gear TECHNOLOGY®

AUG 2014

IMTS 2014

WHAT YOU SHOULD KNOW | EXHIBITOR BOOTH LISTINGS | WHAT YOU'LL FIND THERE

FEATURE: **HOW HONING CUTS COST, BOOSTS PRODUCTION**

GEAR TECHNOLOGY 30 YEARS 1984–2014

TECHNICAL

ASK THE EXPERT: FULLY GROUND ROOT FILLETS; WHY CONTACT PATTERN MATTERS; LUBRICANT ADDITIVES

FIRST INTERNATIONAL INVOLUTE GEAR COMPARISON

FATIGUE TESTING OF GEARS IN POWERTRAIN AXLES, PART I

ADDENDUM

RIDE, SALLY, RIDE

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THE JOURNAL OF GEAR MANUFACTURING

Samputensili G 250 generating and profile grinding machine

The Samputensili G 250 gear grinding machine has been especially developed for very low cycle times and for top-quality and efficient mass production of gears with outside diameters up to 250 mm and shafts with lengths up to 550 mm.

The machine is based on the dual work spindle concept, which eliminates non-productive times almost completely. By means of this feature, the loading/unloading process of a workpiece is carried out in masked time, while simultaneously the manufacturing process proceeds on another workpiece. Simple design concepts in terms of tooling and dressing technology, fast automation and amazing user friendliness are the strengths behind this innovative machine.

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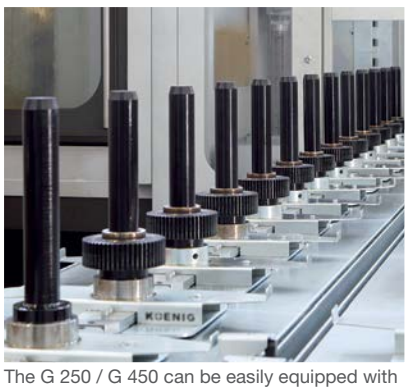
IMTS 2014

September 8-13, 2014



The G 250 / G 450 can be easily equipped with various automation solutions

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www.star-su.com/gear-grinding

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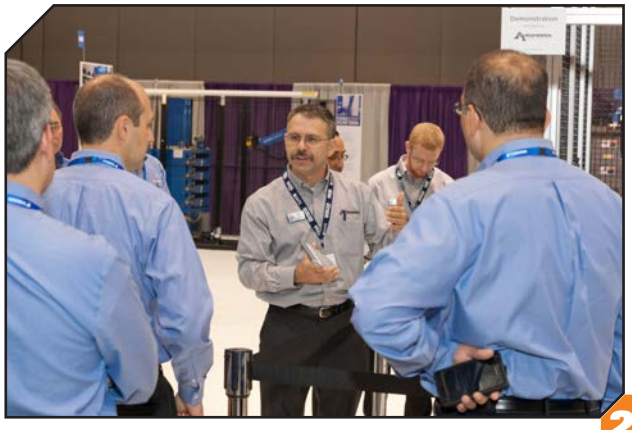

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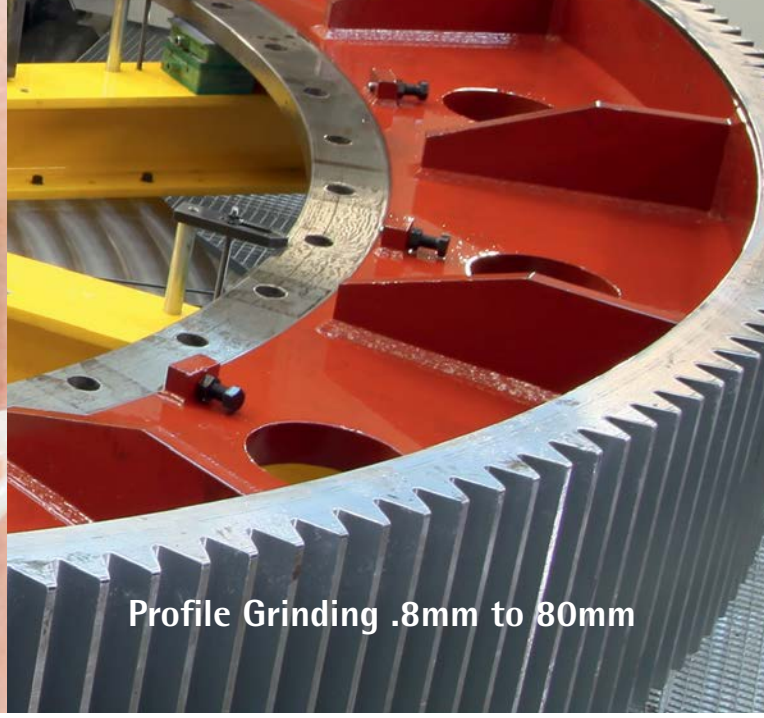
Vol.31, No.6 GEAR TECHNOLOGY, The Journal of Gear Manufacturing (ISSN 0743-6858) is published monthly, except in February, April, October and December by Randall Publications LLC, 1840 Jarvis Avenue, Elk Grove Village, IL 60007, (847) 437-6604. Cover price $7.00 U.S. Periodical postage paid at Arlington Heights, IL, and at additional mailing office (USPS No. 749-290). Randall Publications makes every effort to ensure that the processes described in GEAR TECHNOLOGY conform to sound engineering practice. Neither the authors nor the publisher can be held responsible for injuries sustained while following the procedures described. Postmaster: Send address changes to GEAR TECHNOLOGY, The Journal of Gear Manufacturing, 1840 Jarvis Avenue, Elk Grove Village, IL, 60007.



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Vol. 31, No. 6

departments

Ingersoll photo by David Ropinski

Intelligence in Production.

Liebherr at the IMTS

During development of our innovations, we place particular emphasis on choosing an optimal solution for the respective application. The result: Process stability and an outstanding quality of manufactured components – with the highest level of economy possible.

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Chicago, Il. - USA
September 8 - 13, 2014
North Hall,
Booth N-6930

Generating grinding machine LGG 180/LGG 280
- A single-table solution for gear grinding of workpieces up to Ø180 mm, or up to Ø 280 mm, and workpiece lengths up to 500 mm
- Extremely fast load/unload times of 4 seconds, chip-to-chip, with a single-table
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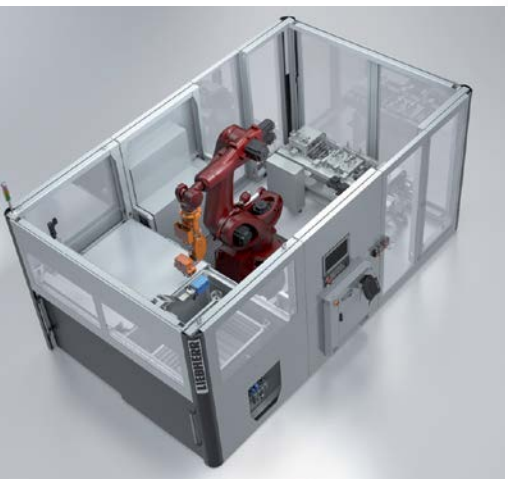

Liebherr Robot Cell LRC 20
- Flexible robot solution replaces complicated sorting systems, increases productivity, and alleviates burden on personnel
- Part weight up to 44 lbs
- Automatic unloading and direct positioning
- Mechanical, magnetic, vacuum grippers

Wenzel Gear Measuring Machine WGT 400
- Longtime stability from granite structure
- Air bearings in all axes for highest precision
- Easy to use software with parameterized input masks
- Max. measurable diameter 400 mm
- Max. face width 500 mm
- Distance between centers 650 mm
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Liebherr Gear Technology, Inc.
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Saline, Michigan 48176-1259
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E-mail: info.lgt@liebherr.com
www.liebherr.com

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The Group

THE GEAR INDUSTRY'S INFORMATION SOURCE

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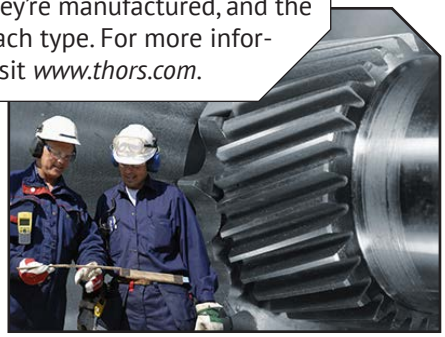
GT Videos

The Gleason Phoenix 280C/280CX Bevel Gear Cutting Machine allows users to reduce cycle times by as much as 35% on the production of bevel gears and pinions up to 280 mm in diameter. See a demonstration video of this and other machine tools on the *Gear Technology* homepage at *www.geartechnology.com*.

LINKEDIN

The THORS Academy Gears Knowledge Center offers a complete overview and understanding of metallic gears. Users learn the different gears available and their classifications based on their relative orientation of the axes of rotation, how they're manufactured, and the advantages and disadvantages of using each type. For more information on the Gears Knowledge Center visit *www.thors.com*.



IMTS 2014

Gear Technology will continue to feature the latest product and industry news items related to IMTS 2014 taking place September 8-13 at McCormick Place in Chicago. All the new technologies, products and can't miss events will be available on our website as well as Twitter and LinkedIn.

Back to Basics

Looking for a good article on gear fundamentals? The *Gear Technology* Articles Archive can be accessed by typing "basics" into the search box on the *Gear Technology* homepage.

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BPA WORLDWIDE

OUR LINE JUST GOT LONGER...

Looking for a partner for your high-production, multi-station machining, assembly and finishing operations?

German Machine Tools of America (GMTA) now offers a broad assortment of vertical turning lathes, horizontal gear cutters, single and double-side grinding machines, the patented **Scudding**® process for gear internals, honing machinery and now, laser welding assembly and parts washing equipment. Our recent additions of the **Arnold** laser line and **Rosink** parts washers mean you have end-to-end expertise from just one phone call.

We're not all things to all people, but we're getting there!

Plus, you enjoy the advantages of **GMTA** application engineering, unmatched experience in the manufacturing technologies for gears and other power transmission components, multi-national support in sales and service, plus the unique assortment of machine tools and related equipment to keep your process at peak efficiency.

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BEGINNING, RENEWING, SHARING

There's an IMTS Journey for Everyone

Publisher & Editor-in-Chief
Michael Goldstein

IMTS is about beginnings.

This year's show takes place September 8-13 at McCormick Place in Chicago. With more than 1,900 exhibitors expected to occupy more than 1.2 million square feet of exhibit space, there will be plenty of technology on display—much of which may have potential for you or your company. Your chance to begin exploring that technology only lasts a week, and it only comes every two years.

More importantly, IMTS gives you the opportunity to begin relationships with suppliers you may not have worked with before. Expanding your network of contacts gives you access to experience, knowledge and expertise that you wouldn't otherwise have. Perhaps there's an expert at Gleason, Liebherr, Klingelnberg or Star-SU who's already helped solve some of the gear manufacturing problems you're currently working on. But you may never know unless you go to IMTS and begin those relationships.

Maybe you're beginning to think more about your company's marketing, but you don't know where to start. We can help with that, because we'll be at IMTS, too. Stop by our booth, N-7214, and we'll be happy to discuss with you—in a friendly, no-pressure way—all the tools that are available to help you communicate your message to the gear industry, to buyers of gears and geared products and related markets.

IMTS is also about renewals.

Just as important as beginning new relationships is continuing old ones. There's nothing quite like a trade show for building camaraderie and rapport among members of an industry. Over my career I've been to many events like IMTS, and I always see old friends catching up. In fact, I've noticed that most gear manufacturers get as much value out of meeting with their competitors—who sometimes also happen to be friends—as they do out of meeting potential customers or suppliers.

Perhaps it's time for you to renew your commitment to upgrading your facility, to lean manufacturing, to increased automation, or to whatever other manufacturing initiatives you know you're supposed to be working on but haven't had the time. IMTS can help with that.

Of course, it's my duty to remind you that we also need you to renew your subscriptions to *Gear Technology* and *Power Transmission Engineering*. Both magazines will be at booth N-7214, and we'll have quick and easy forms on hand that will allow you to continue receiving the finest technical information available for the gear industry for the next two years.

Finally, IMTS is about sharing.

While it's one thing to recognize that IMTS has a lot to offer you, and that you could potentially have a lot to gain from the people you meet there, it's also important to know that *you* have a lot to offer *IMTS*. Many of *you* are the experts who have the experience, knowledge and expertise. Many of *you* have the contacts and stories to share with others.

We hope you'll come to Booth N-7214 and share them with us as well. Our editors will be at the show every day, and they'll be looking for people like you to share their experiences about gear manufacturing. We want to know what technology is working for you, what new trends you're seeing, what gear manufacturing problems need solving. And if you have some interesting gear-related stories to tell, we'd love to hear them. After all, *Gear Technology* has been part of the gear industry for 30 years, and we're all about sharing. We're here to help spread information to the industry.

So no matter what phase of the IMTS journey most interests you, come to Booth N-7214. We look forward to seeing you.

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Using today's most advanced technologies Luren presents the LFG-3540 CNC profile gear grinding machine. Using PC based software, operators can easily learn how to effectively run this gear grinder. With the use of Fanuc controls, direct drive motors, linear motors and great service, we can deliver a very precise gear grinding machine with reliability to match.

get more information at www.lurenchicago.com

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PTG

REVISES MAINTENANCE AND SUPPORT SERVICES

U.K.-based Precision Technologies Group (PTG) has revised its range of machine tool maintenance and support services, to provide what it believes to be one of the most comprehensive and cost-effective customer care packages available for machine tool users globally. Under the name of Absolute Care, the company has created a suite of tailored maintenance solutions for users of its Holroyd ultra-precise milling and grinding machines. A similar range of Absolute Care services is available for owners of PTG Heavy Industries' Powerstir friction stir welders, and Binns & Berry/Crawford Swift heavy-duty lathes, roll lathes, deep hole boring machines and roll grinding machines.

In addition, extensive repair, refurbishment and upgrade services, as well as CNC repair and upgrade solutions, are available for lathes and machine tools from a wide range of other manufacturers. "At Precision Technologies Group, we have always strived to offer the highest levels of machine tool maintenance," comments Customer Care General Manager, Alan Mead. "In creating our menu of Absolute Care services," he continues, "we have made it simpler than ever for our customers to select the precise maintenance solutions they require, and ensure their PTG machine tools provide a long and reliable working life. Additionally, by developing a bespoke range of services for owners of other machine tools, we provide the option of having their equipment maintained to the uncompromisingly high standards that Precision Technologies Group is renowned for."

The Absolute Care services offered by Precision Technologies Group include emergency U.K., EU and worldwide engineer response, remote machine support and fault diagnosis, Planned Preventative Maintenance (PPM), process enhancements, CNC repairs and upgrades, machine refurbishment and reengineering, OEM parts, and a brand new dedicated machine tool care plan.

For more information:
PTG Holroyd Precision
Phone: +(44) 1706 507 831
www.holroyd.com

Vomat

OFFERS FILTRATION TECHNOLOGY FOR METAL COOLANTS AND LUBRICANTS

In tool grinding all individual processing steps are part of a coherent value chain. Therefore it is important that the filtration process of metal coolants is integrated seamlessly in this value chain. When operational requirements or technical improvements cause changes and flexibility is needed, your filtration system should meet those new needs. The filtration specialist Vomat meets these challenges with a line-up of high-tech systems. From stand alone to large industrial central filtration systems Vomat's offerings are of modular design and can be adapted quickly and easily to changing shop and production requirements.

Stephan Hecht of oelheld U.S., Inc., Vomat's general agent in Elgin, Illinois, states: "By design the stand alone Vomat-FA-series models have a flow capacity of 120 to 960 liters per minute. In addition, we provide our customers with a number of add-on modules which can be easily integrated, when the need arises. The array of modules includes

displays for the complete visualization of the filtration process in real time, frequency controlled pumps, internal and external pre-filters and various cooling solutions.

In close cooperation with the customer, Vomat tailors a filtration solution to individual production conditions, which can be can be altered in case requirements change. Hecht adds, "If our client implements technological improvements in his production process, Vomat can help to make sure that the filtration system will meet the new requirements."

