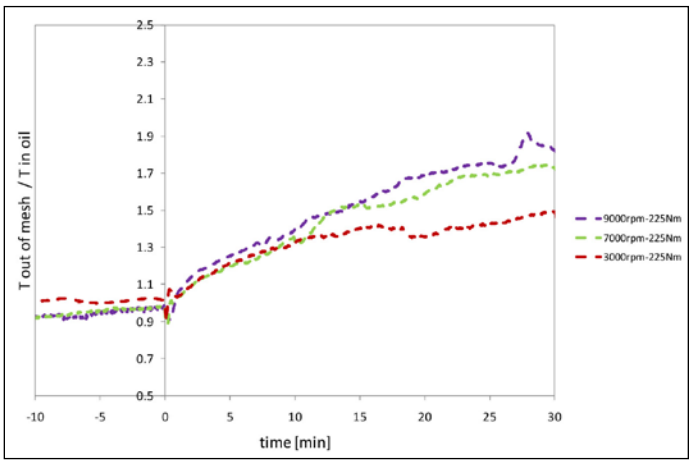

Figure 11 Loss-of-lubrication effect on temperature out of mesh at 225 N-m at various speeds.

The heat generated by meshing gears is principally due to friction power losses (Ref. 7). If the relative sliding is not altered, and if the load remains constant, the possible mechanism to explain the temperature decrease is a decreasing of the friction coefficient. As has been described by others (Ref. 8), the reduction of the friction coefficient could be explained in that perhaps the interacting surfaces, with the combination of pressure and temperature, caused the formation of a carbonaceous layer.

Thus if the operating condition, particularly the load, determines a severe wear ratio, it follows that the formation of the carbonaceous layer is insufficient to cause a reduction of the friction coefficient, and a loss of temperature out of mesh cannot be observed.

A statistical analysis of data (*ANOVA*) was carried out to establish which parameter—material, torque or speed—most affected the heating of the gear. The temperature out of mesh, indicative of gear heating, was considered in performing this analysis. The results showed that torque is the most influential parameter, followed by speed and material.

Gear Post-Test Analysis

At the end of all tests, the gears were visually inspected to determine damage on the tooth surfaces. Post-test photographs of the gear teeth and of the gear body were taken.

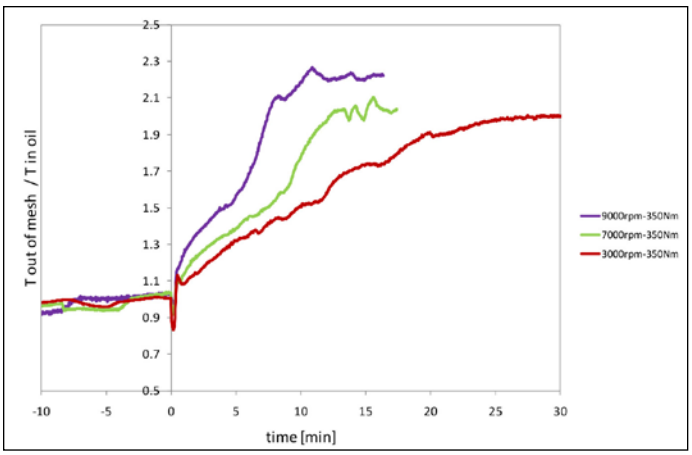

Figure 12 Loss-of-lubrication effect on temperature out of mesh at 350 N-m at various speeds.

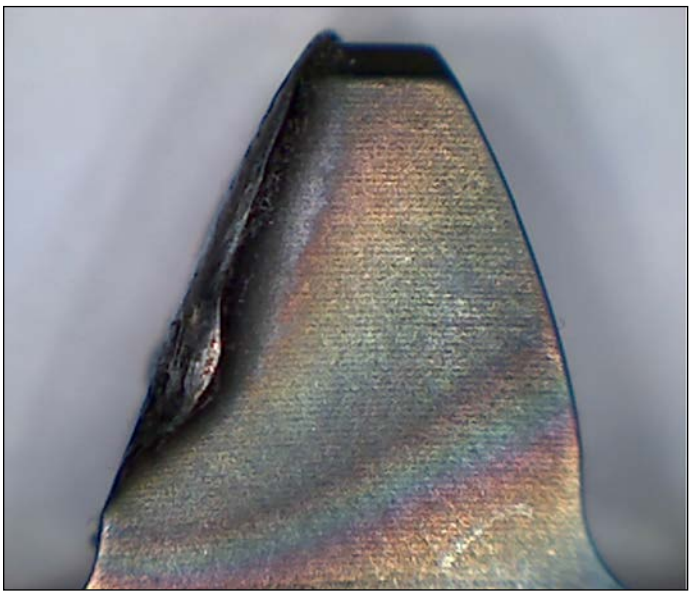

Figure 13 Severe alteration of tooth surface geometry.

In some cases, one tooth was removed from the gear to perform metallographic analysis and hardness measurement. The entire gear appeared to have a great deal of scuffing and metal removal.

Gears employed in the severest test conditions showed a dramatic alteration of surface geometry (Fig. 13).

At the end of one test, both the flank of the tooth, even the flank that carried no load, appeared coated with a dark deposit; such a deposit was even found within the **carter** gearbox (Fig. 14).

Another test revealed a different amount of wear, depending on the material and operating conditions. When employed at high loads, the gear made from Material A showed a more relevant wear than gears made from Material B when employed at high speed.

In Figure 15, post-test photographs of gear teeth made from Material A, and subjected to various test conditions, are shown; after running less than 30 minutes the working time in lubrication loss is indicated.

Teeth operating at minimum torque and an increasing level of speed display a very similar amount of wear. Yet the teeth oper-

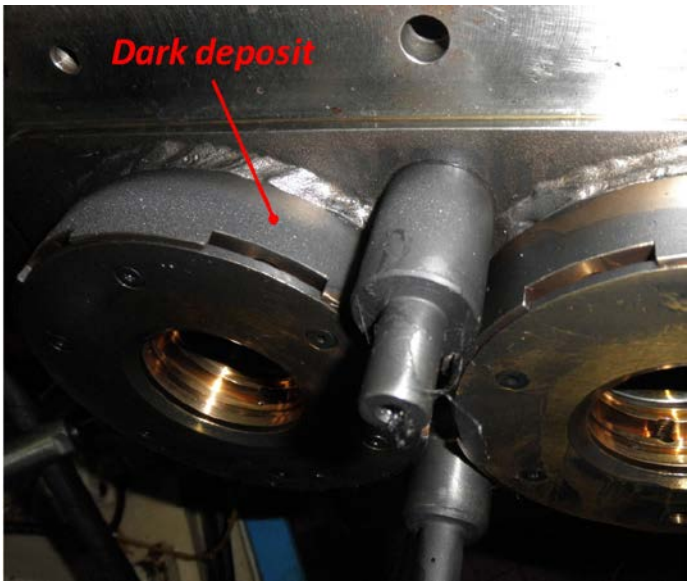

Figure 14 Dark deposit on test gearbox.

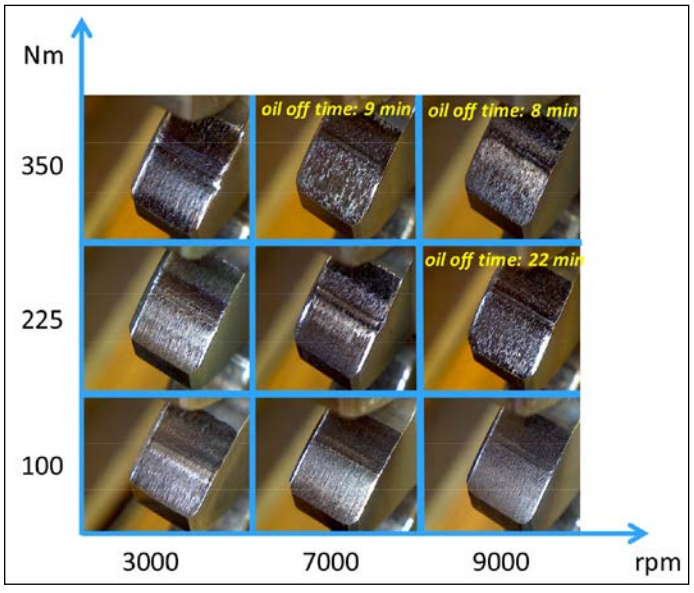

Figure 15 Post-test: effect of the operating condition on teeth wear (Material A).

ating at minimum speed and increasing torque show an amount of wear significantly increased with the increasing torque.

Similarly, Figure 16 shows the effect of the operating condition on gear heating. Gear heating can be qualitatively deduced from the color change of the gear; a dark color indicates higher warming. As operating conditions become more severe, the color change affects not only the teeth but the gear body as well.

In comparing the gear's aspect at minimum torque/increasing speed with the gear's aspect at minimum speed/increasing torque, it can be seen that gear heating was influenced more from load variation than speed variation. This supports the results reported earlier for the temperature out of mesh.

Figure 17 shows the metallographic analysis of a tooth that at the visual inspection showed strong alteration of the active surface; layers of dark material alternating with layers of lighter material are evident. SEM (scanning electron microscopy) analysis showed that the dark areas represent layers of oxidized material due to the progressive plastic deformation of the running surfaces.

Conclusions

An experimental study to establish a baseline for gear behavior running in loss-of- lubrication condition has been conducted. Aerospace-quality spur gears made from two materials and operating at different levels of sliding speed and contact pressure were tested.

Thirty-six tests under 18 different operating conditions were planned using the design of experiment (DoE) technique. Conclusions drawn from the experiments in this study are the following:

- Among the 36 tests carried out, 24 tests ran the required 30 minutes in oil-off condition; 12 were stopped short.
- In all tests the transmission was able to transfer the required power.
- The tests stopped earlier than required were stopped because of test rig safety issues (high vibration).
- In all tests the vibration signal of the gear mesh for Material A was higher than for Material B; moreover, a more relevant increase of the vibration level was observed with the increase of the contact pressure, rather than with an increase of sliding speed.
- As expected, the gears made from Material B were able to run in a loss-of-lubrication condition longer than gears made from Material A.
- The capability of the gears to run in a loss-of-lubrication state differed, depending on the operating condition; a more relevant influence on the oil-off time of the contact pressure, rather than of the sliding speed, was observed.
- The statistical treatment of the results (*ANOVA*) showed that gear heating and wear are influenced more from the variation of the contact pressure than from variation of the sliding speed; this evidence was confirmed with the gears' post-test evaluation.
- A post-test evaluation of the gears showed the presence of plasticized areas in teeth in which severe wear was observed; measure-of-hardness in these areas showed hardening; no relevant difference of the metallographic structure between the two tested materials was observed.

Future Work

The collected data will be used to develop a test model that will serve to demonstrate thermal behavior of the test gearbox in a loss-of-lubrication state.

References

1. Wayne, A., Hudgins and Harold A. Schuetz. "Loss-of-Lubrication of Helicopter Transmissions," *Journal American Helicopter Society, Volume 27, Number 4,* 1982, pp. 3–10.
2. Certification Specifications for Large Rotorcraft: CS29 Amendment 2, 17 November 2008, Annex to ED Decision 2008/010/R Amendment.
3. Andrei, G. L., S. Manconi, E. Manfredi and M. Vitali. 2001, "Equipment for High- Performance Gears Testing," *XXX Italian National Conference on Stress Analysis* (AIAS), 2001, Vol. 1, pp. 127–135 (in Italian).
4. Amorena, M., G.M. Bragallini, S. Manconi, E. Manfredi and M. Vitali. (2005) "Characterization of Aerospace Gears by High-Speed Testing," *International Conference on Gears (GEARS 2005)*, VDI-Berichte, 1904.2, pp. 1091–1105.
5. Mazzitelli, I., F.S. Guerrieri Paleotti, P. Forte, E. Ciulli, M. Amorena and A. Polacco. "Bulk Temperature Measurements of Gears for Scuffing Monitoring," BINDT CM&MFPT, 2010, pp. 1–12, Stratford upon Avon, England, Vol. CD.
6. Handschuh, Robert F. and Wilfredo Morales. "Lubrication System Failure Baseline Testing on an Aerospace-Quality Gear Mesh," NASA Technical Memorandum 2000–209954, May 2000.
7. Anderson, N., S. Loewenthal and J. Black. "An Analytical Method to Predict Efficiency of Aircraft Gearboxes," NASA Technical Memorandum 83716, AIAA–84–1500, June 1984.

Dr. Salvatore Manconi is technical director of AM Testing srl, a technical consultancy and mechanical testing center spun off from the University of Pisa. AM specializes in test rig research and development for mechanical transmission systems.

Dr. Ida Bartilotta is a testing engineer with AM Testing srl.

Enrico Ciulli is a professor in the Department of Mechanical Engineering at the University of Pisa, where he teaches courses in applied mechanics and tribology, and whose research interests include lubrication and friction. He is a member of the Italian Association of Tribology, the Italian Association of Theoretical and Applied Mechanics, ASME, SAE and EUROMECH.

Elena Toson is a Ph.D. candidate at Politecnico di Milano. She worked previously at Avio S.p.a. in Torino, Italy.

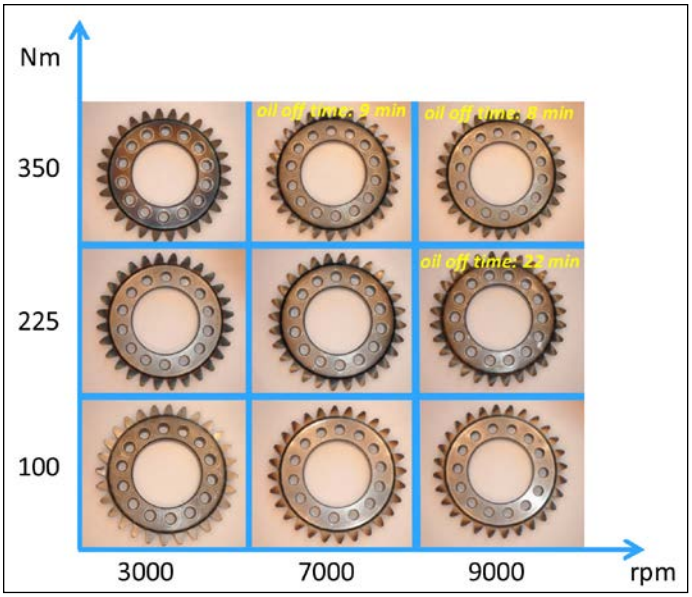

Figure 16 Post-test: effect of the operating condition on gear heating (Material A).

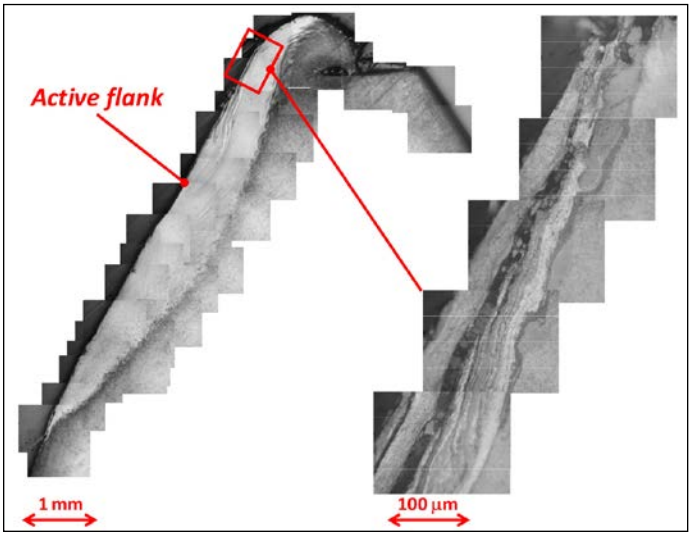

Figure 17 Metallographic analysis.

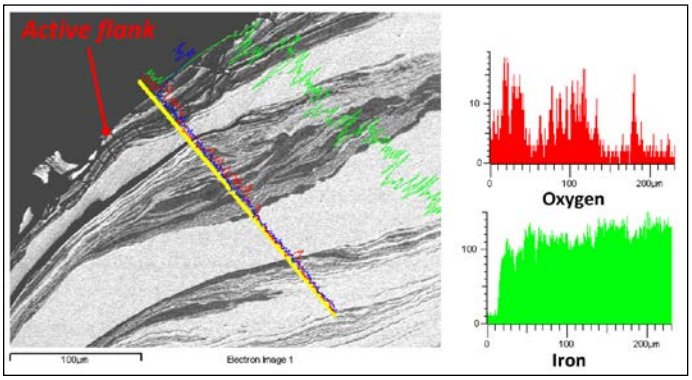

Figure 18 SEM analysis.

Automotive Transmission Design Using Full Potential of Powder Metal

Anders Flodin and Peter Karlsson

For metal replacement with powder metal (PM) of an automotive transmission, PM gear design differs from its wrought counterpart. Indeed, complete reverse-engineering and re-design is required so to better understand and document the performance parameters of solid-steel vs. PM gears. Presented here is a re-design (re-building a 6-speed manual transmission for an Opel Insignia 4-cylinder, turbocharged 2-liter engine delivering 220 hp/320 N-m) showing that substituting a different microgeometry of the PM gear teeth—coupled with lower Young's modulus—theoretically enhances performance when compared to the solid-steel design.

Introduction

Höganäs AB has established—through its demonstration cars and design work—that PM gear technology is capable of replacing gears in automotive transmissions without sacrificing performance. What's more, PM gear technology has the inherent capability to reduce the weight and inertia of the gear wheel, thus reducing mass and energy losses. Another important benefit of lowering the inertia of the gears is the simplification of energy dissipation in the synchronization mechanism with both manual gearboxes and AMT- or DCT-type transmissions.

When designing PM gears, special attention must be paid to using the correct material properties, as verified through Young's modulus and Poisson's ratio. Designers can also improve weight and dynamics by the awareness and understanding of the possibilities that PM offers through its unique production methods. For example—the PM gear manufacturing process enables a reduction in manufacturing steps—thus providing improved cost performance.

Young's modulus and Poisson's ratio can be empirically calculated as a function of density (Eqs. 1 and 2; Ref. 1).

$$E = E_0 \cdot \left(\frac{\rho}{\rho_0}\right)^{3.4} \quad (1)$$

$$\upsilon = \left(\frac{\rho}{\rho_0}\right)^{0.16} \cdot (1+\upsilon_0) - 1 \quad (2)$$

Methodology

System analysis. In order to determine the extent of difference between the microgear and solid-steel design, as well as the possibilities existing for weight reduction, a re-design of a GM (General Motors) gearbox was performed. The chosen transmission was a 6-speed manual transmission rated for 320 N-m, named "M32." This transmission is used in certain Opel Insignia models as well as other GM cars.

Another aim of this work was to understand how much load PM gears must sustain and, from that, to identify the best manufacturing process necessary to meet the stress criteria.

The abovementioned transmission was purchased and disassembled while recording the pull-off forces of the gears and bearings, as well as measuring axial play in the system. The housing was scanned and imported into finite element software (Fig. 1). Shafts and gears were measured, modeled and assembled into the housing. An essential part of the system analysis is bearing stiffness. The bearing representation in this system model is reduced to define the stiffness between two nodes—i.e., inner and outer ring—because this bearing stiffness is strongly non-linear and dependent upon both bearing design and load direction/magnitude.

Simplified modeling techniques were used for the bolts, roller bearing contact between gears and shaft, and the gear-to-gear contacts used in the *system* analysis—where the focus is on deformation of the housing, shafts and bearings. This was done in order to save calculation time. The information from the system analysis is then applied to the *gear* analysis.

The output from the system analysis is gear misalignment and transmission deflections. This data is used as an input for the gear analysis, where the microgeometry is tweaked to realize the best working behavior of the gears, and for addressing the misalignment and bending from shafts and bearings.

Gear analysis. The 6-speed transmission was completely dismantled; all parts were then measured and reverse-engineered to acquire current production data for all gears, shafts and housing. Macrogeometry of the gears was created with a focus on surface stress levels and peak-to-peak transmission error (TE). For first, second, and reverse gear, the driver member could not be exchanged since the gears were cut directly on-shaft;

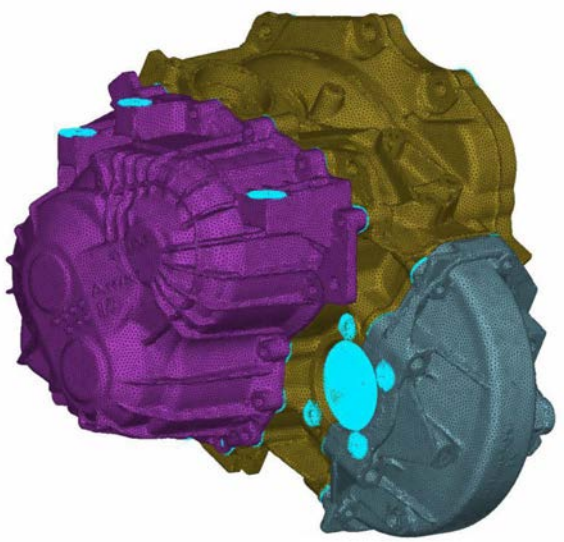

Figure 1 Scanned and digitized housing.