Besides the modular expandability of Vomat systems, it is mainly the innovative filter technology that provides Vomat customers with economic benefits: Vomat systems filter in full flow stream and separate dirty from clean oil 100%, thanks to high capacity precoated filters. The results are lubricants, which meet NAS 7/8 or 3-5 microns in terms of purity and cleanliness. Clean oil is decisive for dimensional accuracy and surface quality of the finished work piece.

In addition, Vomat systems adapt intelligently to changing volumes of sludge and automatically initiate the backflush cycle depending filter contamination. Each Vomat machine is equipped with enough filters, that during the backflush cycle the operator always has full oil flow. This allows for energy efficient, time optimized operation in sync with the customer's grinding machine. The Vomat FA 120 through 420 series machines with dimensions of $1 \times 1 \times 1.6$ meters are also significantly smaller than comparable filtration systems on the market. This keeps transportation costs low, possibly reduces facility alterations and provides the client with more floor space.

For more information:
Vomat (Distributed by Oelheld)
Phone: (847) 531 8501
www.vomat.de

Krebs & Riedel

OFFER INNOVATIVE GRINDING TECHNOLOGY

Krebs and Riedel is a family-owned company and has been in operation in Bad Karlshafen Germany since 1895. With over 190 dedicated employees and an annual turnover of €21 million is one of Germany's leading manufacturers of advanced grinding wheels. An export share of approximately 40 percent demonstrates the international orientation of the company with exports being a major part of their sales program.

Products include conventional grinding and cutting wheels using corundum and silicon carbide abrasives. Super abrasive (CBN and diamond) tools with a vitrified bond have been manufactured with ever rapidly growing sales since 1985. The production of grinding wheels takes place on modern machinery and profiling of the grinding wheels on the CNC machines PM280T & PM550TC with automatic tool change manufactured by M/s Burri Werkzeugmaschinen with the very latest profiling techniques.

The grinding wheel compounds are based on the innovative Multo vitrified bond system and, in conjunction with the grinding media used (high-grade aluminium oxide, micro-crystalline sintered aluminium oxide and the new aluminium oxynitride), guarantee low thermal effects on the workpiece, good retention of profile, and cutting ability with high dressing cycle speeds and high efficiency.

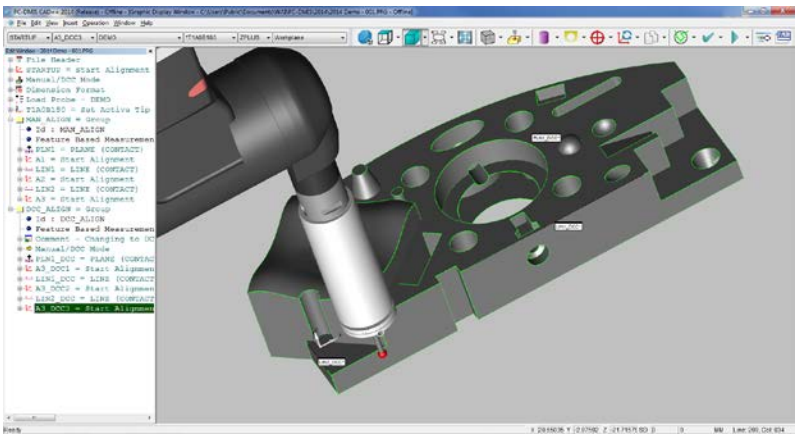
The company is certified in accordance with ISO 9001:2008 and produces the grinding tools in accordance with the internationally valid standards EN, ANSI and JIS. Krebs and Riedel is a member of the Gear Research Circle of the Laboratory for Machine Tools and Production Engineering (WZL) at RWTH Aachen University (Germany).

The range held in stock includes grinding wheels in white high-grade aluminium oxide and sintered aluminum oxide. Due to their selective porosity and grain compound, the grinding wheels guarantee a cool grind with high profile and abrasion resistance. Most recently, the application of dressable vitrified CBN grinding wheels to gear grinding has also intensified. For this purpose, Krebs and Riedel can also offer a product program that is continuously developing.

For more information:
Krebs and Riedel
Phone: +(49) 5672 1840
www.krebs-riedel.com

Hexagon Metrology

LAUNCHES PC-DMIS 2014



Hexagon Metrology recently launched *PC-DMIS 2014*, a major release of its measurement software used for the collection, evaluation, management and presentation of manufacturing data. *PC-DMIS 2014* introduces tools and technologies that will help measurement devices perform better than ever, increase the effectiveness of inspection planning time, and make it easier to complete complex inspection routines. Hexagon Metrology will demonstrate *PC-DMIS 2014* with over 17 major and 81 minor software enhancements in Booth 5202 at IMTS 2014. The new software includes a number of productivity advancements to improve speed of common programming tasks and to improve the overall user experience. "*PC-DMIS 2014* delivers new and improved capabilities based on real-world user feedback from the *PC-DMIS* forum and our technical support teams," said Ken Woodbine, president of Hexagon Metrology software division. "This release is focused on productivity, and sets the stage for future user experience enhancements already in the planning stage and moving forward."

Highlights of *PC-DMIS 2014* include a new 1-click "QuickFeature" feature creation from CAD models, where users can also create Quick Features by hovering their mouse over a CAD model to highlight CAD elements. Contact auto features are created from a single click on the CAD model without using any menu options or dialog boxes.

There is also a 1-click "QuickAlign" capability where users can now select valid combinations of one, two, or three features to create a quick alignment. The QuickAlign feature will also initiate manual and DCC alignments when used at the beginning of a part program. These new productivity tools are packaged in a new QuickMeasure toolbar giving drop-down access to common measurement features, giving more screen real estate to the graphics and the measurement routine. The new software version also includes Copy Parameters and Paste Parameters functions, which copy parameters from one feature or dimension, and paste them to another feature(s) or dimension(s) in the Edit window, making block changes much faster.

PC-DMIS 2014 also rolls out a new Mini Routines feature which can be used to mea-

sure a selected dimension or group of dimensions from a long part program. Mini routines offer characteristic-based measurement and the ability to measure a part of a complete measurement routine. *PC-DMIS* is the flagship software package for Hexagon Metrology measurement devices and a wide range of other measurement equipment in the marketplace.

For more information:
Hexagon Metrology
Phone: (847) 931-0100
www.hexagonmetrology.us

Solid Technical Solutions

OFFERS TEC-FLON LUBRICANTS

Solid Technical Solutions recently introduced its product line of high-tech lubricant materials, Tec-Flon (GM-approved). The Tec-Flon family of non-hydrocarbon, non-silicone, fluorinated oils and greases is designed specifically for use with plastics, in paint shops where silicones are not permitted, or in vacuum environments. The products remain effective when used for high-performance applications, even in high temperature settings. Solid Technical Solutions' Tec-Flon materials meet or exceed the performance requirements of General Motors; and are well-suited for use in electronics, optics, aerospace, cleanrooms, and general assembly applications.

For more information:
Solid Technical Solutions/Tectorius
Phone: (586) 232-3999
www.tectorius.com

Grieve

OFFERS TWO-COMPARTMENT OVEN

No. 978 is a 500°F, electrically-heated, two-compartment universal style oven from Grieve, currently used for various machine shop operations at the customer's facility. Workspace dimensions of this oven measure 30" W × 36" D × 36" H in each of the two heating zones. 6.6 KW per zone (13.2 KW total) are installed in Nichrome wire elements to heat the oven chamber, while a 600 CFM, ½ HP recirculating blower provides front-to-rear universal airflow to the workload. This Grieve universal oven features 4" insulated walls, aluminized steel exterior, Type 304, 2B finish stainless steel interior, double doors and an integral leg stand. Controls on No. 978 include a digital indicating temperature controller in each compartment of the oven, manual reset excess temperature controllers with separate contactors, recirculating blower airflow safety switches and a 10" diameter circular chart recorder, one per compartment, to record part temperatures.

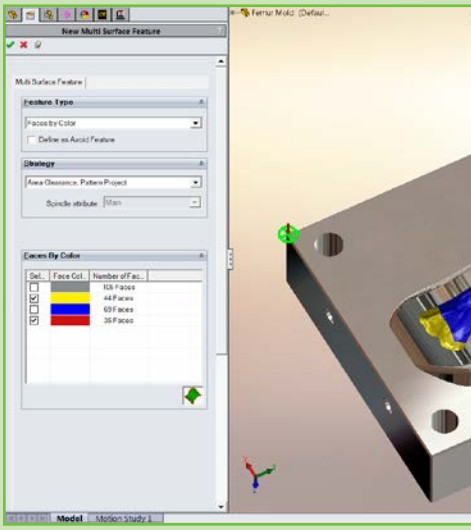
For more information:
Grieve Corporation
Phone: (847) 546-8225
www.grievecorp.com

Geometric

SET TO PREVIEW CAMWORKS 2015

Geometric will preview its latest release of CNC programming automation solution, *CAMWorks 2015*, in Booth E-3320, IMTS 2014 in Chicago. In today's environment, manufacturers need to be able to do more with less - less design time, program time, setup time and machining time. *CAMWorks 2015* focuses on making the entire design to part cycle shorter.

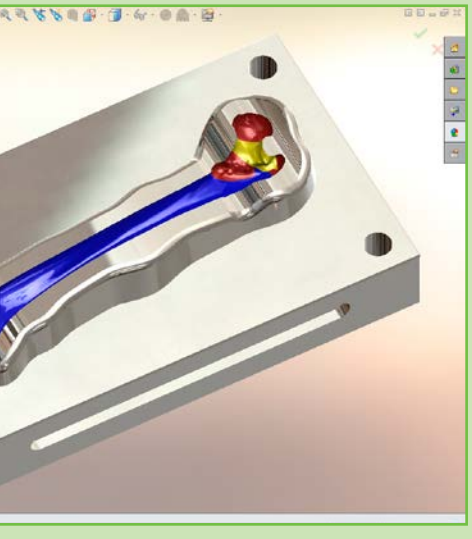
CAMWorks 2015 has over a dozen enhancements focused on shortening the programming time. One example is the color based identification of complex surfaces making it easier and quicker to define features by avoiding the traditional chains and profiles methodology. *CAMWorks 2015* has bolstered its ability to interpret non-prismatic surfaces on solid models as machinable entities automatically. This enhanced ability to leverage feature-based machining for complex requirements in combination with *Intelligent Knowledge Base* (TechDB) allows end users to eliminate the routine elements in CNC programming and focus on their core expertise.



For a job shop, setup time is critical. With an integrated true G-code simulation, *CAMWorks Virtual Machine*, users can make sure that the costly process of dry-runs on the shop floor are minimized with one-click verification. The use of G-code for verification is absolutely critical if you are dealing with sub-programs, macros, sub-spindle transfers, tail-stocks and steady rests.

On the other hand, for production shops, machining time is the key. Users need to makes sure that what they are machining is not only correct but most efficient. The ultra-high performance tool paths from *CAMWorks VoluMill*, has enhanced capability to handle more complex geometries like multi-step irregular islands, that can be very difficult to address with trochoidal tool paths which a number of other systems try to use to address this critical challenge.

For more information:
Geometric
Phone: (248) 404-3500
www.geometricglobal.com



Fanuc America

OFFERS LATEST MACHINING IMPROVEMENTS

Fanuc America Corporation introduces CNC innovations that improve machining performance, ease of use and maintenance at IMTS 2014 Booth #S-8919. These include: introduction of the new Series 0i-F CNC with new commonality of design and 15" display option, a new CNC platform with built in Bluetooth technology and digital servo adapter with new EtherCAT interface.

Fanuc's new Series 0i-F CNC is the latest generation of the Series 0i CNC that now has commonality of design to the versatile Series 30i CNC and a 15" display option. The Series 0i-F boasts common operability, maintainability and networking options as the Series 30i CNC along with having a highly compat-

ible PMC ladder. This translates to easier operation and maintenance across the plant floor. The seamless combination of using the same motors, amplifiers, peripheral devices (safety machine operator's panel, I/O module/unit, iPendant, interface unit for handy machine operator's panel) as the Series 30i further simplifies the ease of use and maintenance of the Series 0i-F. Seamless and common PMC functions among both the 0i-F and 30i-B CNCs include: multi-path PMC, ladder dividing management, function block, multi-language comment and I/O Link i. With an increased axis number of 9 total controlled axes for a 1 path system for both 0i-MD (milling) and 0i-TD (turning) and a 2 path system now available on the 0i-MF with 11 total controlled axes, the Series 0i-F is more versatile to improve machining performance. Additional new features on the Series 0i-F include: 15" display, I/O Link i, FSSB high speed rigid tapping, function for loader control, tolerance control, axis name expansion, program folder management, quick program restart, flexible path axis assignment, multi-path PMC function, ladder dividing management, EtherNet/IP and Profinet.

Fanuc's new standard CNC platform allows for enhanced CNC functionality using PC technology. Built in Bluetooth on the CNC allows for the use of wireless technology that can operate a CNC by keyboard or mouse. So, via remote desktop it is possible to transfer data between a tablet and CNC. Advanced PC applications such as CAD/CAM or

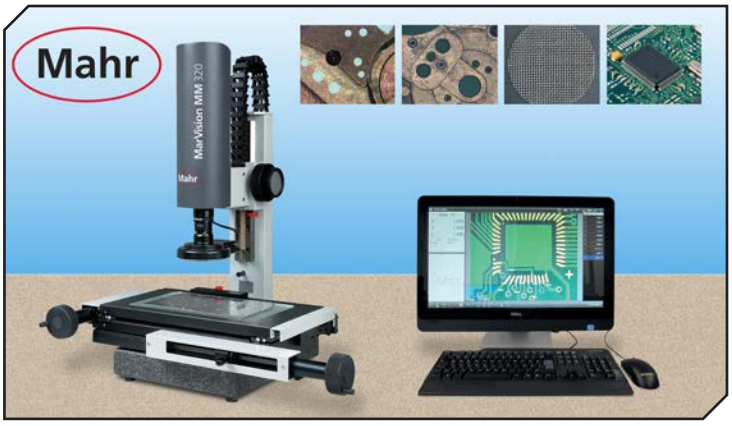
NCGuide are now available on the CNC remotely without leaving the machine. This improves functionality and use of the CNC. Other new features of Fanuc's new standard CNC platform include: enhanced 3-D graphics with Manual Guide i, new data server with larger storage and use of peripheral devices such as keyboard and mouse.

Fanuc's Digital Servo Adapter with new EtherCAT interface adds more power to applications needing high-speed and high-accuracy. The Digital Servo Adapter allows for Fanuc servo motors to be run from a separate controller over EtherCat. From 1 to 8 axes can be controlled, including a spindle interface and multiple large servo motors - up to 3 large servo motors at a time for industrial machines. The Digital Servo Adapter can replace hydraulic and other brand servo drives with high accuracy and high performance Fanuc servo motors. The EtherCat interface is ideal for industrial machines such as: servo press machines, wire saw machines and electric injection molding machines.

For more information:
Fanuc America
Phone: (888) 326-8287
www.fanucamerica.com

Mahr Federal

INTRODUCES MARVISION MM 320



Mahr Federal will feature the MarVision MM 320, a new video measuring microscope with image processing capability, the flagship product for a new line of Mahr optical measuring instruments, at Booth #E5242 during IMTS. Designed for the measurement and/or dimensioning of geometric elements, the MarVision MM 320 incorporates an integrated CCD color camera with zoom lens, a 23" touchscreen PC with keyboard and mouse, and easy to use Windows 7-based *M3* software. Automatic edge detection allows even low contrast features to be measured, and a Multi Touch function provides quick and continuous variable magnification using either touchscreen or mouse.

"MarVision optical measuring instruments offer a quick and reliable solution to many different 2-D measurement and inspection tasks," said George Schuetz, director precision gages for Mahr Federal. "Applications range from cutting tools and precision products for manufacturing, plastics, and medical technology, to miniaturized electronic components. These extremely precise measuring instruments are designed to meet the highest quality and production requirements."