Proceedings of 2012 Powder Metallurgy World Congress & Exhibition, Yokohama.

Table 1 Material data for PM

Material	Elastic modulus (GPa)	Poisson's ratio	Thermal expansion ($°C^{-1}$)	Fatigue limit, surface (MPa)	Fatigue limit, root (MPa)
Powder metal	160	0.28	$12.5\text{-}10^{-6}$	1100@$5\cdot10^7$ Cycles	650@10^7 Cycles

thus, for these parts only modification of the idler and driven members was performed. The final drive is a straight carry-over.

Modifying the microgeometry of the gears is an iterative procedure using the material data, loads and misalignments, with the primary intent of lowering both TE and contact stress. This is accomplished by changing the gear design parameters in the iterations, such as crowning, reliefs, angular deviations, etc.

A duty cycle based upon "typical European consumer usage" and the authors' experience was used to evaluate gear life.

The misalignment data gleaned from the system analysis has been accounted for in the microgeometry of the tooth flanks. The abuse load is 6,500 N-m on differential cage—also based on author experience and vehicle data.

The working behavior of the gears in the system has been modeled for 50-percent-, 100-percent-, 150-percent- and 200-percent-load, and at different temperatures in order to assure functionality under various conditions.

All parts were modeled using linear-elastic material properties; material properties are based on input from Höganäs AB (Table 1). Several different software programs were iteratively used to conduct the analysis of the different components and system.

Results

Following are some most pertinent results, as a complete accounting of all the testing is beyond the scope of this paper.

A parameter that describes the quality of the mesh cycle of two flanks is the peak-to-peak TE. Transmission error is also to some extent related to the noise of the gears and is generally kept as low as possible. When working with a material with a lower Young's modulus—as compared to steel—TE tends to increase if the geometry is copied from the steel design (Ref. 2). This can be "designed away" to some extent in the PM design. Figure 2 shows the maximum TE for three different gear designs during a torque sweep; it is the first gear pair in the transmission and is used for switching from an idling standstill.

The first observation is that the TE is quite high. Since this is the first gear, it is only used for initial acceleration and so a slightly higher TE is acceptable. More important are the displayed "curves"; i.e.—the green curve is the PM gear with the steel-flank design, and is higher for all torques, indicating that the TE will be higher for the copied PM gear—an unacceptable development. The result of design iterations for improving the TE for the PM gear is shown in the blue curve, where the TE is lower for every torque level and is likely to perform significantly better than the PM gear with the steel-gear-copied design (green curve).

This pattern with an underperforming, copied PM gear can be seen for all gears in the transmission. It will not always be better than the steel gear (Fig. 1), but a gear *designed* for PM will always be an improved design compared to a PM gear with the copied steel design.

Table 2 shows the contact and bending stress listed for the sixth gear pair in both original steel and re-designed PM.

The sixth gear was deemed representative in that the result displays a typical improvement number— –17 percent in contact stress—and so is a good example of a gear suitable for PM from a performance point of view. Worth noting is that the bending stress is intentionally increased for the PM gears; this enables designing a lower contact stress for the same gears. Gear design is an iterative trade-off process. As such, the sixth gear pair was judged to be at its best with a lower contact stress—the trade-off being increased root stress. Root stress can also be further reduced with PM technology using the existing optimization procedure (Ref. 3).

The durability of the sixth gear pair is illustrated in Figure 3, where the duty-cycle is taken into account. The red, blue and black lines are S-n curves for sintered, case-hardened, Astaloy85Mo PM gears, with a density of 7.25g/cc and tolerance class of ISO 7 or better. What is learned from the diagram is that, while the tooth root bending fatigue is within acceptable boundaries, the contact stress is still a bit too high, meaning that these gears would require a slightly higher performance level to qualify. The remedy in

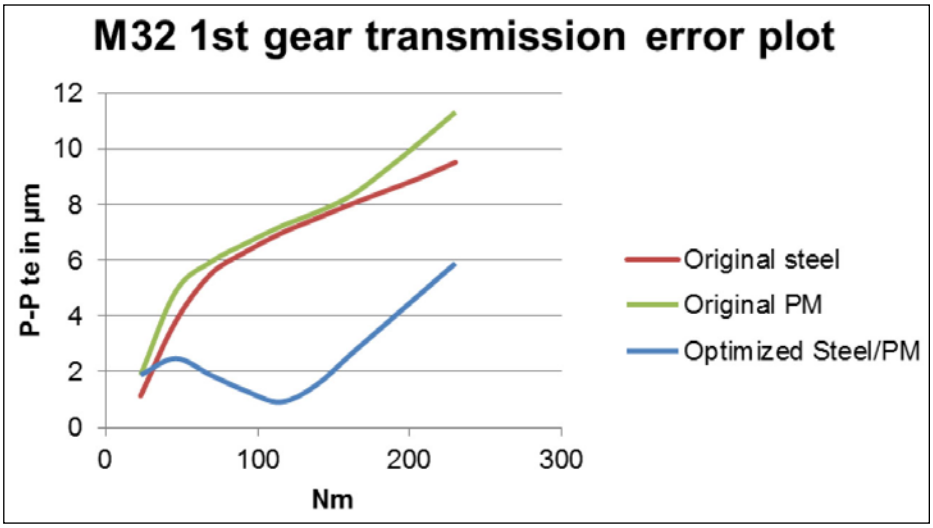

Figure 2 Transmission error for first gear in the investigated M32 transmission.

Table 2 Stress comparison

		6th steel		6th PM		Diff	
Bending stress	MPa	564	624	616	677	8,4%	7,8%
Contact stress	MPa	1504		1285		-17,0%	

this case could be increasing the density to 7.4g/cc by double-pressing and double-sintering, or by switching to a higher-performing material. Shot peening to induce higher compressive stresses and/or superfinishing could be other cost-efficient methods to increase the fatigue limit to the additional seven percent necessary to qualify. But without re-design, a 25 percent performance increase (1,200 MPa to 1,500 MPa) would have been necessary, necessitating significantly more expensive processes that would negate the cost-efficiency of PM.

For this particular transmission re-design the third and fourth gear pair can be made with the shortest possible manufacturing time while providing a 7.25 density. For the fifth and sixth gear pair, some of the abovementioned processes would be necessary in order to boost performance. The first and second gear pair requires either densification or a more radical re-design with asymmetric gear teeth or non-involute gear shape.

The re-design not only takes microgeometry into account, but also macrogeometry for attaining the desired weight and inertia reduction. Inertia reduction also off-sets losses from the accelerating gear mass every time the RPM is shifted. What is more, reduced inertia reduces heat dissipated in the synchronization of the gears; less heat build-up provides a more robust synchronization system and longer service life. The energy savings may also be helpful in designing a simpler and smaller synchronization package, thus reducing either overall dimensions or the transmission (Table 3).

Future Work

The next step is to re-design the first and second gear pair using more advanced design methods. These would include non-involute gearing and asymmetric gear teeth for prototyping the gearbox, but without using any performance-enhancing technologies such as hot isostatic pressing (HIP) or other densification technologies. There are a few unknown factors when departing from the traditional, involute curve shape. For example, while it is very possible to reduce contact and bending stress, the difficulty lies when TE must be kept low for both the drive- and coast-sides in order to prevent noise issues. Indeed, modeling to achieve good mesh properties is required *before* manufacture.

Test transmissions will be built according to the optimized design, using the latest available PM technologies, and will be tested in a car for everyday driving as proof of concept. Test rigs will be employed to monitor these transmissions for durability, noise and efficiency—per specified drive-cycles—in order to demonstrably prove the possibilities of PM in automotive transmissions.

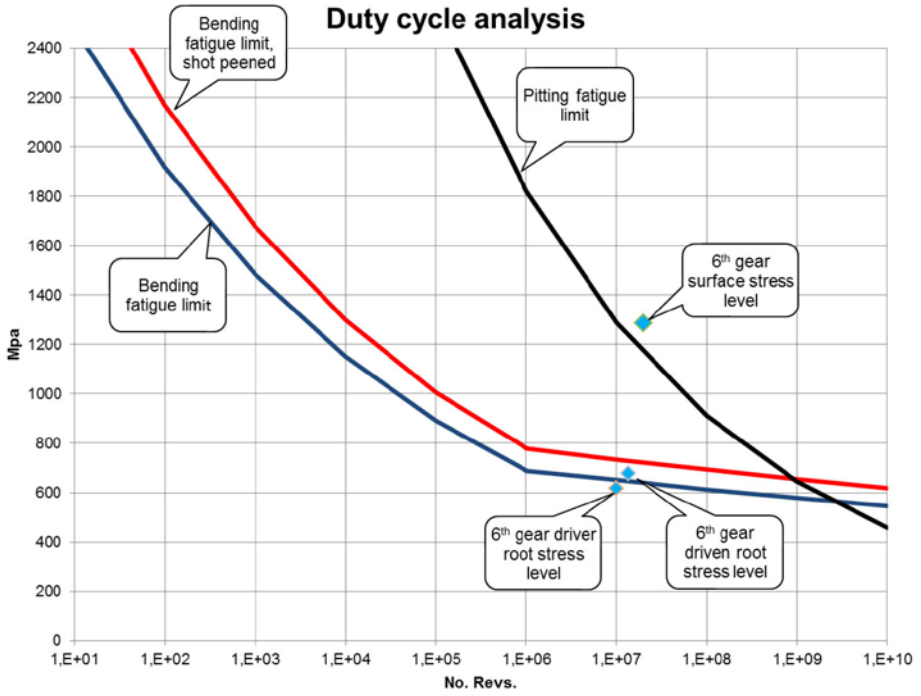

Figure 3 Loads on sixth gear pair with correlating S-n curves for case-hardened Astaloy85Mo PM gears with ISO 7 or better tolerances.

References

1. Flodin, A. and L. Forden. "Root and Contact Stress Calculations in Surface-Densified PM Gears," *Proceedings from World PM2004 Conference* Vol. 2, pp. 395–400.
2. Flodin, et al. "Design Aspects of Powder Metal Gears: Macro- and Micro- Geometry Considerations," *Proceedings from VDI International Conference on Gears*, 2010, pp. 11–21, ISBN 978-3–18–092108–2.
3. Kapelevich, A. and Y. Shekhtman. "Tooth Fillet Profile Optimization for Gears with Symmetric and Asymmetric Teeth," 2009, *Gear Technology* September/October, pp. 73–79.