The MarVision MM 320 rests on a robust hardened granite base with a precision mounted XY table. An optical incremental measuring system assures quick and fine adjustment of the axis, and a laser pointer assists with part positioning. The CCD camera and Navitar Zoom lens with 0.7-4.5× magnification are mounted on a stable Z-column with 200 mm vertical movement. Coarse and fine height adjustment knobs are mounted on both sides for precise focusing. Illumination is provided by a quadrant LED ring top light with four individually controlled segments, and table mounted Telecentric LED transmitted light for more focused measurement of rotationally symmetric parts.

For more information:
Mahr Federal Inc.
Phone: (401) 784-3100
www.mahr.com

TDM Systems

FOCUSES ON TOOL LIFECYCLE MANAGEMENT SOFTWARE

By realigning its strategy towards Tool Lifecycle Management, TDM Systems, a software manufacturer and process consultant, is putting comprehensive customer benefit first. TDM Systems is a leader in electronic management of tools and production equipment. The Schaumberg-based company will exhibit at IMTS 14 Booth No. E-3264, showing how the *TDM 4.7* software package for Tool Lifecycle Management makes life easier for machining companies. The package will also be presented in the Walter (W-1700) and Parlec (W-2300) Booths.

"By refocusing on Tool Lifecycle Management (TLM), we purposely put the overall process front and center," says Managing Director Peter Schneck. "We want to make sure that not only we, but especially our existing and future customers have a clear idea of the distinct advantages of TLM for the entire production process – from defining the tools to using them in planning to ensuring a seamless transfer to and use in production. In particular, a new feature is that the information from the individual process steps is fed back directly from production, ensuring continuous improvement of the data."

However, TDM Systems does not limit its view to the processes within a closed production unit. Global networking is and will remain one of the trends of the future: Machining industry 4.0. Not only companies with international production have to be networked to ensure transparent implementation of in-house production standards. Suppliers, partners and customers also have to build electronic bridges connecting each other.

So will there also be a Tool Lifecycle Management 4.0 in the future? "TDM Systems is currently developing cloud services so that information is available on the local level at all times on the Internet," says Managing Director Schneck. "Our highest priority, however, is on continuous further development of interfaces – such as those for connecting CAM systems and machine control systems – but on the planning and MES level as well. In this area, we are advocating for international standardization. That is the only way to implement Tool Lifecycle Management with maximum customer benefit."

For more information:
TDM Systems
Phone: (847) 605-1269
www.tdmsystems.com

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IMTS 2014: THIS IS BIG

Jack McGuinn, Senior Editor

Well, if it's 2014 it must be IMTS time. And what a time it should be, with manufacturing continuing to lead the economy — what new? — out of the morass that was the Great Recession. The 2012 show was a rousing success — even if not everyone saw it coming — and this year's edition should prove to be even better — the element of surprise notwithstanding. Social media will continue to play a big role, with many exhibitors promising to participate. Also top of mind this show are 3-D printing, additive manufacturing and automation — technologies much talked about but little understood by most. Hey — that's what IMTS is for!

Add on top of all this the co-located **Industrial Automation North America** and the **Motion, Drive & Automation North America** shows and — *whew!* — this is *really* big doings.

What follows is a bare-bones overview of the show, but it will get you where you need to go—and when. It includes some basic information of the gear you'll find spotlighted in each Hall (Pavilion). (*And don't miss our Q&A with show manager Peter Eelman on Page 22.*)

WHAT TO KNOW IF YOU GO

(*Editors' Note: The following information was correct and current as we went to press. But — things change — so you may wish to call ahead to confirm certain dates and times.*)

The Event

IMTS 2014 is the 30th Edition of the one-and-only, can't-be-missed manufacturing technology show in North America. At least 1,900 exhibiting companies will occupy 1,240,863 net-square-feet of the Lakefront exhibit space at the McCormick Place complex immediately south of Downtown Chicago. IMTS is held every even-numbered year in Chicago and attracts more than 100,000 buyers and sellers from over 112 countries.

IMTS PAVILIONS

To save time and laser in on what you're *really* at the show for, the Pavilions within each Hall serve that purpose perfectly. The Pavilions are where the klieg lights shine brightest, as the booths of the leaders — big and small — of each Hall's designated discipline(s) — are concentrated for easy access. Think of the Pavilions as a trade show version of a Lean peg board writ large, i.e. — Every (Exhibitor) in his proper place.

BUILDING

North: Abrasive Machining/ Sawing/Finishing; Gear Generation; Fabricating/Laser/ Additive

East: Controls and Cad-Cam; Machine Components/Cleaning/ Environmental; EDM

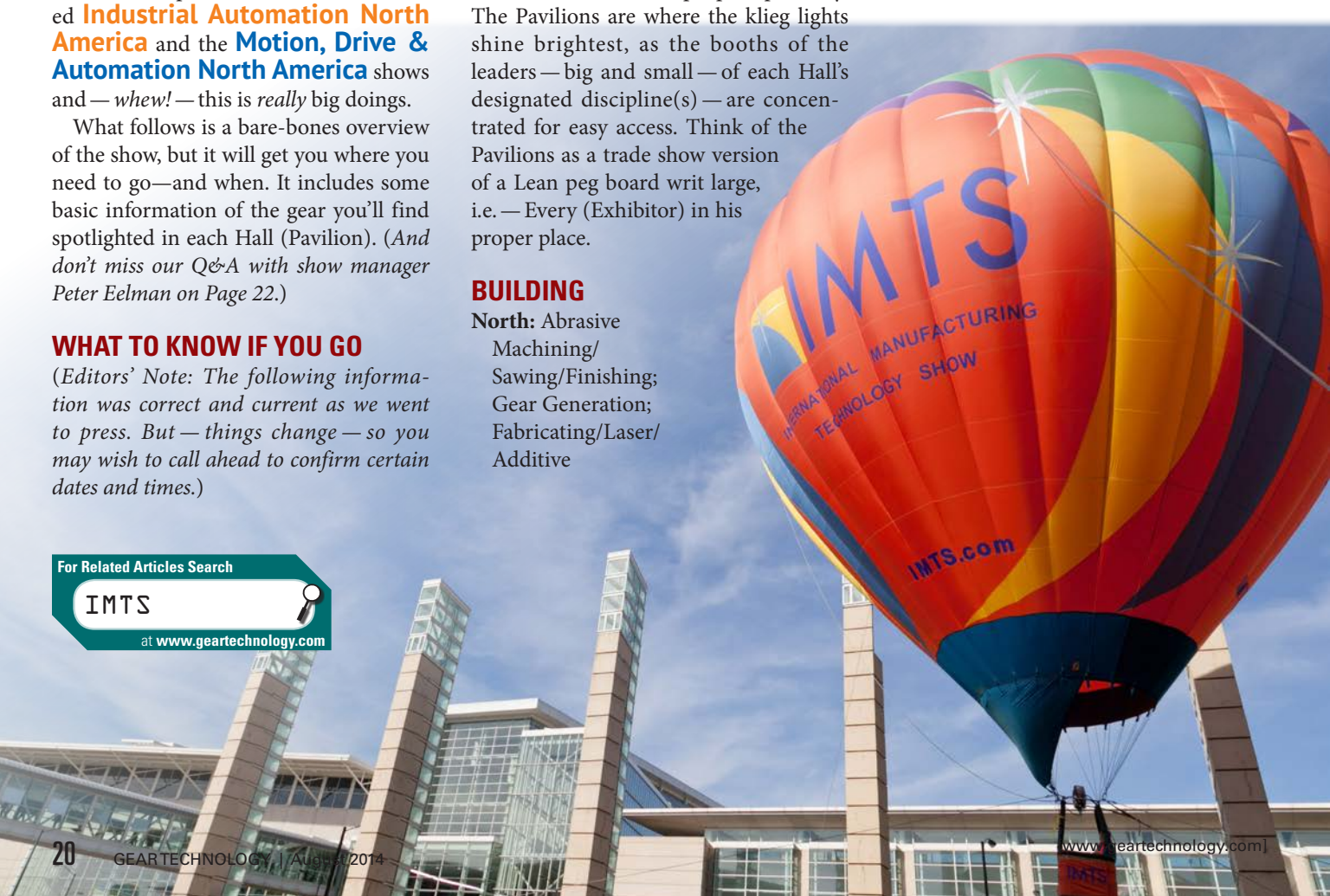
South: Metal Cutting

East: Quality Assurance

West: Tooling and Workholding

Industrial Automation North America at IMTS

Industrial Automation North America brings the international flare and dynamic excitement of Hannover Messe's Process, Factory and Building Automation sector to IMTS, the most comprehensive manufacturing technology trade show in the Western Hemisphere.



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Fact Sheet

Name of Show: IMTS 2014 — International Manufacturing Technology Show

Sponsor: AMT—Association for Manufacturing Technology

Venue: McCormick Place, Chicago, IL U.S.

Show Dates: September 8 (Mon.) – 13 (Sat.), 2014

Attendee Hours

East & West Buildings: 9:00 a.m. – 5:00 p.m.

North & South Buildings: 10:00 a.m. – 6:00 p.m.

Registration. **On-site** registration **only** is available **Monday, Sept. 8** through **Saturday, Sept. 13, 8:00 a.m. – 5:00 p.m.**, in all four buildings of McCormick Place.

Motion, Drive & Automation North America at IMTS

In 2014, Motion Drive, & Automation North America (MDA NA) will be launched at IMTS. This event will feature technologies and solutions for the power transmission, motion control and fluid technology sectors together.

Logistics:

Hotel Shuttle. Complimentary shuttle bus service will be provided during show days to and from the official show hotels and McCormick South, West and East Buildings.

Coat and Bag Check. At the following locations from 9:00 am - 6:00 pm: S100bc, E256, and West - by Gate 40 near info counter. $3 per coat; $4 per bag; the service will not accept laptops.

Renting Scooters/Wheelchairs. On-site location in the Baggage/Coat Check area, near Gate 4 of the Grand Concourse, on the Main Level, you can rent mobility scooters, wheelchairs and oxygen equipment during IMTS. You are encouraged to reserve in advance. To reserve your equipment call toll free 1-888-441-7575, or go to *www.scootaround.com/rentals/i/imts.*

IMTS 2014

Pre-Show Q&A with Peter Eelman, Vice President—Exhibitions and Communications—Association for Manufacturing Technology

Gear Technology (GT): It appeared that the robust attendance at 2012's show almost took some people by surprise; indeed, the 2012 registration reached 100,200—the highest show-to-show IMTS increase ever recorded. Can you comment a bit on the reason for the big numbers of 2012, as well as on what kind of attendance you expect this year?

Peter Eelman (PE): At IMTS 2012 we saw a number of factors converge, resulting in extremely strong attendance. Coming out of the recession, manufacturers were very cautious about equipment investments. By IMTS 2012 we saw pent up demand for new technology and automation to stay competitive. There was a rebound from restricted travel and buying teams were larger. In addition, we changed our marketing strategy, targeting higher-level executives who make the decision to send staff and told them they needed to "Be There" to stay competitive.

Based on early indicators, for 2014 we expect equally strong attendance. As visitors walk in the doors of IMTS 2014, they will know for certain that manufacturing isn't just back—it's growing and thriving.

Our industry is bringing forth innovation at a pace never seen before. We expect automation and additive manufacturing to be areas of major interest to our visitors this year. Automation and additive manufacturing are two technologies making a big impact in manufacturing.

Manufacturers large and small are investing in factory automation, while the possibilities of additive manufacturing, such as 3-D printing, has piqued the imagination of the maker movement and sparked a new wave of innovation and entrepreneurship.

Additionally, automation technology is seeing a huge demand surge from manufacturers of all varieties. Automation has become more reliable and affordable than ever before and is allowing for more flexible and adaptive operations. Worldwide sales of industrial robots reached an all-time high in 2013, according to the International Federation of Robotics. Robots are becoming more collaborative, able to work side by side with human workers. While those robots can focus on the more mundane and repetitive shop floor tasks, the skilled human workers are able to focus on more critical setup, programming, data analysis, and quality improvement tasks.

GT: I'm sure it gets bigger every two years, but how pervasive do you believe social media will be in this year's IMTS — for both exhibitors and attendees?

PE: The IMTS community is very connected through social media. We are active everywhere and based on what we know now, we expect more than half of IMTS exhibitors are using social media to reach the community. During the show Social Media Central will have a presence in each hall. Our Twitter feed will be displayed throughout the halls.

As part of our social media outreach, we are holding the "IMTS: Everywhere You Look" Photo Contest. We're inviting visitors and exhibitors to join in the challenge and spell out I-M-T-S using manufacturing technology, like a 3-D printer, or use their staff, their product, even their lunch if they want! Share the photo on Twitter, Facebook or Instagram and use the #IMTS hashtag to be considered. This contest is open to visitors and exhibitors. The visitor winner will receive a $100 gift card and be featured on the IMTS social media channels. The contest will run until Sept. 7 and the winner will be announced at IMTS 2014 in Chicago.

The exhibiting company with the most creative design will be featured on the homepage of *IMTS.com* and receive a $100 gift card. The contest will run until Sept. 2, and the winner will be announced on Sept. 4. The photograph and company information will be displayed on the homepage on *IMTS.com* from Sept. 4-15.

GT: Taken together — in one central location — you will have the International Manufacturing Technology Show (IMTS) co-located with the Industrial Automation North America show and the Motion, Drive & Automation North America show. Is there anything bigger that takes place in the States?

PE: IMTS is the largest industrial trade show, not only in the U.S., but in the Western Hemisphere. We fill more than 1.2 million net square feet of exhibit space and host more than 1,900 exhibiting companies. Only the Consumer Electronics Show is larger.

GT: How excited should we be about 3-D printing and additive manufacturing?

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IMTS
at www.geartechnology.com

Additive manufacturing and 3-D printing began creating major buzz at IMTS 2012 and continues to be on the tips of everyone's tongue — and for good reason! The technologies continue to gain popular interest, but that is not the most exciting part. The increases in industrial acceptance and continued improvements in the industrial base providing additive parts and services are now the real story line. America Makes is providing a bridge from applied research to the paths for industrial transition, ultimately developing additive manufacturing capabilities into business opportunities.

In fact, additive manufacturing promised to be number one on the "wow" factor list in AMT's Emerging Technology Center. We will see the complete construction of an electric car by IMTS partner Local Motors. Local Motors will build and deliver the first direct-digital-manufactured vehicle at IMTS 2014.

Designed by Local Motors and the IMTS global community, and built using the material science and advanced manufacturing techniques available at the Manufacturing Demonstration Facility (MDF) at Oak Ridge National Laboratory (ORNL), Local Motors will produce an electric vehicle purpose-built for the urban transportation needs of Chicago.

The team starts from scratch employing direct digital manufacturing techniques and technology integration to make the parts and assemble the vehicle. This is a real-world demonstration of achieving sustainable manufacturing by using emerging technologies — such as additive manufacturing — all integrated in a digital environment.

Local Motors recently announced the winners of the first 3-D-Printed Car Design Challenge that was launched in April to uncover concepts that will inform and influence the vehicle. More than 200 entries, representing submissions from 30-plus countries around the globe, were submitted during the six-week challenge. After a weeklong voting period and review of all entries by an independent panel of expert judges, a total of seven designs were selected as winning concepts.

The winning concept — Strati, created by Michele Anoé of Italy — will highly inspire the full-size 3-D printed prototype.

As Lonnie Love, group leader, robotics and manufacturing systems research at Oak Ridge National Laboratory, said, "Michele's design offers an excellent balance between innovation, complexity and practicality. It has good 3-D lines and the retractable roof is really cool."