Anders Flodin is manager for application development at Höganäs AB Sweden. He has a background in mechanical engineering, receiving his Ph.D. in 2000 on the topic of simulation of wear on gear flanks. Since 2000 Flodin has worked on various gear-related assignments in the fields of aerospace, ship propulsion and automotive drivelines.

Table 3 Weight and inertia reduction for redesigned transmission

	Inertia M32 Steel vs Sinter						
	Inertia Steel	Inertia Sinter			Mass (kg)		
	M32	Copied PM	Optimized PM	Diff	Steel M32	Sinter	Diff
1	2154	1769	1670	22%	1,097	0,896	18%
2	1285	1114	1090	15%	0,953	0,819	14%
3	1991	1605	1532	23%	1,159	0,93	20%
4	983	860	848	14%	0,831	0,73	12%
5	244	224	224	8%	0,323	0,297	8%
6	213	196	196	8%	0,387	0,355	8%
R	1336	1140	1109	17%	0,946	0,791	16%

The redesign will in total for this particular transmission remove 1.1 kg of mass.

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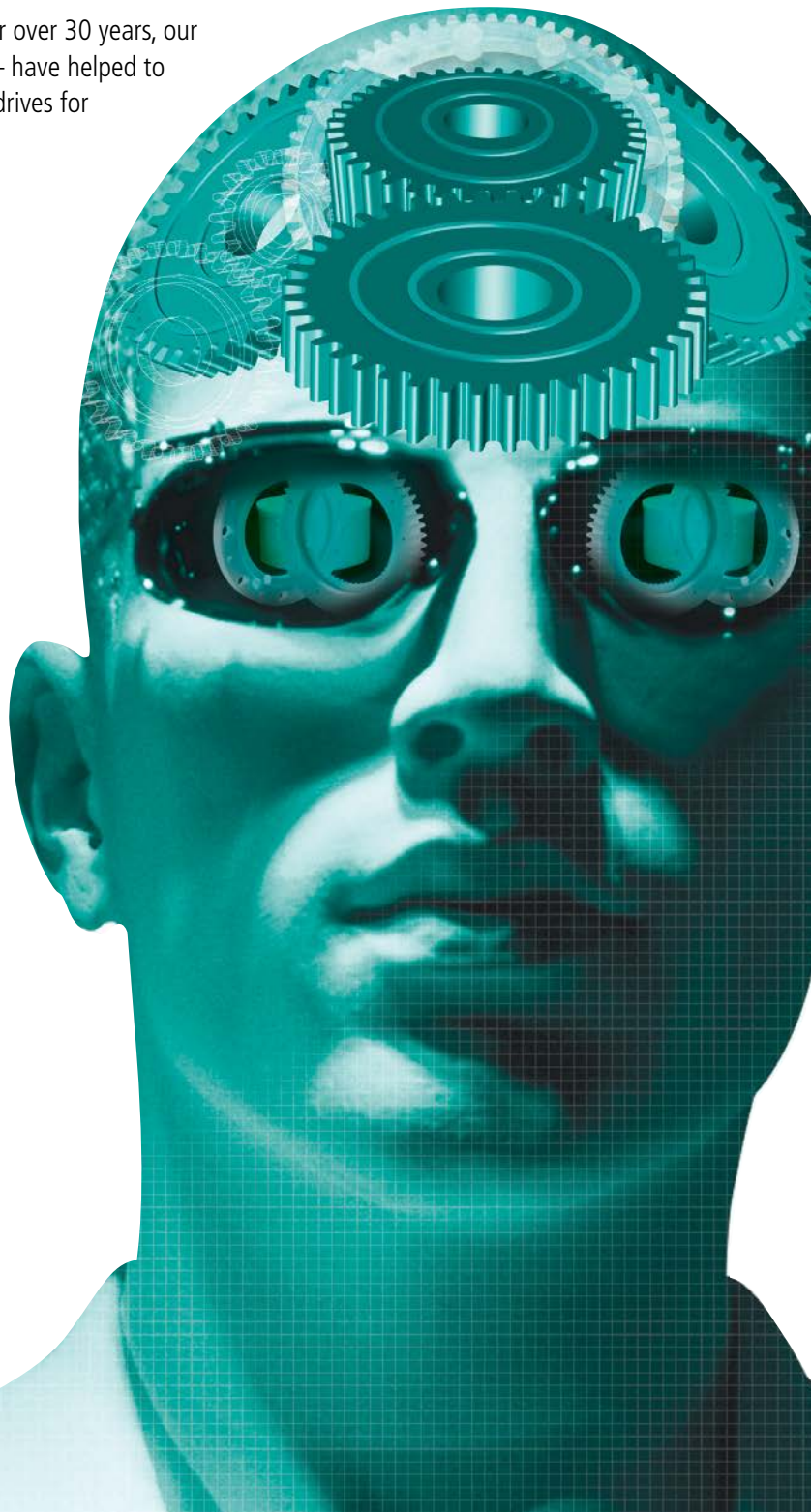

Celanese

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Marposs

CELEBRATES 50 YEARS IN NORTH AMERICA

Marposs Corp. commemorated the 50th anniversary of its founding in North America during March 2013. Marposs is one of the world's leading suppliers of precision metrology equipment for improving productivity and reducing cost in manufacturing. Its products include inspection, measurement and process control solutions including gauges and compensation systems for grinders and other machine tools; manual gauges, sensors, probes and other gauge components; automatic measurement and inspection systems; hardware and software for

data collection and process analysis; tool, machine and process monitoring and control systems; automatic assembly systems; and equipment for leak testing and non-destructive testing.

The North American headquarters in Auburn Hills, Michigan, home to over 130 employees, is one of the 79 offices located in over 20 countries. The company's parent, Marposs S.p.A. in Bologna, Italy, employs over 2,600 people in major manufacturing, sales and service centers around the globe.

Since its inception in 1963, Marposs Corp. has been a vital supplier to the auto, truck and off-road vehicle manufacturing industry, supplying gauges and other apparatus for measurement and inspection of engine and transmission components. More recently, the company has expanded into applications such as ensuring the quality of windshields and other glass components. Today, the company partners closely with original equipment manufacturers and contract manufacturers, providing products as diverse as manual, hand-held and go/no-go fixed gauges, to in-line automatic machines capable of making scores of measurements in only seconds. In some cases, the engineering for new manufacturing programs is generated by the customer and supported by Marposs locally, while the actual equipment installation may be located elsewhere in the world.

Marposs has also continued to grow into markets beyond automotive and other vehicular manufacturing. Industries such as Medical and Aerospace now account for a significant and growing portion of the company's annual sales. Examples of the specialized technologies necessary for these manufacturing applications include a sophisticated camera-based system for detecting microscopic flaws in orthopedic parts such as shoulders, knees and hip joints, and an automated measuring machine for checking air foil components for the aerospace industry.

According to Marposs Corp. President, Ed Vella, the perception of measurement and inspection in manufacturing has undergone a dramatic shift. "Fifty years ago when Marposs Corp. was established, 'gauging' was an ugly word—a necessary evil," said Vella. "Manufacturers knew they needed gauging to help monitor and control quality. But frequently they resented it and made it an after-thought. Today, the majority of our customers understand that by partnering early on with their gauging supplier, they can experience increased productivity, reduce cost in manufacturing and shorten new component launch time."

"Marposs has a diverse and expanding range of technologies, developed in house and through acquisitions, that can be applied depending upon the customer's application," said Vella." We can successfully work with the customer to select the measurement and inspection solution best suited to the requirements for part condition, production rate, flexibility and so on."

Drake Manufacturing Services Co.

HIRES INSIDE SALES AND CONTRACT ADMINISTRATOR

Drake Manufacturing Services Co., a Warren, Ohio, precision machine tool builder, has recently hired **Lauren (Fig) Chandler** as inside sales and contract administrator.

She is responsible for reviewing and processing new machine inquiries, managing sales contracts, and working with Drake's sales, engineering, and production teams to ensure the unrivaled level of customer satisfaction associated with the Drake brand.

Chandler's experience includes a three-year teaching assignment in Kyotanabe, Japan, and an operations administrator internship with Altek Europe Ltd. Her experience abroad complements Drake's global exposure in the machine tool industry.

An MBA graduate of the Weatherhead School of Management at Case Western Reserve University in Cleveland, Ohio, she has a B.A. in East Asian Studies from Wittenberg University in Springfield, Ohio, and is certified as a Six Sigma Green Belt.

Koepfer America

EXPANDS STAFF, ACQUIRES GETRAG'S GEAR TIMING PRODUCTION

Koepfer America has added **Joshua Eggebrecht,** application engineer. His primary responsibilities will be the support of hob and fixture sales as well as Koepfer America's hob sharpening program. Eggebrecht's addition to the Koepfer America engineering support team will enhance customer service as well as the company's ability to design fixtures and other machine-related items in-house. Dennis Gimpert, president of Koepfer America, said of Eggebrecht's hiring, "We look forward to Mr. Eggebrecht's continued support for the Koepfer America engineering team. His enthusiasm and unique skills have already made a positive impact on our services and clients."

Before joining Koepfer America, Eggebrecht completed his Bachelor of Science degree by designing a project to incorporate advanced dispatching systems into a virtual suburban fire department. With this type of pragmatic problem solving, he adds a strong skillset to Koepfer America's workforce. "I am excited about my position here at Koepfer America and look forward to providing both unique and routine solutions to our customers' hobbing and fixturing needs," said Eggebrecht.

Koepfer Acquires Getrag's Timing Gear Production

Additionally, the company, Koepfer Zahnrad- und Getriebetechnik GmbH, headquartered in Furtwangen, Germany, has acquired the Getrag timing gear production in Ludwigsburg, Germany. The acquisition closing happened in June 2013, expanding Koepfer's presence and capabilities for clients worldwide.

Getrag now focuses on its business of transmissions for passenger cars. Getrag, headquartered in Untergruppenbach, Germany, is one of the world's largest system suppliers for transmissions with approximately 12,500 employees and 24 locations worldwide. The 137 Ludwigsburg plant employees are now under Koepfer employment.

Bernd Eckl, executive vice president of sales, marketing and business development of Getrag said April 2nd: "It is our clear strategy to focus on the transmission business globally. With this focus, it has always been very important for us to find a future-oriented solution for our employees in Ludwigsburg. Ludwigsburg has for a very long time not only been contributing to our success, [but] it will always be a place of history for our company. We are grateful for the job our employees have done here. This is why we are happy to have found a strategic buyer who acts with discernment and offers the employees the future prospects they deserve."