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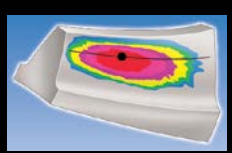

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IMTS 2014

The following exhibitors are suppliers of products or services that may be of interest to gear manufacturers who visit IMTS 2014. The Booth numbers include a letter indicating the building location (N=North, S=South, E=East, W=West, C=North Building, Hall C). **Bold listings indicate advertisers in this issue.**

Alphabetical Company Listings COMPANY	BOOTH
3M Abrasive Systems Division	**N-7063**
Absolute Machine Tools, Inc.	E-5225, S-8536
Acme Manufacturing Company	N-7255
Action SuperAbrasive Products	N-7217
Advent Tool & Manufacturing, Inc.	N-6799
Alpha Magnetic Workholding	N-7030
American Broach & Machine Company	N-7027
Anca Inc.	N-7414
Andantex USA Inc.	E-5146
Asahi Diamond America, Inc.	N-7066
Atlanta Drive Systems, Inc.	N-6046
Avantec Zerspantechnik GmbH	W-211
Baldor Electric Company	E-5748
Barnes Bore Honing & Finishing Systems	N-7451
Bates Technologies, LLC	N-7451
Blum-Novotest, Inc.	E-5535
Bohle Machine Tools, Inc.	S-8966
Bourn & Koch Inc.	N-6924
Broaching Machine Specialties Co.	N-7229
Broach Masters/Universal Gear	**N-7112**
Ceratizit USA, Inc.	W-2446
Chevin Tools, Inc.	W-2093
Chongqing Juya Machine Tools Co., Ltd.	N-6681
C.L.C., S.r.l.	N-6918
Command Tooling Systems LLC	W-1446
Comtorgage Corporation	**E-5814**
DMG Mori	**C-813, S-8900**
Dontyne Gears Ltd.	N-6778
Drake Manufacturing Services Co.	N-6948
Dr. Kaiser	N-7240
DTR Corporation	**N-6557**
Dura-Bar	W-1272
DVS Group - Diskus Werke AG	N-6770
Elumatec North America	N-7024
EMAG L.L.C.	N-6846
Emuge Corp.	W-1536
Engis Corporation	N-6751
Erasteel, Inc.	N-6382
Euro-Tech Corporation	**W-2453**
Federal Broach & Machine Company, LLC	N-7046
Felsomat USA, Inc.	N-7040
FFG Werke GmbH	N-6924
Fives	N-7018
Fives Cincinnati - Metal Cutting | Composites	N-7018
Fowler High Precision	E-5236
Frenco GmbH	**W-2453**
Fromag	N-7220
Fuji Machine America Corporation	S-9059
Gear Technology	**N-7214**
Gehring	N-6740
German Machine Tools of America	**N-6670**
Gleason Corporation	**N-7000**
Gleason Cutting Tools Corporation	**N-7000**
Gleason K2 Plastics	**N-7000**

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Gould & Eberhardt Gear Machinery	N-7030
Guyson Corporation of U.S.A.	N-6066
Hainbuch America Corporation	**W-2413**
Hammond Roto-Finish Co.	N-6759
Hangsterfer's Laboratories, Incorporated	N-7526
Harbin Tool Works	W-122
Hassay Savage / Magafor / GMauvaisUSA	W-2356
Helios Gear Products	N-6918
Hessapp	N-6924
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Höfler div. of Klingelnberg	**N-6837**
Honsberg	N-6924
Horn USA, Inc.	W-1722
Index Corporation	S-8136
Ingersoll Cutting Tools	**W-1822**
Itaca, SRL	E-5602
Erwin Junker Machinery, Inc.	N-7057
Kapp Technologies, LP	**N-7036**
Kasto, Inc.	N-6737
Kennametal Extrude Hone	W-1522
Kennametal Inc.	W-1522
Kitagawa-NorthTech Inc.	W-2412
Klingelhofer Corporation	N-6737
Klingelnberg	**N-6837**
Koepfer America, LLC	N-6918
Lambert + Wahli, AG	N-6918
Lapmaster International, LLC	N-7451
Leistritz Advanced Technologies Corp.	**N-6746**
Liebherr Gear Technology, Inc.	**N-6930**
LMT USA, Inc. and LMT Onsrud LP	W-1732
LMC Workholding	W-1314
Luren Precision	**N-7074**
MAG Huller Hille	N-6924
MAG Witzig & Frank	N-6924
Mahr Federal Inc.	E-5242
Maier Machine Tools, LLC	S-8980
Marposs Corporation	E-5519, N-7433
Mazak Corporation	S-8300, C-858
MD Tooling, LLC	W-1579
Micro-Vu Corporation	E-5501
Miller Broach Inc.	N-6197
Mitsubishi Heavy Industries America, Inc.- MI	**N-7046**
Mitsubishi Materials Corporation	**W-1426**
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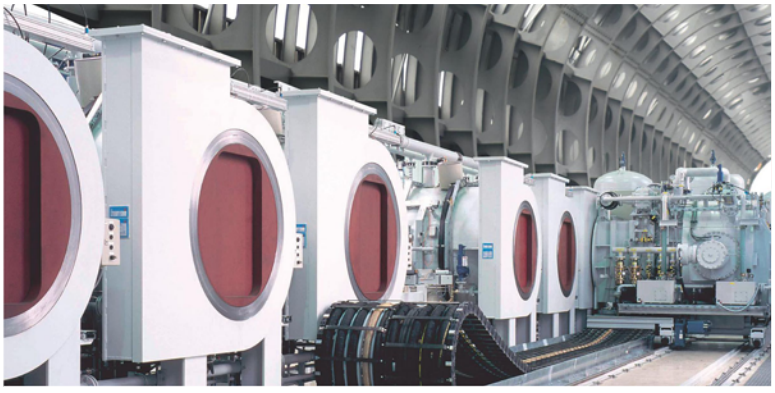
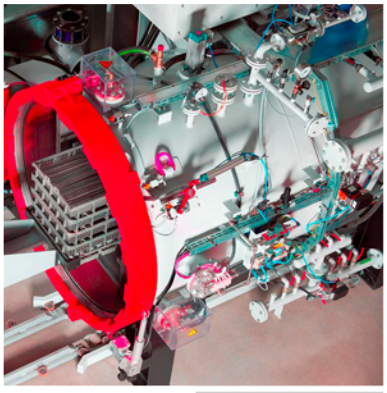

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Osborn International	N-7523
Performance Tooling Solutions Int'l	W-2115
Polygon Solutions Inc.	W-1954
Power Transmission Engineering	**N-7214**
Pratt & Whitney Measurement Systems Inc.	N-7094
Promess, Inc.	E-5382, N-6640
PWS Praezisionswerkzeuge GmbH	N-7344
Qanzhou JianYue Diamond Wheel Co., Ltd.	W-1091, W-2083, N-6681
QC American LLC	N-7027
Radiac Abrasives, A Tyrolit Company	**N-7440**
Redex-Andantex	E-5146
Reishauer Corp.	N-7040
Richard Daley College - Advanced Manufacturing Program	C-822
Riten Industries, Inc.	W-1336
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Samp S.p.A.	N-6924
Sandvik Coromant	**W-1500, C-895**
Schiess GmbH	S-8148
Schneeberger J. Corporation	N-6938
Schunk, Inc.	W-2000
Seco Tools, LLC	**W-1564, C-884**
Setco	N-6534
SHL Automation	N-7263
Siemens Industry Inc.	E-5010
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Redex-Andantex	E-5146
SKF USA Inc.	E-5185
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Absolute Machine Tools, Inc.	E-5225
Fowler High Precision	E-5236
Mahr Federal Inc.	E-5242
Promess, Inc.	E-5382
Micro-Vu Corporation	E-5501
Zeiss Industrial Metrology	E-5504
Marposs Corporation	E-5519
Blum-Novotest, Inc.	E-5535
Itaca, SRL	E-5602
Wenzel America, Ltd.	E-5698
Baldor Electric Company	E-5748
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Zhangjiagang Ruizheng Tool Co., Ltd.	N-6681
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Klingelhofer Corporation	N-6737
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DVS Group - Diskus Werke AG	N-6770
Dontyne Gears Ltd.	N-6778
Advent Tool & Manufacturing, Inc.	N-6799
Studer	N-6800
United Grinding North America, Inc.	N-6800
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Klingelnberg	**N-6837**
EMAG L.L.C.	N-6846
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Star SU LLC / Star Cutter Company	**W-2258**
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IMTS 2014 PRODUCT PREVIEW

KLINGELNBERG

Booth N-6837

Klingelnberg will once again be exhibiting its grinding machines for bevel gears and cylindrical gears and its precision measuring technology at IMTS. Visitors to the event will be able to see four machines in action including:

Viper 500

The adaptable Höfler Viper 500 gear grinding machine is designed for component diameters of up to 500 mm, and is suited for both the smallest and the largest lot sizes. It is available in three different configurations, depending on your individual requirements: Profile grinding (Viper 500), small grinding wheels and multiple-wheel technology (Viper 500 K), and generation grinding (Viper 500 W). Users with frequent product changes in particular will find that the flexible machine concept provides an even more dynamic and efficient production process.

P-40

Klingelnberg will also be introducing the latest P-40 at the exhibition. Due to their comprehensive range of functions, the P series machines replace up to four conventional measuring devices. With its basic mechanical accuracy and a modern compensation strategy, the P-40 is a machine with long-term stability that is capable of performing high-speed

measurements in the highest accuracy class, directly on the shop floor. Features include an ergonomic operator panel, a vibration isolation function and an air-conditioned control unit.

G-60

The CNC-controlled Oerlikon G 60 bevel gear grinding machine from the G model series provides grinding performance combined with high-precision final machining of the curved-toothed bevel gears of any gearing system, including the teeth of face-type clutches. The G 60 operates up to a ring gear diameter of 600 mm. All G series spiral bevel gear grinding machines have a vertical grinding spindle, which ensures that the swarf drops directly downward. A special feature is that all drive units are above the grinding area, meaning that they are kept free of swarf deposits. The entire inner paneling is made of stainless steel – providing a clean and tough working area. All of the necessary additional components are integrated in the closed machine paneling. These are accessed through special maintenance doors. The adjusting work that is needed during re-tooling is assisted by convenient auxiliary functions like a standard semi-automatic grinding wheel changer, for example.

Helix 400

The Höfler Helix 400 gear grinding machine is a profile grinding machine for components with a diameter of up to 400 mm. Its well-engineered mechanical system makes it a reliable partner for sophisticated manufacturing. Apart from this, the innovative control and software functions make it suitable for customized profile and tooth trace modifications in special series production. The proprietary *GearPro* software guarantees ease of use, even for complex applications.

For more information:
Klingelnberg America, Inc.
Phone: (734) 470-6278
www.klingelnberg.com

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IMTS 2014 BOOTH # N-7046

STAR SU LLC

Booth N-6924

Star SU LLC will showcase the latest in linear motor technology offered by Star at IMTS 2014 in September. Engineered to manufacture complex cutting tools, the new Star NTG-4L tool and cutter grinder is a five axis, CNC controlled cutter grinder for manufacturing, sharpening and reconditioning a wide variety of cutting tools. The machine features include a mineral cast base for increased damping and thermal stability performance. All three axes are driven by linear motor technology, which eliminates almost all elasticity, backlash, friction effects, and drive chain vibration typically found in ball screw and belt driven designs. Both of the NTG rotary axes are have integrated torque motors for high and precise torques at optimal speeds. The machine is suitable for high mix, low volume jobs due to its quick setup and stability. For the high volume manufacturer, an optional robust automation package utilizes a Fanuc LR Mate robot allowing for an increase in productivity without sacrificing quality.

The G 250 from Samputensili will also be featured at IMTS. The G 250 is a generating and profile grinding machine, designed for cylindrical gears with a maximum outside diameter of 250 mm and shafts with lengths up to 550 mm. The machine is based on the dual work spindle concept, which eliminates non-productive times almost completely. By means of this feature, the loading/unloading process of a workpiece is carried out in masked time, while simultaneously the manufacturing process proceeds on another workpiece. Unlike other applications, the gear meshing is

conveniently carried out directly in the grinding position for better accuracy purposes and minimum changeover time. Indeed, only in this position the meshing can be achieved with micron-level accuracy. Therefore the G 250 represents a suitable solution for those customers who need very low cycle times and efficient mass production of gears. In the G 250 the minimum axis distance between worktable and grinding wheel is only 40 mm, and its grinding spindle can achieve 12.000 rpm. Due to the combination of these two unique features, the grinding process is also possible using profile/threaded grinding wheels with very small outside diameter, mounted on the main spindle. Workpieces with tool diameter limitations, for example shoulder-type gears, can be ground without

any additional devices. Similarly, double and triple pinions with very small distances can be ground with the proper tooth-to-tooth alignment. An add-on optional spindle multiplier up to 24.000 rpm, with quick connection system to the main spindle, allows the use of electroplated CBN profile grinding wheels with outside diameter down to 25 mm. The grinding spindle with its specifically large tool capacity allows the use of long grinding worms to raise the tool life of single or combination worms of roughing and finishing tools employing electroplated CBN or ceramic bound grinding worms and wheels. Therefore customers can always rely on the most efficient technology or the most beneficial combination to complete their grinding task.

For more information:
Star SU LLC
Phone: (847) 649-1450
www.star-su.com

GLEASON
Booth N-7000

Gleason will demonstrate advanced machines, tooling, and global customer support services at IMTS 2014, covering a wide array of processes for the complete production and inspection of all types of bevel and cylindrical gears. Visitors to Gleason Booth #N-7000 will be introduced to these products and technologies. Among the technologies exhibited at the show will be:

Genesis 200GX Threaded Wheel Grinding Machine: The 200GX is a new addition to the highly popular Genesis series. The two spindle concept combines maximum productivity with minimized idle and set up times. Fast, easy software-guided setup of the machine allows you to set up your machine from one workpiece to another in just 20 minutes using only one tool. "First Part Cycle" - fully automatic workflow after setup until grinding the first workpieces and the ability to interface with Gleason GMS machines via QR codes increase productivity. Easily accessible machine components make maintenance simple and efficient while standard dimension grinding wheels and dressing tools allow you to use your existing tools. All of this in an energy efficient small footprint machine designed to meet the needs of customers in high-productivity high-quality environments.

300PS Power Skiving Machine: The 300PS combines unique machine, cutting tool, workholding and power skiving process expertise to offer users significant performance improvements, particularly in operations where shaping, forming, pressing and broaching are typically used. As compared to shaping, for example, the 300PS can deliver productivity rates as much as eight times higher. The modular tool-less workholding is designed for fast installation and changeover to handle the highest process forces, with superior internal chip evacuation. Power Skiving Technology Software enables users to easily simulate the entire cutting process and plan the most effective process strategy. Users can analyze the influence of different cutting tool geometries and process parameters. The Technology Software allows you to decide if a given part can be safely and economically power skived or whether it would be better shaped, making Power Skiving as simple and familiar as shaping.

Phoenix 280G: This machine has no rails, wires, or pipes in the work chamber to collect swarf, keeping the chamber clean for low preventive maintenance. In addition, the 280G offers rapid set-up and all major set-up items can be completed without tools (tool-less), including the grinding wheel, coolant header and workholding. The coolant header has small blocks that can easily be exchanged by hand, while the grinding wheel can be released hydraulically. The 280G's automatic stock divider, mounted in close proximity to the workspindle, helps ensure consistently high gear quality. The unit automatically determines the tooth slot position of the pre-finished gear to provide accurate and reliable stock division, helping eliminate operator errors.

300GMS Analytical Gear Inspection Machine: The 300GMS was developed specifically to meet the needs of automotive transmission gear producers for a faster, more economical solution for complete gear and even non-gear parts inspection. It is the first GMS to feature the new Windows 7-based Gleason *GAMA 3.0* applications software suite which, like its *GAMA 2.0* predecessor, offers users a highly intuitive user interface and simple input screens for programming of workpiece and cutting tool data. The 300GMS is equipped with new ergonomically mounted operator workstations and a Gleason Diagnostic Module – both designed to greatly

improve the operator's effectiveness at every stage of the inspection process.

The Gleason Diagnostic Module puts a number of powerful tools right at the operator's fingertips, including an environmental monitoring station to record temperature and humidity, and video telephony, note pad and voice mail messaging capability, enabling the user to capture video, describe a particular programming issue and transmit it over the web to others in the customer's organization or to Gleason for support.

Additionally, the company will feature its gear cutting (Pentac Plus RT) and workholding solutions (Quik-Flex Plus) and attendees can learn about Gleason's new line of hydraulic workholding as well as its diverse range of global services.

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

KAPP NILES
Booth N-7036

Two new Kapp Niles gear grinders and the latest portable gear inspection system from R&P Metrology GmbH will be introduced at Booth N-7036. The ZP 12 marries the best of the ZE and ZP series machines to offer a compact yet highly productive solution at a great value. The KX 260 Twin has extended the application range of the Twin series to include long shafts typical of truck transmissions. R&P's RPG PM 750/1250 is the first portable gear checker/CMM with dual functionality for use in the lab or on the production floor.

The new Kapp Niles ZP 12 provides the range to grind any gear diameter up to 1,250 mm with a fully dressed grinding wheel. The direct drive tool spindle has increased power, and the dual dressers shorten dressing time. Hob cutters and worms can now be ground and measured on this machine. The intuitive software is enhanced to speed the setup and optimize stock removal.

The new Kapp Niles KX 260 Twin is built on a shared modular platform with 500 mm axial travel. The machine includes two identical workpiece spindles, arranged at opposite sides of an indexing table for absolute shortest cycle times. A special feature of this machine is the process flexibility for profile and

generating grinding two gears on one shaft, in one cycle. Dressable or CBN plated wheels can profile grind up to module 10 (2.5 NDP) gears. Dressable worms grind gears up to 5 module. Kapp CBN plated worms are utilized for gears with constraints for normal grinding.

R&P Metrology's RPG PM 750/1250 is a flexible solution for measuring larger gears on production machines that may not have on-board inspection. The design makes it moveable within the plant. The optional "docking station" with granite base and rotary table allows the PM 750/1250 to become a standalone, fully featured four axis generative gear inspection machine when not required for portable measurement.

For more information:
Kapp Technologies
Phone: (303) 447-1130
www.kapp-usa.com

EMAG
Booth N-6846

At IMTS 2014, EMAG will feature manufacturing systems for precision metal components with multiple machines from its new modular standard VL and VT product families on display. These modular standard machines offer a systematic approach that is advantageous to establishing a highly efficient manufacturing process, with different operations offered on the same platform, allowing for easy interlinking and eliminating any great capital investment for automation.

The VL vertical pick-up lathe series opens up new opportunities for the machining of a wide range of chucked components. Small gearwheels, planetary gears, sun gears, sliding sleeves, synchronizer rings or flanged components, for example, can be machined with great efficiency. The smallest lathe of the VL product family, the VL 2, machines workpieces with a maximum diameter of four inches and a length up to six inches. Increasing in size, the VL 4, VL 6 and VL 8 offer a number of different turning and milling operations within the framework of a single closed-loop pro-

duction process. Specially designed for the handling of large components, the largest vertical turning machine of the series, the VL 8, is suitable for commercial vehicle production, handles workpieces up to 16 inches in diameter and 12 inches in length.

Built within the same modular concept is the VT-Series for machining large quantities of shaft components. With four axes, a self-loading turret and integrated automation, the VT 2-4 machines shafts with a max diameter of 2.5 inches and 16 inches in length. Spindle speeds of up to 6,000 rpm achieve extremely short cycle times as the shaft is clamped vertically between workspindle and tailstock and machined from two sides. The vertical alignment of the workpiece ensures process integrity, where the unhindered chip flow prevents the build-up of chip nests in the machining area.

Integrating the technologies of the EMAG Group into these new modular standards, the VLC 200 H will make its North American debut at IMTS 2014. The VLC 200 H hobbing machine integrates EMAG-Koepfer technology into the EMAG vertical platform, including the pick-up design, where the main spindle removes the raw part from the conveyor belt, transfers it to the tailstock flange and removes it from the machining area after the completion of the hobbing cycle. Gears with a maximum diameter of 8 inches and module 4 can be dry-milled at greatly shortened cycle times.

EMAG will also present its entire portfolio of production technologies, from turning, hobbing and grinding to those that complement traditional metalworking processes, such as its production laser welding, heat shrink technology and electro-chemical machining (ECM) capabilities. ECM processes offer non-contact machining with no heat affected zone or mechanical stress to components with no tool wear. An ECM machined blisk will also be on display.

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

FELSOMAT
Booth N-7040

Felsomat Corporation will feature the latest gear honing technology at Booth N-7040. With the introduction of the Felsomat Power Speed Honing (Model FPSH) machine, they continue to redefine gear manufacturing technology. The FPSH 180 is specifically designed to be part of the Felsomat Flexline concept. The FPSH represents the highest performance and process stability achieved in the field of gear honing. The FPSH begins with the hobbing process performed by the FHC 180 hobbing machine. Next the integration of

the ALD SyncroTherm inline heat treatment process ensures reduced thermal distortion of the gears. This means that less stock needs to be removed from the gear flanks resulting in shorter gear honing cycle times. The FPSH can hone gears up to 160 mm diameter and module 0.5 – 4.0 mm. Stock removal between 40–80 microns on each flank is possible depending on the heat treatment deviation, and grinding burn is not a possibility due to the low cutting speed. In addition to the FPSH, Felsomat's Flexline integrates the entire gear manufacturing process into one uninterrupted chain and is comprised of the following machine/processes: Felsomat Turning Cell FTC 180, Flex Hobbing Center FHC 180, Flexline Integrated Heat Treatment and the Laser Welding Cell FLW 180.

For more information:
Felsomat Corporation
Phone: (847) 995-1086
www.felsomat.de

REISHAUER CORPORATION

Booth N-7040

The RZ260 features Reishauer's unique continuous generating gear grinding and is based on the RZ150 series. The RZ260 has not only been increased in size, all relevant components have been adapted to handle higher loads and forces that 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. An important focus in the design of the machine concept was adaptability to the different production requirements of numerous customers. The machine can be fitted with one or two work spindles. The version with two work spindles is used to minimize the loading times – as introduced with the Reishauer RZ150. When investment and tooling costs must be minimized and/or the workpiece handling times are not critical, the RZ260 with a single work spindle might be a more suitable choice. When grinding gears with space limitations or small lot sizes, it might be advantageous to use the changeable profile grinding spindle enabling the use of a small plated or dressable wheel to grind gears using the discontinuous profile method. Both versions of the RZ260 can be equipped with a fixed or CNC-controlled axis for swiveling the dressing tool. With this option, the flexibility of the dressing tools can be increased since

the same tool can be used for a range of gears as compared to the fixed dresser where the tools are normally workpiece specific.

Also on display will be polish grinding on a beveloid gear used in a marine transmission. The grinding wheel has two different sectors and compositions; one area is used to grind and remove the heat treat distortion, and the other area is used to polish the tooth surface. This process achieves a surface finish of .07 micron. In addition to the improved surface, the polish ground process rounds out the edges at the transition of the workpiece flank and face. The topography of the flanks remains unchanged.

Like all Reishauer gear grinding machines, the RZ260 has been developed for the high demands of the continuous generating gear grinding process, also known as the Reishauer style. All design characteristics that lead to the success of other Reishauer machines have been incorporated in the RZ260. This includes the Reishauer Generating Module for highest gear quality, Reishauer LNS Low Noise Shifting technology for very low gear noise emissions, Polish Grinding for surface roughness reduction, Reishauer Twist Control Grinding technology to create defined values for flank twist and the Reishauer HMI for fast change over and set-up times.

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

LIEBHERR GEAR TECHNOLOGY, INC.

Booth N-6930

With a one-table design and a new-design grinding head, the new Liebherr LGG 180 and LGG 280 machines greatly reduce grinding times for twist-free profile and generating grinding. The LGG180 will be demonstrated by Liebherr at IMTS 2014. The machines are designed to deliver consistent high large-scale production quality in automotive applications, including conical gearing. According to a Liebherr spokesman, "With this series of space-saving machines, vehicle manufacturers can 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 up to 500 mm.

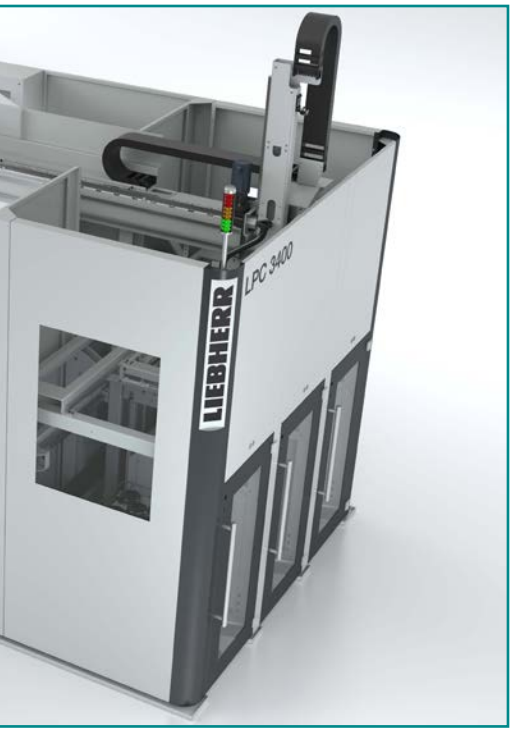
The advantage to the one-table solution is higher quality throughout the entire production. There is one clamping fixture, one geometry. Every machined part is manufactured under the same

conditions for the highest reproducibility. The one-table approach provides the statistical capability and reliability in continuously producing controlled µ-range finish quality for gear noise optimization. The new grinding head allows for rotation speeds up to 10,000 rpm and has spindle power of 35 kW. With this performance data, the head enables high cutting speeds and high feed rates. The new grinding machine can exploit the considerable potential of the innovative 3M abrasive Cubitron II. Changing the grinding arbor with HSK-C 100 tool holder is a fast and simple process. Also available is a second grinding head for featuring a small worm diameter for collision-critical parts.

The machine will enable undulations to be applied specifically to gear wheel flanks for noise optimization purposes for the first time. The ability to produce sub-µ range waviness cost-effectively gives designers a whole new range of optimization options. The touch screen user interface on the machine control permits easier, intuitive programming and machine operation and incorporates an integrated webcam. The control also can incorporate substantial additional documentation, such as fixture layouts and tool mounting instructions. The LGG machines are easily coupled with Liebherr automation solutions to create a fully automated production line for the highest quality gears in the least possible cycle times.

Additionally, Liebherr Automation will demonstrate a smart part handling solution that can remove randomly placed items from a container and place them accurately in a machine or production line, utilizing 3-D image recognition system software, a robot, and a sophisticated handling strategy. This intelligent removal of items, such as the automated picking of unsorted components, is referred to as random bin-picking. Specially developed grippers with additional axes enable collision-free access and the removal of items from the container, and subsequently allows for precise positioning of the item into a fixture or pallet.

The Liebherr custom bin-picking solution, designed for components weighing between 1 and 50 kilograms, deliver the potential for productivity and efficiency increases in a range of parts producing industries, including automotive, aerospace, general machining, and commercial vehicles. The company has developed process-reliable solutions that



achieve the cycle times and high availability rates manufacturers require.

The advantages of this scalable automation process include increased productivity, improved machine utilization rates, reduction of the need for additional machines to achieve desired plant production volumes, and more consistent production quality.

Liebherr has created complete systems for, among other sectors, for the automotive industry. This includes the efficient channeling of non-rotationally symmetrical components which arrive randomly in a bin and can be placed into production lines and hardening ovens. The beginning of a production line is the key point where picking from the bin is necessary.

An important breakthrough occurred with the object recognition system. The 3-D laser scanner precisely recognizes the components for picking. Outside light of any type in the production building has zero effect on the ability to pick a part. It will even recognize black, brown and rusty parts. The accompanying software segments identify and select information about items and constraints in the bin provided.

For more information:
Liebherr Gear Technology
Phone: (734) 429-7225
www.liebherr-us.com

MARPOSS CORP.

Booth E-5519

Marposs Corp. will introduce its new G25 gauging probe for contact scanning for pre- and post-process cycles on gear grinders and machining centers. Although the G25 device resembles a touch probe, it is actually a gauge with the ability to do both part surface scanning and perform touch functions for part positioning and measurement. The compact G25 device was developed to

gauge parts while still fixtured in the machine in case reworking is required. When used for gear grinding, the G25 gauge identifies the part location and tooth spacing for purposes of aligning the part with the grinding wheel prior to grinding. The same device is then used to scan the profile of the finished part in a continuous cycle. The new G25 gauging probe has excellent measurement stability at high speeds, enabling a significant reduction in inspection time compared to using a touch probe. Other applications to which the new G25 gauge is suited include grinding of non-round parts where the user needs to check certain characteristics of the part after it is ground, or for verifying that a face of the part is in the correct orientation. The G25 probe is available with either analog or digital output depending upon the user's requirements.

For more information:
Marposs Corporation
Phone: (248) 370-0404
www.marposs.com

ZOLLER
Booth W-2022

Zoller offers presetting, measuring, inspecting and managing of simple to complex tools for quality assurance, inspection of goods or extensive tool management tasks. "Not only measuring solutions, but also the use of cutting tools. The key to efficient tool usage and optimized tool life along with an economic manufacturing process leads to a professional tool management system. The still unknown and unused potential for cost savings in this area is enormous in many businesses," explains president and owner Alexander Zoller.

The well-established Bronze, Silver and Gold TMS Tool Management Solutions packages offer new functionalities such as a regrinding for the coordination of grinding cycles and incoming goods inspection. Experience the future of modern tool data management live at the booth: Tools can be downloaded from the Tooldata-Cloud, provided by major tool manufacturing companies and master tool data pools.

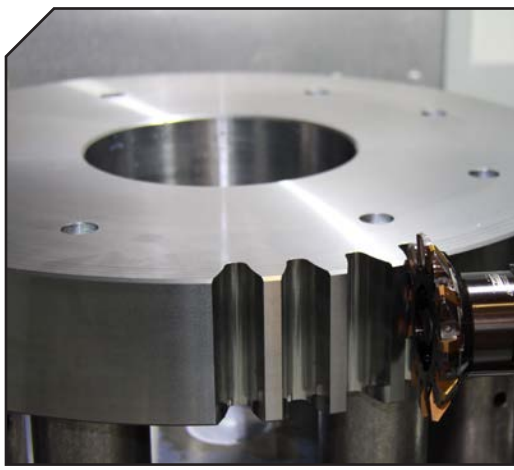
At IMTS, Zoller will present not only their universal inspection machines Genius and Smartcheck, but also new developments in the Pom series as well as the completely newly designed 3DCheck and their high-end Titan machine.

The 3DCheck is a new six-axis CNC-operated machine for the three-dimensional digitalization of workpieces. A target-performance comparison with a CAD model or a pre-scanned tool is now an easy and fast task. The compact tool inspection unit PomBasic for job-shop applications right next to the grinding machine is now also available with a high resolution camera for micron tools. Zoller's automation solution Roboset in combination with a CNC-operated tool presetter is of special interest to all companies with high tooling throughput levels such as tool manufacturing and grinding businesses, as well as in the quality assurance aspect. Roboset loads the Zoller presetter automatically and unmanned, 24 hours a day, 7 days a week.

For more information:
Zoller
Phone: (734) 332-4851
www.zoller-usa.com

DMG MORI
Booth S-8900

In the last two years, DMG Mori has expanded their gear milling portfolio to include more machine platforms that produce more types of gears. The highlight of the show will be the power skiving technology displayed on a multi-tasking machine platform that combines turning operations with milling operations and gear production. DMG Mori's

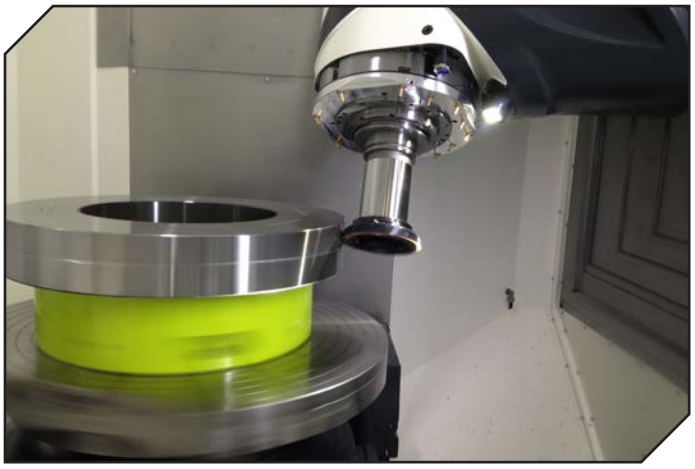


DMC 80 FD duoBLOCK machine will demonstrate machining of an ID gear using a power skiving process. As compared to conventional shaping processes, the power skiving process is a highly productive process for machining of ID and OD gears. The demonstration will show that the machine and process is suitable for even automotive volume production. The same machine will also demonstrate the machining of a spiral bevel gear using the flankmilling process. In addition, it will measure the spiral bevel gear using the onboard standard measurement probe and a point cloud generated by the DMG *gearMILL* software. Using the data gathered by the probe, the *Gear Pro* involute software from Zeiss will prepare the flank charts for the gear. This in-machine checking of gears is a unique feature and can be extremely useful for quick check measurement of large gears before removing them/unloading them from the machine. This feature is available for measurement of all types of gears.