Koepfer has announced its plans to generate additional orders for the plant. The plant's backlog is filled through 2016.

Ipsen

COLLABORATES WITH EXONE ON 3-D PRINTING SOLUTIONS

When constantly out-doing the competition is the name of the game, meaningful collaborations are of the utmost importance. Ipsen is pleased to have been selected by ExOne, a global provider of 3-D printing machines and printed products, as a vacuum furnace provider as a part of an initiative to streamline production in the field of additive manufacturing and offer customers a complete 3-D printing package. David J. Burns, ExOne's president and COO, noted, "We sought to simplify the purchasing process for 3-D printers by offering a complete printer-furnace package. Ipsen is ideal for us to collaborate with given their industrial focus and global presence."

Ipsen is committed to improving the world around us by helping customers realize their visions of a better future, and Ipsen pursues those visions with integrity and passion. This pursuit involves continuously creating evolutionary and revolutionary innovations by exploring new ideas, methodologies and technologies. "As technical experts dedicated to lean manufacturing, Ipsen was chosen due to our reputation for custom innovations and focus on product development," explained Geoffrey Somary, Ipsen USA president and CEO. "We are excited about this collaboration, and the opportunity to pool our knowledge with ExOne to provide a reliable solution for customers."

Dayton Progress

ANNOUNCES PLAN TO TRANSFER PUNCH BLANK PRODUCTION

On November 6, 2012 Dayton Progress was acquired by Misumi Group Inc. of Japan, for the strategic reasons of geographic fit and numerous internal synergies between the companies. Dayton Progress has long been known for the quality of its high performance semi-finished punch blanks, which allow rapid manufacture and shipment of more than 300,000 different part numbers each year and a consistent order-to-order product performance. All Dayton blanks are currently made in Dayton, Ohio for all Dayton plants worldwide. Misumi has a very large modern factory complex in Vietnam which supplies all Misumi punch making factories worldwide with very high quality and high performance blanks. Over the next several years, the Misumi Vietnam blank factories will expand and adopt the Dayton Progress blank-making process, after which most manufacture of Dayton blanks will transfer from Ohio to the Misumi plant in Vietnam. All the benefits of economy of scale will be realized. Dayton customers will continue to enjoy all the performance benefits of the Dayton blank, made with the *same process* and the *same steel* as before. Quality, metallurgical integrity and consistency and delivery all will be unaffected by this transfer. There will be no impact to the 500+ jobs at the Dayton Ohio location as a result of this transfer, which will free up space and capacity for continuing growth.

QuesTek

HIRES CHIEF EXECUTIVE OFFICER

QuesTek Innovations LLC is pleased to announce **Dr. Aziz Asphahani** is joining the organization as the new CEO effective July 1, 2013. He will be leading the company's efforts in growth and business development.

QuesTek designs, develops, and commercializes new high performance materials, such as Ferrium S53, which was designed for the U.S. Air Force as a more corrosion resistant alternative to incumbent ultra high strength steels that require toxic cadmium coatings. Its Ferrium C61 and C64 alloys are being evaluated under Army-funded programs as next generation rotor shaft and transmission gear steels by Boeing and by Bell Helicopter.

"We are extremely fortunate that Aziz is joining the QuesTek team as our chief executive officer. He brings a wealth of experience along with a history of strong leadership. As our materials design technology continues to mature and we move into newer and more advanced design programs, his guidance will prove invaluable to our continued success," said Mr. Raymond Genellie, Jr. (co-founder & VP of operations) and concurred by Dr. Greg Olson (co-founder & chief science officer).

Asphahani has an extensive background in both metallurgy and business, having acted as director of technology/R&D at Cabot Corporation, vice president of sales and marketing at Haynes International, and president at both Cabval and Carus Chemical Company.

He has also been very active in a number of professional organizations including having served as president of ASM International, ASM foundation chairman, director of NACE and member of the American Chemistry Council board of directors.

Asphahani holds a Diplome Ingenieur – Physics from Ecole Centrale de Paris and a Ph.D. in Materials Science from the Massachusetts Institute of Technology. He is an expert in alloy development and metallic corrosion, has been awarded eight

patents and has authored more than 65 papers on high alloys and corrosion control throughout his career.

"I am truly excited about joining this talented team of scientists and engineers, focused on innovations and rapid implementation of advanced materials design, through their expertise and experience in integrated computational materials engineering," says Aziz.

Solar Atmospheres

AWARDS EDUCATIONAL SCHOLARSHIP

Solar Atmospheres of Western Pennsylvania (SAWPA), in conjunction with the Metal Treating Institute (MTI) and Industrial Heating, has awarded an education scholarship to Sarah Luna of El Paso, Texas. Luna is majoring in Metallurgical and Materials Engineering and will soon begin her senior year at the University of Texas at El Paso.

The scholarship was part of the Master Craftsman Heat Treater of the Year award, won by SAWPA, through which an endowment of $1,500 is presented annually to a student in a metallurgy or materials science program. MTI president Tom Morrison states, "MTI feels it's imperative that the heat treating industry encourage and reward the next generation of engineers and metallurgists. Every industry is fighting to win the hearts of the younger generation and we love it when we can be involved in helping lead someone to an exciting career in heat treating."

Luna was selected by a Solar Atmospheres committee based on her academic record, honors, demonstrated leadership, participation in school and community activities, and work experience. President of SAWPA, Bob Hill, adds, "Sarah is a very intelligent woman who truly loves the material engineering career path that she has chosen. During her co-op at NASA, Sarah worked on corrosion issues with the space shuttle, analyzing orbital debris, and new materials that are cited for future deep space exploration."

The award was presented by Hill and *Industrial Heating* associate editor Bill Mayer at Solar's vacuum heat treating facility in Hermitage, PA. Mayer notes, "*Industrial Heating* is honored to donate the funds for this scholarship. We would like to thank Solar Atmospheres of Western PA for taking the time and effort to conduct a national search to find a worthy candidate, and we want to congratulate Sarah Luna and wish her the best of luck in her career."

"The vacuum heat treating performed at Solar Atmospheres of Western PA is amazing. It was very interesting to learn about the unique processes for specific parts. The furnaces were pretty incredible and I especially liked seeing range of products processed from the Boeing Dreamliner seat tracks to the tiny medical device parts. Thank you for everything," Luna said.

EMO 2013: Intelligence in Production

Even though machine tool demand had a weak start in the first quarter of 2013, experts look to the second half of the year to provide growth in orders. "The year's second half now has to provide a counterweight, if the predicted growth in production output of one percent is not to be put at risk," said Dr. Wilfried Schäfer, executive director of the industry association VDW (German Machine Tool Builders' Association) in Frankfurt.

Expectations in Germany are once again focused on the expanding markets of Asia. In China, particularly, by far the biggest market for the German machine tool industry, faster economic growth is again being forecast. North America will remain a stable market this year as well. Russia, thanks to its substantial need for modernization in its domestic industrial sector, likewise continues to be an attractive customer.

There are also good signs from the international automotive industry, which is deploying strategic investments in the battle for market share, and from the aerospace and mechanical engineering sector. All of them intend to be making above average capital investments in 2013. There will be a good opportunity for this at the EMO Hannover 2013 (September 16–21), where you'll find the latest innovations in the field of production technology. Here's a look at some of the EMO exhibitors:

Liebherr-Verzahntechnik

STAND A11, HALL 26

Liebherr-Verzahntechnik will be showcasing three new machines at the upcoming EMO show. These are solutions for the automotive and commercial vehicle industry in particular: two hobbing machines, one with separate Chamfer Cut unit for workpieces up to 180 mm and one with two horizontally arranged workpiece spindles with separate press deburring unit. Also the company will present a newly designed gear grinding machine for both profile and generating grinding.

"Given their extensive technological capabilities, the new machines are designed towards meeting current and future industry requirements," said Dr.-Ing. Hansjörg Geiser, manager development and design gear cutting machines. "It was our goal to provide the perfect solution for each particular application. The result is key: process reliability and the quality of manufactured components – delivered as cost-effectively as possible."

Newly designed gear grinding machine for profile and generating grinding with palletizer (courtesy of Liebherr).

Hobbing Machine Integrates Chamfer Quality with One-Cut Machining

Liebherr-Verzahntechnik's new gear hobbing machine with integrated Chamfer Cut unit for deburring and chamfering the face edges is based on renowned technology. After hobbing with the usual one-cut strategy, the Chamfer Cut tool additionally generates precise and reproducible chamfers that are increasingly demanded by the market. The newly developed solution eliminates the former main disadvantage of Chamfer Cut, namely that the chamfering process prolongs machining time. In the past,hobbing and chamfering took too much time at the same setting. "We have solved this by integrating a complete second machining unit for Chamfer Cut tools – two machines in one so to speak," said Dr.-Ing. Oliver Winkel, director of application technology and responsible for technological development of gear cutting at Liebherr-Verzahntechnik. Geiser added: "The main design engineering challenge was to execute the chamfer-cut unit at a reasonable cost." We thus integrate the deburring unit within the existing machine dimensions without any impact on space requirements.

Functionality, operation, and CNC programming are based on familiar machine design. The operating changeover from the existing machine is thus relatively simple, once standard user training has been provided. Chamfering no longer prolongs machining time by having it take place in a separate unit within the same machine, whilst the next workpiece is already hobbed. Both chamfer tools are no longer located directly next to the hobbing tool, but in the separate unit. "We know from gearbox design development that the subject of 'chamfering' is becoming more and more important. This innovation enables the machine to combine an already undisputed high chamfering quality, provided by the proven Chamfer Cut procedure, with cycle times that corespond to the demands of the automotive industry," said Winkel.

Press Deburring with Hobbing Machine

For some workpieces, chamfering/deburring using the chamfer cut facility is not feasible. For these cases, Liebherr has developed a gear hobbing machine, which applies a multi-cut strategy including press deburring. Continual loading and press deburring occur in parallel during machining time.
Separate machine operations take place on two machine tables, each able to swivel 180° and easily accessible: roughing in two phases, pressing, and finishing. After the blank is locked in and tightened, it is swiveled and the first cut of the gear takes place on table 1, while on table 2, the chamfer is produced by pressing. After another swivel, finishing takes place in order to eliminate the bulging that occurs as a result of pressing. The finishing process is key to this cycle. It is a stand-alone process not subject to crossover impacts generated by a parallel process on the neighboring table.