DMG Mori is also launching its new horizontal machining center NHX 4000 2nd Generation. This machine provides a very cost effective way to produce large

diameter cylindrical gears. The super accurate B-axis (rotary table) ensures machining of excellent quality gears and a pallet changer (standard feature) eliminates the setup time altogether. The fast tool changes will reduce the cycle time and a large tool magazine will keep the machine running overnight. This machine will show a 19 in. diameter spur gear machined using the InvoMilling process and a 26 in. diameter herringbone gear machined using the flankmilling process.

In addition to this diverse gear portfolio, DMG Mori will demonstrate its technological expertise with their hybrid manufacturing machine. This machine combines the additive (3-D printing in metals) and subtractive processes into one machine to produce a finished part from just powder. It uses a powder spray technique that gives 20x to 40x deposition rates for depositing material and then conventional milling turning processes to remove material from any unwanted areas. The combination of these two processes on a single platform and the ability to execute them sequentially provides unparalleled freedom to design engineers – enabling them to design parts in ways they have not even imagined.



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

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NORTON (SAINT-GOBAIN)

Booth N-7051

Norton will be exhibiting its Norton Vitrium^3, the next generation of bonded abrasives products, engineered for maximum performance and cost savings in precision grinding. Norton Vitrium^3 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 Vitrium^3 are now attainable in all Norton abrasive grains, from proprietary Norton Quantum ceramic alumina to conventional aluminum oxide. Norton Vitrium^3 features a stronger bond construction that allows suitable form and corner holding for improved part quality and higher tolerances, reduced dressing time and wear, an improved holding power utilizing less bond-to-abrasive ratio and an increased porosity that 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 Vitrium^3 is re-shaping the world of precision grinding to meet these needs," said Scott Leonard, director of product management at Norton Saint-Gobain. "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

GMTA

Booth N-6670

German Machine Tools of America (GMTA) will be showing their complete family of gear-making machines, grinding, milling and turning centers, plus the newest additions to the line, Rosink parts washers and Arnold laser machines. Manning the booth will be President Walter Friedrich, VP Scott Knoy and executives from the various companies represented by GMTA in North America including Wera, Pittler, WMZ and Praewema, in addition to Rosink and Arnold. All are high-quality German machinery companies.

For more information:
GMTA
Phone: (248) 921-0122
www.gmtamerica.com

WENZEL AMERICA

Booth E-5698, N-6930, E-5510

Wenzel America's metrology expertise will be highlighted in three separate booths across two pavilions. Their cutting edge, 3-D Scanning CORE machine will be featured at their own booth in the QA pavilion. An XO CMM, featuring Wenzel's Phoenix structured light projection sensor will also be showcased. Wenzel's flagship, LH Generation CMM with standard Renishaw probe, will be on display at Renishaw's booth, also in the QA pavilion. Their newest WGT Gear Machines will be exhibited at Liebherr's booth in the Gear Generation Pavilion.

For more information:
Wenzel America, Ltd.
Phone: (248) 295-4300
www.wenzelamerica.com

KOEPFER AMERICA

Booth N-6918

Koepfer America, LLC will proudly introduce the CLC 200-SZ gear shaping machine at IMTS 2014. This machine will be the first of its model to meet the North American market, and it represents a competitive and fully customizable solution for high-precision, CNC gear shaping.

CLC has built gear shaping machines for gears up to 118" (3,000 mm) diameter; however, the CLC 200-SZ can cut external gears up to 7.874" (200 mm) diameter and has a maximum rating of 5 DP (mn 5.0). The machine will also demonstrate standard features such as a CNC electronic guide, stroking speed of 1,000 strokes per minute, a movable cutting head, and 3.937" (100 mm) stroke length. The machine can also cut internal gears up to 11.811" (300 mm) diameter.

CLC machines distinguish themselves with a rigid construction for cutting high-precision parts. These gear shapers can also be customized for a customer's specific application. For example, a tilting column can be provided for cutting tapered gears. Lastly, these machines utilize direct-drive torque motors, and, optionally, either Fanuc or Siemens CNC controls.

The CLC 200-SZ gear shaping machine will be Koepfer America's featured new product at the show, accompanied by a Koepfer Model 160 gear hobbing machine and a Wenzel WGT 400 gear inspection machine. This group of demonstration machines will represent Koepfer America's wide range of gear manufacturing products.

For more information:
Koepfer America LLC
Phone: (847) 931-4192
www.koepferamerica.com

EMUGE CORP.

Booth W-1536

At IMTS, Emuge Corp. will showcase their comprehensive line of clamping solutions. Emuge's workholding division specializes in providing highly accurate, almost maintenance-free customized solutions for applications from low volume job shops to high volume automotive production environments. "Our workholding group stays close to our customers to learn about their unique challenges and production environments. Doing so helps us develop the best solutions for their applications," said David Jones, precision workholding manager at Emuge Corp. The precision workholding lineup on display will include Emuge's System SG that is used in many machining operations such as hobbing, shaping, and shaving for gear production, as well as milling and inspection. The System SG's large surface area contact with the workpiece provides a clamping solution which is very rigid, accurate and repeatable. The high precision System SP is used not only to clamp workpieces but also to clamp tools. By applying an axial force, the clamping sleeves move in the direction of the force and expand radially. This eliminates the clearance between clamping sleeve and body, and between clamping sleeve and workpiece. System SP achieves concentricity of ≤ 0.002 mm (corresponding to ≤ 0.0001 inch).

For workpieces that have a short clamping base or for diameters with a very large tolerance, System SZ is an option. By applying an axial force, a slitted collet is radially expanded by a cone. Simultaneously an axial movement occurs, clamping the workpiece. When the eccentricity between pitch circle and seating bore is very small, diaphragm clamping System SM is suitable. It allows clamping of the gear wheel at the pitch circle for machining the seating bore. The gear wheel is clamped in both axial and radial directions. System SH is a solution if there is not enough room for a mechanical clamping system and for clamping long, thin-walled workpieces or a number of similar workpieces. System SH is a closed system which uses hydraulic pressure to clamp the workpieces.

For more information:
Emuge Corp.
Phone: (800) 323-3013
www.emuge.com

ZEISS INDUSTRIAL METROLOGY

Booth E-5504

Zeiss Industrial Metrology is introducing the latest generation of the successful Zeiss Contura. This system provides a platform for flexible, reliable quality assurance. It is even more precise than its predecessor and offers a large package of optical sensors on top of additional measuring ranges. *Zeiss Calypso 2014* software and a highly tuned overall system enable Zeiss Contura to maintain a high standard in the industry. The Contura has made high-performance measuring technology available to the masses. The latest generation will continue on this proven path. A reliable measuring system is the result of the interaction of its components: design, sensors, software and service. "With Zeiss Contura, customers receive a well-balanced system and thus a guarantee for stable, reproducible precision. Put simply: results you can rely on," says Andrzej Grzesiak from Zeiss Industrial Metrology business group. Thanks to its robust design, Zeiss Contura can also be used near production. The latest and most powerful scanning sensors from Zeiss are available for the machine. Another new feature is the range of measuring volumes. The Zeiss Contura family has eight different sizes starting with a measuring volume of $700 \times 700 \times 600$ mm up to $1200 \times 2400 \times 1000$ mm.

For more information:
Zeiss Industrial Metrology
Phone: (800) 327-9735
www.zeiss.com/metrology

DONTYNE GEARS

Booth N-6778

Dontyne Gears is a newly formed company set up to help in the development of gear systems. DG naturally uses the versatility of Dontyne Systems software to optimize design for production and performance, but also has access to the highest level of small and large volume machining equipment to produce such components. These components can be inspected on high quality gear inspection equipment and tested in test rigs ranging up to 160 mm centers. Proximity and collaborative links to Design Unit and Offshore Renewable Energy Catapult (formerly NaREC) in the North East of England ensure a solid knowledge base for R&D projects of the highest caliber and the possibility of larger scale development programs. DG will help define and implement a test program for standard gearing and custom gear forms. The company will also consider collaborations with machine tool manufacturers and tooling companies in the development of equipment and processes using various production methods and materials. IMTS is a chance to get to know the personnel and discuss potential collaboration.

For more information:
Dontyne Gears
namerica@dontynesystems.com
www.dontynesystems.com

FIXTUREWORKS

Booth W-1686

Fixtureworks, a supplier of workholding and machine tool components, fixturing accessories and material handling products will showcase its extensive product lineup during IMTS 2014, Featured in the exhibit will be Fairlane Products full line of fixturing accessories including grippers, rest pads, Swivots swivel/pivoting positioning components, Quick Release ball-lock pins, rollers and bumpers. Included in the Fairlane Products lineup are the new Urethane Covered Bearing Rollers. These covered bearings have a smooth urethane surface that is cast directly to a precision sealed ball bearing. They provide smooth, quiet and non-marring operation with excellent abrasion resistance and durability. They are available with hardness ranging from 35 to 95 durometer in 1'to 3' diameters.

The exhibit will also feature the company's full lineup of manual clamps from Imao, OK-Vise and Mitee-Bite. Clamps that provide quick and secure fastening for repetitive machining operations and are suitable for easy load/unload of workpieces. The clamps come in a variety of sizes from heavy-duty to mini, clamping-force options from as little as 2 to over 2,200 lb. and configurations that include swing, pull, snap, hook, toe and side.

In addition, also on exhibit will be Kipp spring plungers, rest and riser pads, levers, handles, knobs, and hand wheels; Imao supports and stops, risers, T-nuts, sliding mounts, springs, supports, grid plates and blocks; OK-Vise single and double wedge clamp designs; Mitee-Bite low-profile edge clamps; and Modern Industries mPower product line which includes quick change precision locating and mounting systems and modular tooling, plates and columns.

For more information:
FixtureWorks
Phone: (888) 794-8687
www.fixtureworks.net

HAAS AUTOMATION

Booth S-8119

Five-axis machining is an effective means to reduce setups and increase accuracy for multi-sided and complex parts. Machining those parts quickly further increases throughput and improves the bottom line. The UMC-750SS universal machining center from Haas Automation, Inc., is a high-speed solution for quickly machining 5-sided (3+2) and simultaneous 5-axis parts.

The UMC-750SS is a 5-axis, 40-taper universal machining center with 30" × 20" × 20" travels, 1,200 ipm rapids, and an integrated high-speed, dual-axis trunnion table. The machine is equipped with a 15,000-rpm inline direct-drive spindle, a high-speed 40+1 tool side-mount tool changer, and Haas Automation's powerful high-speed machining software.

The UMC-750SS's high-speed, roller-cam trunnion table offers 150 deg/sec feedrates to quickly position parts to nearly any angle for 5-sided (3+2) machining, or provide full simultaneous 5-axis motion for contouring and complex machining. The trunnion provides +110 and -35 degrees of tilt and 360 degrees of rotation for excellent tool clearance and large part capacity, and the 630 × 500 mm table features standard T-slots and a precision pilot bore for fixturing versatility. To simplify job set up, the UMC-750SS features Dynamic Work Offsets and Tool Center Point Control, and comes standard with Haas Automation's Wireless Intuitive Probing System.

The machine's 15,000-rpm inline direct-drive spindle is powered by a

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30-horsepower vector drive system that yields 90 ft-lb of cutting torque. The Haas inline system couples the spindle directly to the motor to reduce heat, increase power transmission, and provide excellent surface finishes.

A wide selection of high-productivity options is available for the UMC-750SS, as well, including a belt-type chip conveyor, high-pressure through-spindle coolant systems, expanded program memory, and much more.

For more information:
Haas Automation
Phone: (805) 278-1800
www.haascnc.com

SANDVIK COROMANT

Booth W-1500

Cutting tool and tooling systems supplier Sandvik Coromant has announced that leading CAD/CAM software companies Edgecam, Top Solid and GibbsCAM are integrating the Adveon Tool Library. Built into software, Adveon helps customers to further improve machining productivity and security, and saves time during machine setup. By reducing the engineer's input, both consistency and quality of data are improved. Additional CAD/CAM companies are in the process of integrating Adveon as well.

The library has standardized methodology, designed specifically to facilitate quick and safe CAM programming. Adveon allows users to: develop their own tool library/database, select tools for production, overview and maintain the assortment, build tool assemblies quickly and safely, see immediate results in 2-D and 3-D models and instantly export to CAM or simulation software.

Adveon works with any tooling supplier that bases their catalog on the ISO 13399 standard, thus assuring the accuracy of geometrical information.

The advantages of Adveon are far reaching. The open catalog area allows drastic reduction of time spent on finding and defining cutting tools, which eliminates the need to search for information in catalogs or interpret data from one system to another. This in turn helps the manufacturer gain rapid access to the required cutting tool information in order to source the most suitable machining solution paired with the most efficient cutting tool selection. Through Adveon, users can select the tools used in their daily operations, maintain and amend the assortment and create their own tool libraries by copying and pasting from the catalog area. Virtual tools can be assembled in a fast and secure manner and data quickly exported for CAM programming and simulation.

According to CAM system suppliers, the automated input of cutting tool data to CNC systems can increase the productivity of a machining process by as much as 20 percent.

Klas Forsström president of Sandvik Coromant comments: "Pressure to reduce time from design to production combined with the ever-increasing complexity of tools makes rapid access to accurate and current tool data more critical than ever. Companies can no longer afford to rely on manual data entry and operators need a single tool library that can manage tools from multiple manufacturers. Adveon has been designed from the 'ground up' to address these challenges and we are pleased that the leading CAD/CAM companies have integrated the tool library system."

Additionally, Sandvik Coromant will display its InvoMilling technology at IMTS as well as its patented Inveio technology featured in its newest inserts. Products featured include the CoroMill 172, Capto MACU, CoroCut QD SL, CoroDrill R846 and more.

For more information:
Sandvik Coromant
Phone: (800) 726-3845
www.sandvik.coromant.com

HWACHEON MACHINERY

Booth S-8129

Hwacheon Machinery America will demonstrate its high-precision machining centers for die-mold applications. Hwacheon's Sirius range of 3-axis vertical machining centers feature 20,000-rpm high-speed spindles for the UM and UL+ models and 12,000 rpm spindle for the UX model.

A number of useful options make mold-die machining more efficient with Sirius machines. Equipped with integral motor spindles with jacket cooling and oil-jet cooled bearings and rigid roller linear guide ways, the machines deliver stable performance over long cycles. According to the company, the Sirius range of high speed die and mold machining centers provide the industry high capability, extreme precision at an attractive price.

The UM model demonstrated at Hwacheon's open house featured a 850 mm (33.46") × 500 mm (19.70") work table with 800 kg (1,764 lb) load capacity, strokes of (X, Y, Z) of 750 mm (29.53") × 500 mm (19.70") × 450 mm (17.72"), and rapid positioning of 24 m/min. The 40-taper (BBT & HSK optional) tools are changed in 2.5 seconds.

The bilateral gate structure in Sirius-UM effectively distributes the vibration, weight, and heat throughout the entire frame. Finite element analysis methods help to minimize the frame distortion which may be caused by machining conditions or environment. The distance between the spindle and the body is designed short, so the machine stays stable after a prolonged operation.

The spindle is integrated with the motor to limit vibration, noise, and power loss at high speed rotation. The cooled jets of oil are injected directly onto the spindle bearing for effective cooling, and the motor and the spindle assembly are jacket-cooled to limit the displacement caused by heat. To achieve greater precision, standard Hwacheon software (*HSDC*) monitors the spindle for possible thermal displacement and makes necessary adjustment in real time.

Sirius-UM provides powerful feed performance using the Z-axis 6-block LM guide. The servo motor is coupled directly to the drive; and while the tensile preload ball screws provide smooth operation, the roller linear guide allows for rapid feed and rigid performance.

Before final finish passes, Sirius machines can, with Hwacheon HFDC (Hwacheon frame displacement control system) software, dynamically compensate for any changes that may have occurred in machine kinematics due to temperature, vibration or changes in the tool itself.

Hwacheon mold-making machine tools feature standard integrated software developed in conjunction with Fanuc CNC for thermal displacement control and compensation. Software measures thermal conditions in the machine during the cycle and uses the information collected to dynamically verify and control accuracy.

In this way, Hwacheon machine can control the kinematics of the machines for contour machining, optimizing machine performance for roughing, semifinish, and finish machining without employing a number of different programs. The Sirius machines include software that other machines do not or offer only as options.

HTLD Tool Load Detection software provides real time measurement of tool load ensuring consistent and safe machining. Constantly monitoring tool damage and deterioration for prevention of complete tool failure causing work piece damage, this software ensures accuracy and performance. Such a system will measures tool load very frequently, such as every 8 msecs.

Hwacheon high efficiency contour control (HECC) system offers an easy to use programming interface system which provides a precise, custom contour control for the selected work piece while supporting longer machine life and reduced process time. Such software will offer different options for cutting speed and accuracy, and for surface finish and geometry. A customizable display provides real time monitoring and easy access. This software may be used with existing NC systems and is compatible with G-Code programming.

Optima, a cutting feed optimization routine utilizes an adaptive control method to regulate the feedrate in real time to sustain a consistent cutting load while machining. As a result, cutting tools are less prone to damage and machining time is reduced. The system controls the feed velocity to maintain consistent cutting load. Features include a graphic display of tool load and feedrate, convenient operation using G-code programming, and a number of data sets for specific tool and process control. Additionally, highly sensitive thermal sensors mounted at various locations in the machine castings where thermal displacement is possible can permit software monitoring and correction of detected thermal displacement.

Hwacheon spindle displacement control (HSDC) is also possible with software. As a spindle rotates at high speed centrifugal forces and heat expand the spindle taper causing error in Z-axis. This axis accuracy is vital to precision mating of die components. In addition to a high precision cooled spindle, software can be used to constantly monitor temperature at a number of points within the spindle assembly predicting thermal displacement. The system can then makes necessary adjustments and effectively minimize thermal displacement, preventing Z-axis error due to taper expansion as the spindle rotates at high speed.

For more information:
Hwacheon Machine Tools
Phone: (847) 573-0100
www.hwacheon.com

EXSYS

Booth W-1671

Exsys Tool, Inc. will exhibit a wide range of innovative manufacturing technology. Among the products on display will be the Preci-Flex modular quick-change tooling system, the compact Eppinger C3, C4 and C5 Connection Base Holder, Deco-Flex modular adapters for Swiss automatic machine tools, and modular Gressel vises. The company will also highlight its comprehensive Exsys Tool Repair LLC. service that specializes in repairing and rebuilding driven tooling for CNC turning centers.

The Preci-Flex modular quick-change tooling system features a selection of adapters engineered to hold different cutting tool and shank designs. The adapters' common connecting feature locks into a standard base unit on the machine turret, enabling tool/adapter assemblies to be preset offline then quickly switch in and out of the base unit. Tool positions repeat within +/- 3 µm, eliminating the need to re-center, touch off, or make test cuts.

The Preci-Flex conical and flat-face planar interface duplicates the taper of the standard ER collet, enabling ER collets, albeit at lesser repeatability, to be used along with Preci-Flex adapters to mount collets, endmill holders, expanding collet chucks and shrink fit tooling on a single base holder. Operated at the front face of the turret, the connector provides two tons of clamping force, and its compact design maximizes torque transmission and rigidity, increasing accuracy and productivity.

Representing another example of advanced modular quick-change tooling technology, the compact Eppinger C3, C4 and C5 Connection Base Holder makes fast and simple tool changes possible as well as requires minimal space within a machine tool so it can easily handle larger workpieces.

For Swiss automatic machine tools, Exsys Tool will exhibit Deco-Flex adapters that have minimal envelope dimensions so they can increase manufacturing flexibility in a Swiss machine environment. The compact design also enhances rigidity, boosting machining efficiency.

The Deco-Flex connection features a conical and flat-face planar interface that ensures concentricity and repeatability. The system also offers specific adapters that combine with fixed and/or rotary tool holders to optimize tool performance and flexibility. Tools can be preset off the machine, allowing adapter/tool changes to be completed in seconds and thereby reducing setup times while increasing machine uptime.

On the workholding side, at IMTS, Exsys will present three innovative workpiece clamping systems from Gressel:

•Gripos modular machine vises clamp by tension rather than compression, producing no deflection of the vise baseplate, and are gradually and precisely adjustable from 10 to 100 percent gripping force. Turning a lever 160 degrees provides mechanical amplification with complete clamping in less than a second, minimizing set-up times.

- Grepos 5-axis power vises feature the same actuation technology as GRIPOS vises and provide force amplification from 0-40 kN direct on the workpiece. The design of the vise permits access to the both sides as well as the underside of a part, facilitating true 5-axis complete/simultaneous machining.
- Solinos modular single-clamping vises for small workpieces feature interchangeable jaws and are offered in mechanical or hydraulic versions, providing clamping force up to 20 kN. Clamping range is adjustable without jaw removal, enabling quick change-overs between different parts. The vises can be directly integrated into pallets.

For more information:
Exsys Tool, Inc.
Phone: (800) 397-9748
www.exsys-tool.com

POLYGON SOLUTIONS INC.

Booth W-1954

Polygon Solutions' latest rotary broach product not only expands their tooling product line, but it also brings an innovative solution to manufacturers hoping to capitalize on the 'Made in USA' re-shoring trend. Polygon Solution Inc.'s new 'Made in USA' broach is a rotary broach with multiple text letters allowing machinists to stamp or mark their part in a lathe or milling machine without removing the part from the machine. Polygon's rotary broaching system is usually used for making hexagon or square holes in precision machined products. The new 'Made in USA' broach will have its official debut at IMTS.

Polygon Solutions first introduced an innovative and award winning adjustment free Rotary Broach Tool Holder in 2010, ideal for CNC machines because of maintenance free sealed bearings and a new pressure relief system. The company later announced a series of letter broaches in 2012. The broaches have letters or numbers and are inserted into Polygon's broach holder to mark parts. The different identifying marks improve quality to distinguish between mixed lots of parts made in the same machines.

The 'Made in USA' broach was first tested during Polygon's annual National Association of Manufacturers (NAM) Manufacturing Day tour in 2013. Lee Virtual School students in Fort Myers, Florida were taught about product development and how the new rotary broach 'wobbles' or displaces material to create the text. Polygon showcases new products to students in hopes of promoting the desire for STEM education in a new generation of engineers and machinists.

"Made in America is one of the strongest selling points we have, even for our U.S. Customers," says Matt Chambers of Marine Concepts in Cape Coral, Florida."The quality of the overseas product has been from the start an inferior product, and as the cost of quality is more than ever being taken into account, not only are we sought after for quality but our total cost for our customer is less." Marine Concepts and Polygon Solutions Inc. actively work together as members of the Florida's Southwest Regional Manufacturing Association (SRMA).

Polygon's new broach is not limited to the 'Made in USA' mark. The company sells its tools worldwide and is also developing the system to mark logos, slogans and symbols. "We've had a few challenges to get it to work perfectly," says Peter Bagwell, product engineer at Polygon. "But we keep working with our customers and our partners to get it right. Customers re-shoring their parts want to show they are now made in the United States."

Partners include the Precision Machined Product Association and National Tooling & Machining Association. Bagwell adds, "We've learned from our customers that our rotary broach holder is very easy to set up in the machine and very easy to use for making small hexagon and square holes. We hope the new 'Made in USA' broach helps them achieve an even higher level of satisfaction in both their parts and ours."

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

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Honing of Gears

Gerhard Flores, Andreas Wiens and Oliver Stammen

Introduction

The honing of gears — by definition — facilitates ease of operation, low noise and smoother performance in a transmission. Honing also contributes to reduced friction in the powertrain. Both the intense cutting (roughing process) as well as the functionally fine- finishing of transmission gears can be performed in one setup, on one machine. Honing in mass production is a well-established process, owing to the intelligent machine layout and other combinations with defined cutting geometries. As such, it should be technologically and economically considered as a serious production method. Furthermore, the combined process of flat surfacing and honing on one machine is an even more recent innovation for the finish machining of planetary gears in mass production. The design of components for modern vehicle transmissions such as manual, automatic or dual clutch styles seeks to reduce friction, thereby increasing gear efficiency and function. Therefore, for the gear bores of various active transmission components and planetary gears, low-friction and wear-resistant contact topographies are required. There is also the desire for economical finish machining of the bore in one process, whenever possible.

The finish machining of transmission components in mass production is currently being done using rough honing and finish honing. In one process — consisting of two steps on one machine — the functionally accurate shape and position tolerances, as well as the desired surface structure, can be achieved. Therefore secondary hard turning and grinding processes are seldom required as finish processes in mass production — neither individually nor as combined processes in a work cell.

The diverse quality characteristics require an adjustment to individual process components of honing. The manufacturing quality of the conventional hone process is defined by the terms "dimensional tolerance" and "surface finish." Furthermore, for the function of gear wheels, the quality terms "axial run-out" and, respectively, "perpendicularity" and "radial run-out" (out of round) are relevant. If one also wants to use honing for the finishing of gear wheels, the process of these broadened quality terms is modified accordingly.

Function and Quality

With the bore in a control wheel, i.e. — any free gear in a transmission vs. spline-mounted, thus requiring bore finishing — the transmission component functions as a rotary and translational slide-way. The tolerances are selected accordingly. The honed surface topography with high load bearing area benefits the frictional behavior and uniformly distributes the application of force. The honed surface profile with a large topographical contact surface enables a stabilization of the lubricating film, when mixed lubrication condition occurs. Honing produces a tribologically friendly surface that prevents a breakdown of the lubricating film on the contact surfaces. This acts to reduce friction and minimize wear under high loads on the contact surfaces, as well as under the light loads on a rotating idler. Also, the oblique angles of the honing marks contribute to the even distribution of the lubricating oil in the lengthwise and circumferential direction of the bore.

In order to avoid local high surface pressures, there are also tight shape and position tolerances of the required macro-geometrical conditions for equal lubrication gap widths. The tight geometrical tolerances (axial run-out) and radial run-out have a positive effect on the smooth operation of the gear wheel sets. This is the purpose of the statistical tolerance limits. At a machine capacity of cmk ≥ 1.33, for example, the straightness is reduced from 3 µm to about 2.1 µm, despite very different wall thicknesses.

Table 1 Quality characteristics for honing gears

Dimensional tolerance	∅	Diameter
Shape tolerance	⌭	Cylindricity
	○	Roundness
	—	Straightness
Directional tolerance	//	Parallelism
	⊥	Perpendicularity
Run out tolerance	↗	Axial run-out, Radial run-out
Surface tolerance	√Rz, Ra	arithm. mean deviation R_a averaged surface Roughness R_z

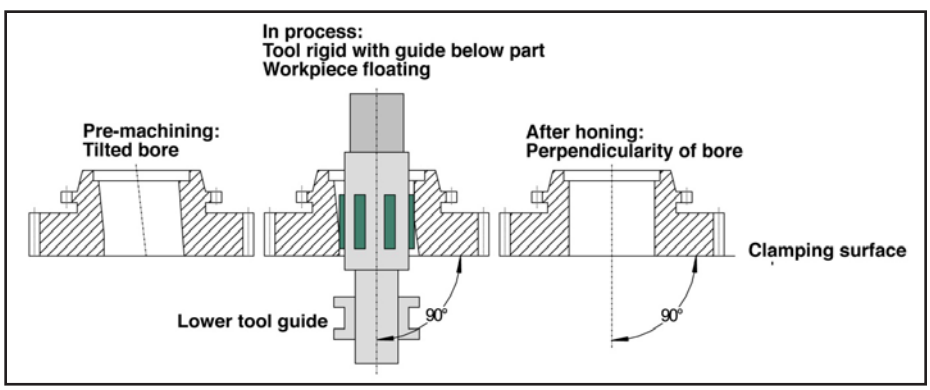


Figure 1 Machining principle for position correction of gear wheel bores in gear wheels.

Honing involves the boring of gear wheels (Ref. 1) (such as planetary gears, transmission gears, switching sleeves, lay-shaft gears, bevel gears) of various shape, dimension, material and hardness. Honing of transmission gears goes beyond the previous quality terms. The following tolerances can be defined as (Table. 1):

In addition to the geometric tolerances, highly stressed components are increasingly evaluated according to the near surface zone of the functional surface. The mechanical and thermal stress of the material due to the machining forces during the final machining steps contributes to the residual stresses in the area near the surface. For example, abusive grinding imparts detrimental residual tensile stresses, whereas honing imparts beneficial compressive stresses because the honing process has comparatively low machining forces and temperatures.

Honing Control Wheels: Machining Principle

An important feature of honing is the alignment of both tool axis and bore axis. In the conventional layout of tool and part, the expansion of the tool results in an equiaxial alignment. The tool-part system has designated degrees-of-motion freedom that enables the centering and tilting to identical axis positioning. An improvement in dimension, shape and surface quality is achievable with this mechanical system.

If the position of the bore needs correcting, that is — the perpendicularity of the bore axis to the front face — or the axial runout of the front face to the bore axis — then the angular degree-of-freedom (tilting) must be replaced by a rigid, perpendicular repositioning of the tool axis and clamping surface (Ref. 2). The reference surface for honing is the machined front face, which is supported on the clamping level (Fig. 1); centering on an inaccurate gear tip circle diameter is not necessary.

Now, the center of the gear wheel bore can align itself to the tool via the floating part holder. In this condition the radial run-out (bore-to-gear teeth) remains unchanged; the deviation of the angle position of the bore axis to the tool axis is corrected in the subse-

Table 2 Layout of honing machines for machining components

	Control Wheel Machining
Machine type	Rotary indexing machine
Spindle configuration	vertical
Fixture	Floating single part holder
Qty. of hone operations	2
Tools	In-process adjustable multiple stone tools with CBN-abrasives of various grit
Machine layout	• Load and unload • Mechanical pre-gaging • Rough honing • Pneumatic post-gaging[1)] • Finish honing • Pneumatic post-gaging • Spin-dry

1) Instead of pneumatic post-gaging, a pneumatic in-process gage can also be used.

quent material removal. Next, the tool machines the raised areas of the lateral surface. With the additional clamping, the entire bore is machined and a new bore axis is established.

Honing Transmission Components: Machining Concept

The common principle among the various possibilities for gear wheel machining is the moveable part holder and the rigid tool holder. Also, the conventional honing process with adjustable honing stones has been carried through. For honing such components, vertical rotary indexing machines with the single part holder in floating fixtures are used (Table 2).

The preparation consists, as a rule, of boring and hardening, so that they must be machined in two honing operations. The tools are exclusively loaded with CBN-abrasives. Furthermore, fully automated production honing machines are equipped with various standard components such as gage stations, handling systems, force-controlled electromechanical feed devices (EMZ-F) and electromechanical ball-screw stroke drives.