"We chose this strategy, since external mechanical encumbrances should be excluded during machining, especially during the precision finishing process. The quality of the components, of the flanks in particular, and the reliability of the process as a whole benefit from this," said Geiser. The blanks are loaded from the attached palletizer cell, where they are stored in baskets, as per the automotive standard.

One-Table Solution

Liebherr's new machine for profile and generating grinding combines short grinding times with consistent high large-scale production quality. "This machine gives users fast processing combined with the advantages of a one-table solution," said Dr.-Ing. Andreas Mehr, grinding and shaping technology development and consultancy at Liebherr-Verzahntechnik.

For this reason and given its compact dimensions, the machine is especially suited to vehicle and transmission manufacturers and their suppliers. To facilitate installation of production lines for a complete series, making optimum use of the available space, the machines for both 180 and 280 millimeters have the same external dimensions. Vehicle manufacturers can thus develop a complete production line, in which all gearing components for a passenger vehicle transmission can be ground: planetary and sun gears, bore-type gears, as well as drive and pinion shafts with lengths of up to 500 mm. "Choosing a one-table solution means one setting, one geometry. The advantage is higher quality throughout the entire production. Every machined part is manufactured under the same conditions for the highest reproducibility. A key argument in favor of the one-table solution is the statistical capability and reliability in continuously producing controlled µ-range finish quality," Mehr said.

In order to minimize any thermal impacts, the machine bed has been manufactured using a thermally stable material. The core of the machine is the newly developed grinding head. Conventional solutions have been chosen here in several areas in order to be prepared for yet higher quality requirements. The new grinding head allows for rotation speeds up to 10,000 rpm and has spindle power of 35 kW. Given this performance data, the head enables high cutting speeds and high feed rates. This top-rate performance makes the machine future-proof. There are also reserve capacities for new developments and coming higher demand. The new grinding machine can exploit the considerable potential of the innovative abrasive, Cubitron II.

Innovations at EMO 2013

Geiser looks ahead to showcasing the machines: "We are looking forward to unveiling three of our innovations at our booth. The exhibition slogan 'Intelligence in Production' means implementing particular customer requirements in the most diverse production locations in a globalized economy. Our solutions support customers by achieving this goal – through high efficiency and availability as well as worldwide reproducible quality and user-friendly operation."

For more information:
Liebherr-Verzahntechnik
Phone: +(49) 831 786-3285
www.liebherr.com

DMG/Mori Seiki

STAND D44, HALL 27

DMG/Mori Seiki will demonstrate its full gear milling portfolio with a focus on *gearMILL* software and the InvoMilling process. The InvoMilling process will be demonstrated on the NT series multi-tasking machines as well as the DMU series machines. "The demonstrations center around the flexibility of the machines, which leads to greater productivity in small and medium batch production," says Nitin Chaphalkar, manager of advanced solution development. In addition to newly developed processes, traditional gear machining processes such as hobbing and broaching will be demonstrated on NL (3-axis lathe) and NT machines. A wide variety of machines large and small (from NT6600/6000 (6 m bed length) to NL2500) will be exhibited. Machining of all types of gears such as spiral bevels, spur, helical and internal gears will be demonstrated on these platforms.

DMG's NL2500 will be demonstrated during EMO Hannover (courtesy of DMG).

For more information:
DMG/Mori Seiki
Phone: (847) 593-5400
www.dmgmoriseikiusa.com

EMAG

STAND C33, HALL 17
STAND B39, HALL 26

EMAG will be presenting the VL 2 single-spindle vertical pick-up lathe for the machining of small chucked components. Nowadays, everywhere you turn in an industrial production environment you encounter the expression "downsizing" — where the term describes infinitely more than just the scaling down of the passenger car engine and its displacement. There is also a change in the direction the production of electric motors and pumps for the energy industry and for general mechanical engineering is taking, with constituent components getting smaller and smaller.

However, the trend towards downsizing increases demands for greater precision and that makes the manufacture of small components a real challenge. "Shrinking" components and new smaller components present a particularly complex task for the mechanical engineering companies that manufacture them. One kind of machine used to master the task is shown by the turning specialists at EMAG — with the VL 2. This vertical turning machine represents a new platform for automated, high-precision production processes and low component costs in the manufacture of small chucked components.

The EMAG VL 2 machine opens up new opportunities for the machining of a wide range of small chucked components. Small gearwheels, planetary gears, sliding sleeves, pump components, synchronizer rings, chain gears or flange components — with a maximum diameter of 100 mm and a length of up to 150 mm — are machined on a vertical pick-up lathe with great efficiency. The machine design focuses on providing a variety of manufacturing technologies for soft and hard machining plus a complete automation system at a very favorable price-performance ratio. When developing the VL 2, EMAG had — right from the start — its eyes fixed firmly on the investment costs for the user and the fact that those costs should be kept as low as possible. "We wanted to design a machine that guaranteed the highest possible degree of productivity in the manufacture of small components, and we have been very successful in that pursuit with our VL 2. Here, too, size is of great importance. The machine's compact construction ensures that the chip-to-chip times are kept low," explains Guido Hegener, managing director of EMAG Salach Maschinenfabrik GmbH.

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

EMAG's VL 2 represents a new platform for automated, high-precision processes (courtesy of EMAG).

Precision Technologies Group (PTG)

STAND 026, HALL B51

The theme of the 2013 EMO Hannover metalworking trade fair — "Intelligence in Production" — couldn't be more appropriate for UK-based Precision Technologies Group (PTG). As a leading global provider of ultra-precision rotor and thread grinding machines, rotor milling machines, heavy duty lathes, deep hole boring machines and friction stir welding technologies, PTG has built its reputation on developing intelligent manufacturing solutions.

The Zenith 400 embraces a variety of grinding technologies (courtesy of PTG).

The Zenith of Grinding Technology

Officially launched at EMO 2011, the Zenith 400 helical profile grinding machine, from PTG company Holroyd Precision Limited, has the capability to grind rotors of up to 420 mm diameter and is able to use tooling from other Holroyd grinding machines, as well as tooling from competitors.

Representing a whole new generation in grinding machine technology, the Zenith 400 features an easy-to-use intuitive control system that incorporates both a development and production software suite. It is also the first Holroyd grinder to embrace all three grinding technologies: aluminium oxide, 'diamond hard' plated Cubic Boron Nitride (CBN) and vitrified, dressable CBN.

Powerstir Friction Stir Welding

Powerstir Friction Stir Welders, from PTG Heavy Industries, provide yet another example of PTG's commitment to intelligent metalworking. Offering far-reaching opportunities for jointing often difficult-to-weld alloys, where special attention is paid to structural rigidity, Powerstir models produce superior high strength welded joints without the detrimental and visible effects often associated with conventional welding.

In 2012, a Powerstir machine was developed for use in the manufacture of railway car bodies for China's high speed rail network. This feat of design and construction further demonstrated PTG's precision engineering capabilities — particularly as in building the machine in question, the organization also had to develop a 30 m x 4 m gantry.

Presenting a Wide Range of Intelligent Solutions

Visitors to Stand 026 B51 will be able to explore the wide range of technologies and services that is provided by the following PTG companies: Holroyd Precision Limited, PTG Heavy Industries, Precision Components and PTG Customer Care.

In addition to ultra-precise large screw rotors, produced using Holroyd Precision Limited's Zenith 400 helical profile grinding machine, a number of bespoke helical forms from Precision Components Limited will also be on display.

Delegates will also be able to view the superior, high strength welded joints created by Powerstir Friction Stir Welders from PTG Heavy Industries, as well as components and tooling.

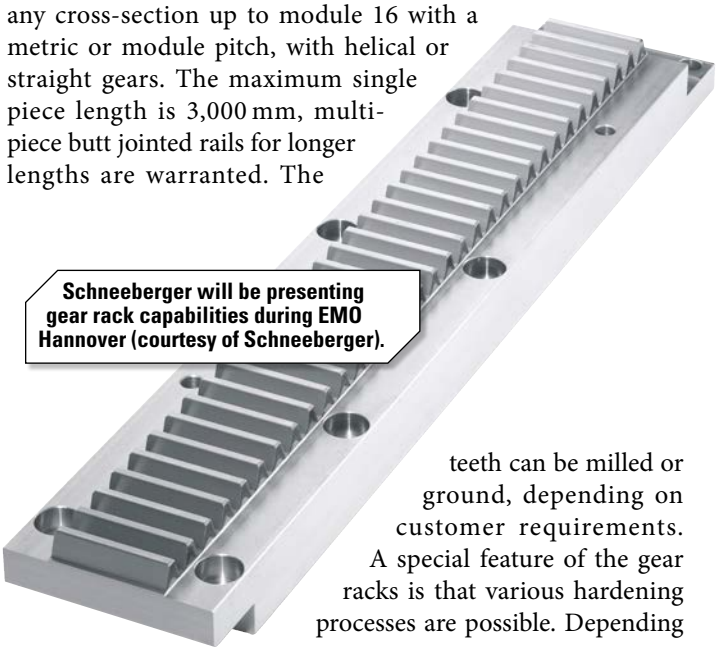
"Over the years, EMO Hannover has established itself as the global meeting point for the entire international metalworking sector," comments PTG Chief Executive Officer, Dr. Tony Bannan. "At EMO 2013, we intend to demonstrate exactly why the Precision Technologies Group is a leading choice for intelligent metalworking solutions."

For more information:
Holroyd Precision Ltd.
Phone: +(44) 1706 526 590
www.ptgltd.com

Schneeberger GmbH

STAND A36, HALL 7

Gear Racks: Any gear rack and gear rack guideway can be produced according to customer drawings. Gear racks are an economic drive element, especially with long strokes of more than 2 m. They are preferably applied in dirty environments and/or with big axial forces, since this drive element has the same constant stiffness over the whole length. Schneeberger offers any cross-section up to module 16 with a metric or module pitch, with helical or straight gears. The maximum single piece length is 3,000 mm, multi-piece butt jointed rails for longer lengths are warranted. The teeth can be milled or ground, depending on customer requirements. A special feature of the gear racks is that various hardening processes are possible. Depending



Schneeberger will be presenting gear rack capabilities during EMO Hannover (courtesy of Schneeberger).

on the applying load the customer may choose among weak, induction hardened or case hardened and nitrided gear rack. The best gear quality is Q5 in accordance with DIN (individual pitch error fp = 0.006 mm, cumulative pitch error Fp = 0.020/300 mm).

Schneeberger offers flexible organization, in-house induction hardening, maximum length 3 m, any helix angle between -30° and +30°, same accuracy with helical right hand and helical left hand. Standard gear racks: Metric or module pitch, up to module 16, helical tooth or straight tooth system, Milled or ground, arbitrarily combinable.

Measuring Technology: With their latest product release — AMS absolute — Schneeberger now offers the machine tool industry their magneto-resistive measuring technology with an absolute digital interface. The system offers the proven advantages of this technology, such as reliable high precision, a single reading head for all monorail sizes, as well as the availability of single piece rails, with integrated measuring system, up to 6 meters in length. Given this, AMS absolute will find many additional applications in special areas of industry and the machine market. AMS absolute also has status and diagnostics features. An LED display on the intermediate electronics unit displays various system status levels e.g. fault-free operation & voltage too low.

Additionally a diagnostics box can be installed in line, and a serial interface allows diagnostics and configuration parameters to be displayed and changed. Therefore, AMS absolute offers increased operational reliability attained by processing valid information. The general construction of AMS Absolute is a monorail linear guide and integrated measuring scale with an incremental track and a separate code track. The measuring scale is protected against damage and disturbance by a hardened cover strip which is laser welded to the rail. The reading head is mounted in a sealed attachment housing which fixes directly to the carriage. The information from both tracks is continuously recorded by the contact sensor and the absolute position calculated by the measuring electronics.

For more information:
Schneeberger
Phone: +(49) 07081 782-0
www.schneeberger.com

Seco Tools

STAND A56, HALL 4

Seco Tools will spotlight innovative metal cutting solutions paired with unique manufacturing techniques. Products on display will include an enhanced Turbo 10 series of square shoulder mills, the Double Octomill face milling cutter and the Square 6 milling cutter.

Turbo 10 Square Shoulder Mills

The enhanced Turbo 10 series of square shoulder milling cutters now includes more inserts with new geometries and radii as well as helical cutters for increased machining flexibility in tough materials. The insert range expansion includes both direct pressed and ground insert alternatives with corner radii ranging from 0.4 mm to 3.1 mm. The new geometries for the ground insert range provide increased performance in materials with unique challenges, including aluminum, stainless steels and titanium alloys.

The Double Octomill provides 16 cutting edges to minimize cost per edge for a lower cost per part (courtesy of Seco).

The new helical cutters are ideal for helical shoulder milling applications that require process stability, flexibility and high precision. The cutters are available in diameters ranging from 20 mm to 54 mm and include Weldon, Seco Weldon, Combimaster heads, Seco-Capto and Arbor mounting options.

All Turbo 10 cutters include precision milled pocket seats that improve run-out, stability and tool life by providing optimal contact between the tool body and insert. Integrated through-coolant channels support high productivity and promote excellent chip evacuation. Because of their high levels of flexibility, Turbo 10 cutters work in slotting, shouldering, ramping, facing, pocketing, plunging and turn milling applications.

Double Octomill Face Milling Cutter

The Double Octomill face milling cutter is highly versatile in that it can be used for both roughing and finishing operations. And while more traditional face mills typically use inserts with four edges, the Double Octomill provides 16 cutting edges to minimize cost per edge for a lower cost per part.

Seco achieves 16 cutting edges because each pocket on the Double Octomill cutter features a negative axial angle that allows for the use of double-sided inserts. The inserts them-

Seco's Turbo 10 series includes more inserts with new geometries (courtesy of Seco Tools).

selves use a positive rake angle to minimize power consumption while achieving higher cutting speeds for a significant increase in productivity.

The Double Octomill is available in three different pitch versions. On the normal and normal+ versions, the insert locks into place via a center lock mounting with a strong screw. The close pitch version offers wedge mounting using a new, stronger and self-orienting wedge.

Square 6 Milling Cutter

With three cutting edges on each side, six in total, Square 6 cutters provide lower cost per cutting edge and bring enhanced performance to a variety of operations, including face milling, contouring, plunging, slotting and square shoulder milling. With three geometries, two radii, eight grades and six indexable cutting edges, the Square 6's peripheral ground inserts allow users to achieve greater accuracy, exacting tolerances and high-quality part surface finishes when machining tough materials.

For more information:
Seco Tools
Phone: (248) 528-5444
www.secotools.com

Sandvik Coromant

STAND B20, HALL 5

At EMO Hannover 2013 cutting tool and tooling systems specialist, Sandvik Coromant, is offering a "journey of discovery" including the launch of an innovative technology that will set new standards for metal cutting performance. EMO visitors are invited to join Sandvik Coromant at the company's Smart Hub at 2:00 on September 17 for the unveiling of this new tool generation.

Sandvik helps optimize milling applications for large gears module 12-22 (photo by David Ropinski).

Gear milling technologies will be showcased during EMO (photo by David Ropinski).

"What will you Discover?" is the theme of the 528 m2 Smart Hub, where an international team of Sandvik specialists will be based throughout the event. Visitors will be able to explore the latest drilling, milling and turning technologies as well as finding out about important manufacturing industry trends.

A yellow "Discovery Line" provides a guide through a number of key Sandvik Coromant solutions including the new generation of tooling technology, the latest developments in high-pressure coolant (HPC) applications and toolholders for sliding head lathes.

Elsewhere in the Smart Hub there will be several displays relating to specific sectors and applications. For example, there will be special areas for hard part turning (HPT) in the automotive sector and details of solutions for the aerospace and energy industries. New gear milling technologies and the use of Silent Tools in drilling applications will also be showcased.

Continuing the theme of innovation, Sandvik Coromant president, Klas Forsström, will be giving a lecture on next generation machining at this year's VDMA Congress. This event with its "Inspired by Technology" theme runs in parallel with EMO and Forsström's lecture will take place on September 17.

For more information:
Sandvik Coromant
Phone: (800) SANDVIK
www.sandvik.coromant.com

August 4–7—ASME 2013 Power Transmission and Gearing Conference. Portland, Oregon. The Power Transmission and Gearing (PTG) Committee of the American Society of Mechanical Engineers, Design Engineering Division invites guests to participate in the ASME 2013 Power Transmission and Gearing Conference. This conference will be held in conjunction with the ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conferences (IDETC/CIE 2013). Power transmission and gearing researchers and engineers from around the world attend this conference. This is an ideal forum for enhancing power transmission and gearing engineering, providing attendees an opportunity to become familiar with the latest research findings and applications that address critical engineering issues. Topics include gear geometry, gear analysis, gear dynamics, gearbox design, lubrication and wear, transmission systems, bevel gears, power transmission topics and more. For more information, visit *www.asmeconferences.org*.

August 8–10—International Gear Transmission and Equipment Expo 2013. China International Exhibition Center, Beijing, China. With an emphasis on high-end manufacturing in China, the Expo is a great starting point for business meetings and technical exchange. Forum topics for the 2013 show include: new materials and techniques, high accuracy machine tools, heat treatment technology, shot-blasting technology, trends in gear cutting, gear measuring developments, automotive transmission technology, fatigue resistance and a technology roadmap for the gear industry between 2013 and 2030. The reoccurring themes for the 2013 show include the reallocation of upstream and downstream resources, tackling core technology and industrial upgrading. 680 exhibitors and more than 50,000 visitors will take part in the 9th GTE Expo. For more information, visit *www.chinagte.com*.

August 19–21—Gear Failure Analysis Seminar. Big Sky Resort, Summit Lodge, Big Sky, Montana. In AGMA's Gear Failure Analysis Seminar, attendees will examine the various types of gear failure, such as macropitting, micropitting, scuffing, tooth wear and breakage. Possible causes of these failures will be presented, along with some suggested ways to avoid them. Robert Errichello will use a variety of tools and methods — lectures, slide presentations, hands-on workshops with failed gears and Q&A sessions — to give you a comprehensive understanding of the reasons for gear failure. Participants are encouraged to bring their own failed gears or photographs and discuss them during the Q&A sessions. The seminar brings together a vast amount of knowledge not available elsewhere. It will help you solve everyday problems whether you are a gear engineer, user, researcher, maintenance technician, lubricant expert, or manager. The course manual can be used as a permanent reference and guide for failure analysis. For more information, visit *www.agma.org*.

September 16–21—EMO Hannover 2013. Hannover, Germany. Under the motto "Intelligence in Production," EMO will be showing what modern-day production technology looks like and who is offering it. "Everyone wants to be there. That's why once again the EMO Hannover is well set to continue its success story," says Carl Martin Welcker, general commissioner of EMO Hannover 2013. At the beginning of the year, more than 1,600 companies from 34 different countries had already registered: they will be occupying around 145,000 m^2 of net exhibition space. Thus the current registration status is significantly higher than the comparable figure for the preceding event. The flourishing demand among vendors of production technology evidences the high perceived importance of EMO Hannover as one of the sector's international highlights and as a superlative platform for innovations. "Meet the world at EMO" is one of the most important arguments for participating. It's not only German manufacturers who have registered for large-size stands. Asian companies are particularly prominent in showing the flag, firms from Japan, China, Taiwan and Korea who are keen to play a bigger role on the global market. They have once again upsized their areas compared to the preceding event's equivalent period, a trend that's been observable for some years now. In all, Asia currently accounts for a good fifth of the EMO's exhibitors. For more information, visit *www.emo-hannover.de*.

September 17–19—Gear Expo 2013. Indiana Convention Center, Indianapolis, Indiana. Gear Expo is a biennial event designed exclusively for the gear industry. For three days, gear buyers and manufacturers network and build relationships that benefit their respective companies. Attendees see firsthand the latest technology on the market and discuss trends in the industry with experts. Exhibitors have the opportunity to meet face-to-face with attendees and other exhibitors and will display more than 750,000 pounds of machinery on the show floor. Thousands of professionals from around the United States, international manufacturing hubs, and emerging markets conduct profitable business transactions and collaborate on the innovations that make their operations more streamlined. The ASM Heat Treating Society Conference and Exposition is co-located with Gear Expo 2013. For more information, visit *www.gearexpo.com*.

October 15–17—School for Gear Manufacturing Technology. Anaheim, California. Hosted by Gear Manufacturing Inc. (GMI), this three-day seminar is designed to give the student a deeper understanding of the relationships between the geometry of the gear and the manufacturing and inspection processes leading to a practical, logical approach to trouble shooting. In this regional course we address the problems associated with gear generation (hob and shape) and gear finishing (grind and shave), for cylindrical gears, in respect to the machine tool and the associated tooling and cutters. Analysis of inspection results from traditional manual and digital inspection processes are covered in depth. New for 2013 is an introduction to the new AGMA standards which relate directly to the international ISO standards. For more information, visit *www.gearconsultinggroup.com*.

October 16–18—Kapp-Niles Rocky Mountain Gear Finishing School. Boulder, Colorado. The Sixth Annual Kapp-Niles Rocky Mountain Gear Finishing School (RMGFS) is designed to benefit gear manufacturing engineers, machine operators and production managers, as well as gear designers. The opening presentation, Gear Basics, provides a solid foundation, including a section on gear nomenclature for relative newcomers. The RMGFS provides both classroom-style and shop floor lessons, each focusing on advances in profile and generating gear grinding. In the multi-layered program, sessions are interconnected and lead each step to the next. Participants study the principles and mechanics behind different gear finishing processes, apply them through practical sessions on a Kapp-Niles machine, and hold group workshops for discussions. For more information, visit *www.kapp-usa.com*.

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4 → What is your primary JOB FUNCTION (check ONLY one)

- ❑ Corporate Executive (B)
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- ❑ Manufacturing Production Department (D)
- ❑ Manufacturing Engineering Management (E)
- ❑ Manufacturing Engineering Department (F)
- ❑ Product Design, R&D Management (H)
- ❑ Product Design, R&D Department (I)
- ❑ Purchasing (L)
- ❑ Marketing, Sales or Communications (M)
- ❑ Quality Control Management (P)
- ❑ Quality Control Department (Q)
- ❑ Other (Please describe) (N)

_____

5 → How are YOU involved with gears (check all that apply)?

- ☐ My company MAKES gears (20)
- ☐ My company BUYS gears (22)
- ☐ I DESIGN gears (23)
- ☐ I am a SUPPLIER to the GEAR INDUSTRY (please specify product or service) (24)

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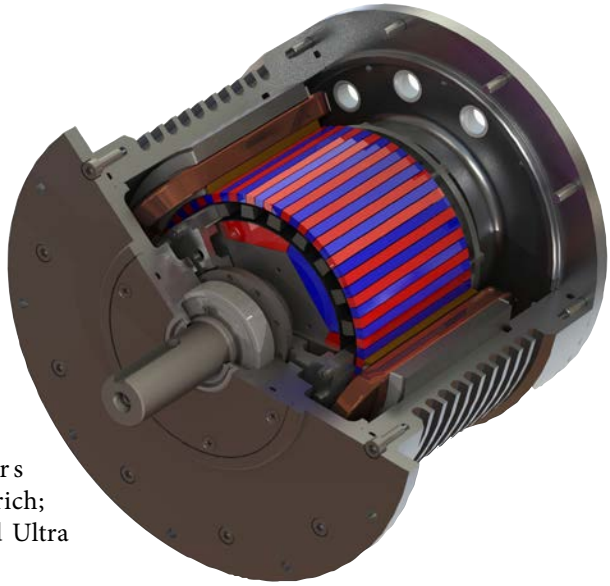
Magnetic Gearing Attracting More Followers?



"Going green" and energy efficiency are goals that all industries—especially in Europe and the United States—are working on, in such sectors as electric motors, lubrication, gears and on and on. Drumroll here please for magnetic gearing, or, more precisely—magnetic transmission technology. It is a concept now being utilized in wind and marine turbines; marine propulsion; hybrid and all-electric vehicles; ancillary drives; flight surface actuation; landing gear deployment; mining crushers; conveyors; and earth moving equipment.

A pioneer in magnetic gearing, Magnomatics Ltd (*magnomatics.com*) is located in Sheffield England. It was established in 2006 as an adjunct entity of the University of Sheffield charged with commercializing their research in the areas mentioned above. In charge of the technical aspects of the operation are Dr. Kais Atallah and Professor David Howe, from the electrical machines and drives research group at the University.

According to the Magnomatics website, magnetic gearing is both an environmental and performance upgrade over traditional gearing because of the following attributes: reduced maintenance and improved reliability; lubrication-free; higher efficiency than conventional gears; precise peak torque transmission and inherent overload protection; physical isolation between input and output shafts; inherent anti-jamming transmission; significantly reduces harmful drivetrain pulsations; allows for misalignment/vibration of shafts; and very low acoustic noise and vibration.

The company site includes what might be construed as a mission statement:

"Our technology allows a step-change improvement in a broad range of applications and industries in which a high torque density (i.e., reduced size/mass), high efficiency or improved reliability is desirable. Our engineers have extensive experience in bespoke design for custom-specific applications and can quickly quantify the benefits that our technology can offer."

Magnomatics customers include: Messier-Bugatti; Goodrich; Turbo Technologies; Macon; and Ultra Electronics.

Two of the more intriguing developments being marketed by the company are a magnetics-based CVT and IVT, and what Magnomatics calls a PPD machine.

The CVT (or contactless, high-efficiency continuously variable transmission system with inherent overload protection), and IVT (infinitely variable transmission), according to a website description, boast high efficiency; contactless, lubrication-free variable transmission; inherent overload, torque fuse capability; and speed of prime mover matched with variable speed load. The magnetic CVT is said to allow a variable speed drive to be connected to a fixed speed load, to be highly efficient and compact, to require no cooling or lubrication and to be suitable for applications as diverse as hybrid vehicles and wind turbines.

The company's PDD machine is an extension of the low-ratio magnetic gear; it was invented and demonstrated by Magnomatics in 2005. According to the company, it is arguably regarded as the most significant advancement in electrical machine design in the past 20 years. The new technology combines the high-torque density of the magnetic gear and the functionality and performance of a brushless, permanent magnet machine to offer robust torque output for direct drive applications. Performance claims for the PPD technology include: significant size reduction over conventional direct drive machines; ultra-high efficiency that eliminates the need for ancillary cooling; reduced maintenance and improved reliability over mechanically geared drives; inherent torque overload protection; high power factor (typically >0.9); standard power electronic controllers; and the possibility for two output shafts with different rotational speeds.

And lest you might be thinking this all sounds like blue-sky, over-the-top claptrap, consider that Magnomatics in 2012 received £2.5 million (> $4,382,000 U.S.) in funding to develop magnetically geared motors and generators for the hybrid and electric vehicle market. They also were recognized with a £100,000 (> $151,000 U.S.) Smart award to help in developing its next-generation MAGSPLIT product, a power-split device that combines the functionality of a magnetic gear and a motor generator in a compact unit. It substantially improves system efficiency and, therefore, fuel economy, compared to the mechanical gear and motor/generator combination found in many of today's hybrid cars.

And presently, Magnomatics is working with strategic partners to develop: high-efficiency and ultra-compact generators to address the challenging requirements of wind and tidal energy production; ultra-compact and efficient marine propulsion systems; wheel hub motors and continuously variable transmissions that allow flexible system topologies for commercial hybrid and electric vehicles; and fluid-free, low-mass actuators for aircraft flight surfaces.

For more information:

Magnomatics Ltd.
Park House
Bernard Road
Sheffield
S2 5BQ
UK
Phone: +44 (0)114 241 2570
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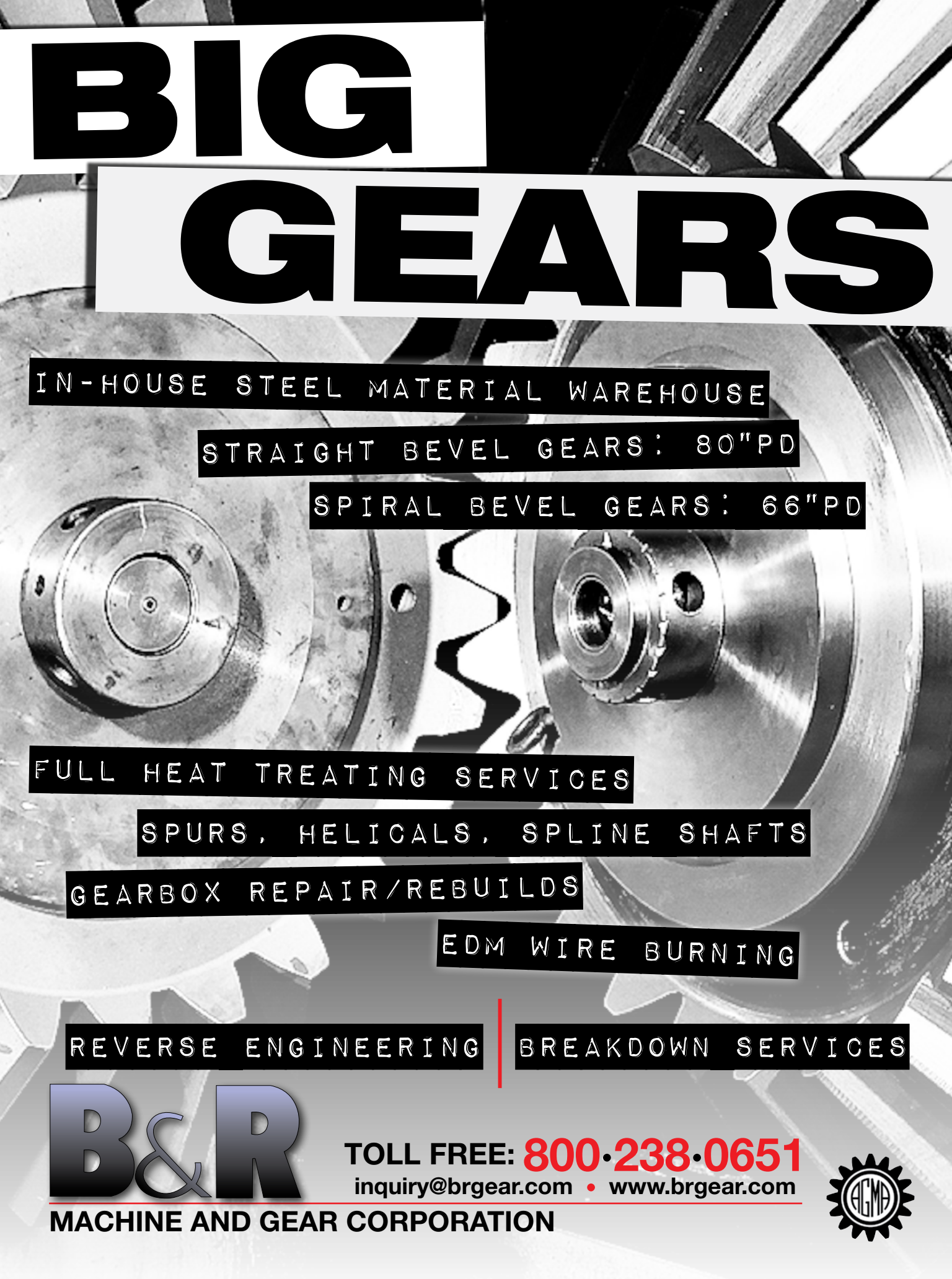

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