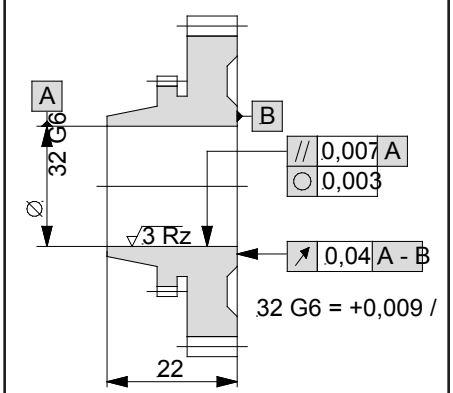
Honing Transmission Components: Requirements and Process Considerations

Because honing of hardened gear wheels has undergone major development in the past few years, this illustration is presented simply as an example. The hardened gear wheels are mainly machined on fully automatic, multiple-spindle, rotary indexing honing machines. The machining concept for individual machining consists of conventional multiple stone tools. The attachments are designed to be interchangeable for various gear wheels. Honing a gear wheel bore is defined by the following quality terms and tolerances (Table 3):

The high stock removal during rough honing with a honing allowance of up to 0.350 mm is the prerequisite for the successful implementation of the honing process in the mass production of gear wheels. This is how honing maintains its competitiveness compared to hard turning. The smoothing of the surface end quality takes place in the second machining station only by changing the cutting material and adjusting the process parameter; the radial run-out achieved in pre-machining should remain unchanged.

The layout of a machine for machining gear wheels shows the stations named in Table 2. After the load and unload station, the mechanical pre-gaging is performed. Here, the minimum dimension of the bore is checked in order to prevent a collision with the tool. Rough honing

Table 3 Required machining quality on a hardened gear wheel



Control wheel 4th gear	
Total hone allowance	≤ 0.350 mm
Cycle time	20 s
Hone time	18 s
Machine utilization	120 parts/h at 80%
Material	Forged steel
Preparation	Turned and hardened on 680 HV30

Table 4 Machining parameters for honing gear wheel bores

	Rough honing	Finish honing
Qty. of honing stones	4 to 6 (depending on diameter)	
Cutting material	CBN	
Grit size	B213	B 46
Bond	Sinter metal	Sinter metal
Dimension	4×4×25 mm	4×4×25 mm
Cutting speed	145 m/min	95 m/min
Feed	electromechanical (EMZ-F)	
Allowance	0.200-0.300 mm	0.015-0.025 mm
Hone time	approx. 18 s	approx. 18 s
Gage-control	Pneumatic in-process gaging	Pneumatic post-gage with feedback function

Figure 2 Machining stations for honing gear wheels.

works with robust parameters — especially at a high cutting speed of about 150 m/min and large removal rates of about 20-30 µm/s in diameter. The subsequent finish honing operation completely removes the rough profile of the rough honing operation and leaves behind the functional component quality (Fig. 2). Pneumatic post-gaging is the final quality assurance; spinning the gear minimizes the spreading of the honing oil.

The machining parameters are summarized in the following (Table 4):

The high removal rate is primarily determined by the high delivery rate and high cutting speed. With increasing rpm, a rise in material removal is clearly noticeable (Fig. 3). The mathematical removal characteristic is determined by the feed rate; i.e., by the diametric preset diametrical honing stone feed-per-unit-of-time. The difference between calculated and measured stock removal results from feed losses caused by deflecting the components in the complete feeding system. The increasing deviation from about 1,500 rpm is explained by an increase in coolant flow at increased rpm. The influence of the stroke speed in the area examined is not significant. Because of the material properties and the high cutting capacity, the rough honing operation produces less fine-grained hone sludge. Instead, fine, long continuous chips in the form of a steel wool ball result.

The function of CBN abrasives of a middle concentration (stock removal ≤ 0.300 mm in 18 s) is decisive for the entire process. The use of low-viscosity honing oil ($\eta = 4.6\ mm^2/s$) has a positive effect on the cutting behavior and, thereby, on the consistent manufacturing quality and tool life. In addition to the constructive design of the hone tools, the condition of the abrasives is of vital importance. They are composed of a metallic binder, fused with the proper concentration of CBN abrasive crystals (Fig. 4). Apart from the selection of binder and grain material, the sinter parameters in the manufacturing process of honing abrasives determine the quality. The hone tools are rigidly connected to the spindle. Below the part, the tool body is formed as a carbide-reinforced guide shaft. The tools, depending on design feasibility, have as many abrasives as possible; this improves the machining accuracy with regard to dimensional stability and increases cutting performance and tool life.

The individual processing with conventional abrasive tools is the most economical variation of gear honing. The stationary fixtures are arranged under the two hone spindles. With the rotary index movement, the gears are loaded into the fixture. The fixture consists of the floating part holder and the zero-clearance, hold-down device (Fig. 5). The part is situated on one of the flat sides of a moveable pallet. The hydrostatic friction bearing of these pallets enables effortless, but not un-damped, movement on the flat. A torque recorder in the gear teeth has been proven effective. This occurs by means of the insertion of the gear into an integrated switch sliding sleeve or by applying a safety catch. The zero-clearance hold-down to accept the upper facing axial force helps with the deformation-free fixation of the gear. The lower guide stabilizes the tool axis to the clamping level at a right angle.

The described process design can reliably achieve the required tolerances. (Note: The roughness and the axial run-out are not statistically evaluated here. (With the finish hone stones [B46], the Rz value amounts to about 1.5 – 2.5 µm, and the axial run-out precision of 15 – 25 µm only meets about 40% to 50% of the tolerance. The cycle time achieved is 20 s, with an allowance of ≤ 0.300 mm

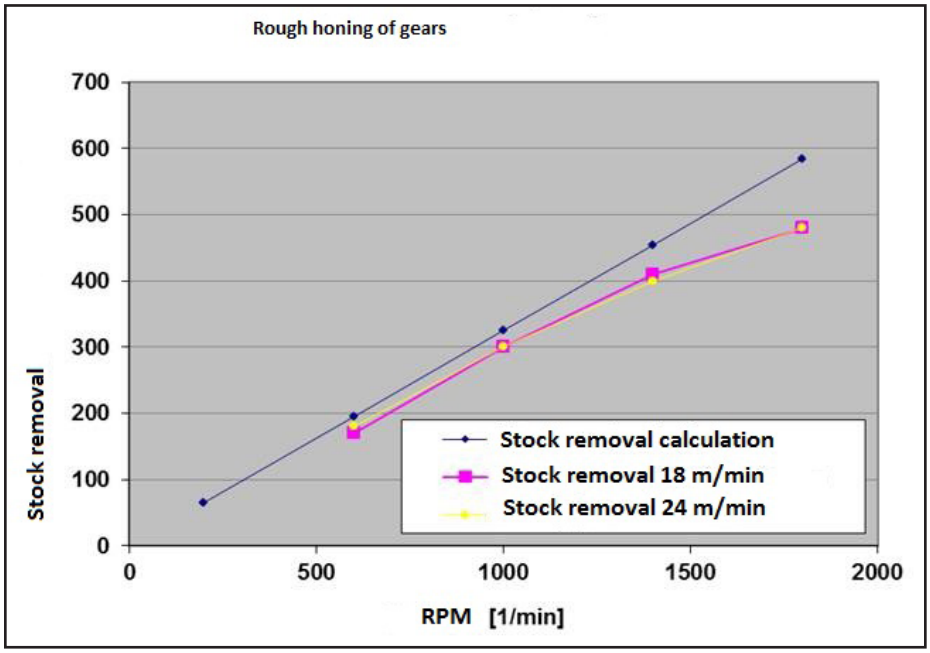


Figure 3 Correlation of rpm and stock removal: control wheel diameter 35 × 26 mm; forged steel; 680 HV30; hone time 18 s; L600 honing machine.

Figure 4 Hone tools with lower guides and CBN abrasive crystals (B213/B46).

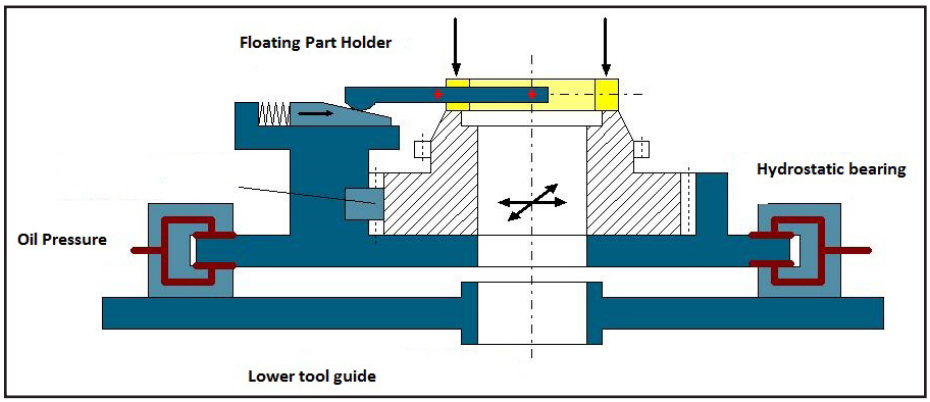


Figure 5 Floating uptake with zero clearance hold-down.

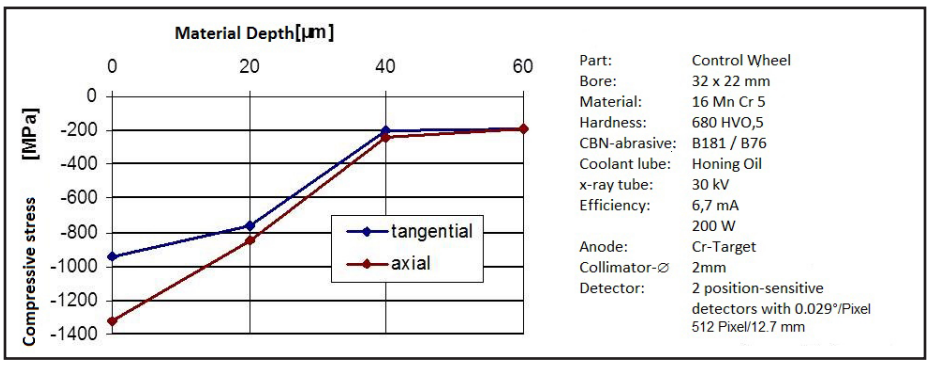


Figure 6 Progression of compressive stress with increasing material depth.

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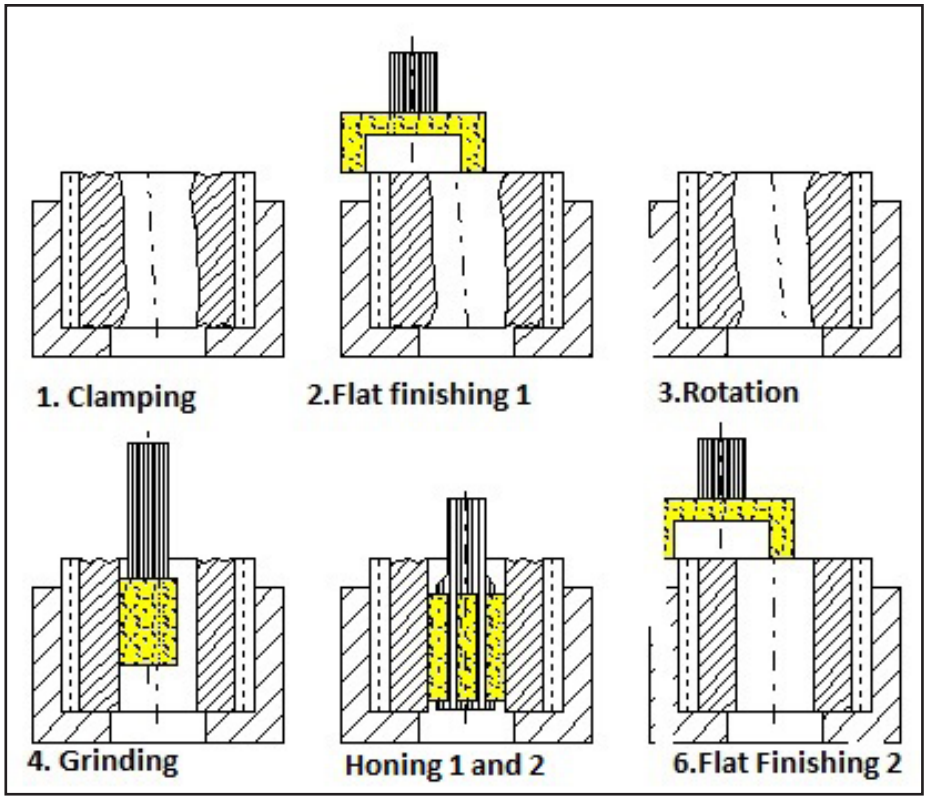

Figure 7 Process steps for combination machining.

in the first operation (determined by cycle time). The quality parameters of diameter, roundness and parallelism are also calculated to meet tolerances and satisfy the statistical tolerance limits.

Measuring the residual stresses with x-ray diffraction shows the condition of the material structure in the area of the near surface zone of the honed bore surface. The stress in the area of the functional surface is substantially influenced by the hardening process and the stress of the finishing operation.

The available measurements (Fig. 6) were taken with a Stresstech XSTRESS 3000 instrument; the values were measured axially and tangentially. The hone angle of about 20° causes an uneven distribution of the compressive stresses in both directions on the honed surface. With increasing material depths, that is, where the surface is traditionally less impacted by the machining forces, the uniformity of the clamping method is measurable. This is a good indication of how the consistency of the impact force in honing differs radically from that of turning and grinding the same surfaces with, for example, extended tooling. The high residual compressive stresses clearly exceed the values of such competitive processes (Ref. 2).

Honing Planetary Gears in Combination Machining

As demonstrated, the combination machine with the processes of flat finishing, grinding and honing offers a new possibility for machining planetary gears. This rotary indexing machine completes the processes on the part, one after another, in one clamping. This versatility allows various machining geometries, such as one bore and one face surface to be machined — each with tight tolerances relative to the other. The compact machine workspace essentially consists of a circular rotary table on which the rotary-driven units are constructed, and the central column, where the machining units are assembled to the upright surfaces. The result is a self-sufficient machine with a small footprint and short transport route in the indexing of the part. The circular rotary tables make the machining units easily accessible for maintenance work and tool changes.

Figure 7 depicts the process steps for such combination machining. The part is only pre-machined on the front and in the bore. The gear wheel is located in the fixture with an unfinished side up, and is clamped radially on the gear teeth. The

tip diameter or the involute teeth are the geometric-identifying elements for the position of the part. The upper front is machined by flat finishing 1 (Example 1). Then the part is turned so that the previously finish-machined end surface fits in the fixture as the locating surface. In the subsequent grinding operation the bore is ID ground centric to the gear teeth. With this, the desired radial run-out tolerance is achieved.

The above enables the subsequent station to work with a tightly clamped hone tool, because the alignment is made to the unchanged clamping fixture and guarantees the centric ground bore; therefore, a new bore axis will not be partially processed. The hone process consists of a rough hone and finish hone operation. Between the two hone operations is a gage station in which a plug gage records the rough hone diameter using the principle of pneumatic length measurement. After finish honing, the flat finishing (Example 2) takes place. Here, the second end face is machined parallel to the first end face. (See Figure 8's depiction of the individual machining stations.)

Figure 8 Machining stations for machining planetary gears.

The machine concept is designed such that other process sequences are configurable. There is also the opportunity to integrate modified modular units such as deburring, wheel dressers, belt finishing or reaming. The concept of combined machining is especially useful in the manufacturing of planetary gears. Previously, the manufacturing processes for flat finishing, ID grinding and honing required different machines.

The consolidation of the processes into one machine allows high capital investment savings, increased productivity and reduced operational footprint (Fig. 9). For planetary gears, cycle times of 7 s with material removal in the bore of ≤ 0.15 mm are achieved.

Summary

The possibility of position correction with high-precision and material removal of up to 0.350 mm in 18 s placed the single-machine honing of control wheels firmly into current automotive manufacturing technology. Despite very high cutting performance, the low machining forces and temperatures enable the lowest near surface zone variances and high residual compressive strength. The surface roughness with a high load bearing area in low cutting depth, and the hone angle structure have a positive tribological effect on the sliding function of the gear wheel.

An additional innovative manufacturing strategy is the use of machines for combination machining; it is especially advantageous in the machining of planetary gears. Here, the process of flat finishing, ID grinding, and honing are systematically combined in a single machine.

Figure 9 Machine for combination machining of gears.

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Importance of Contact Pattern in Assembly of Bevel Vs Cylindrical Gears

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

Why is there so much emphasis on the tooth contact pattern for bevel gears in the assembled condition and not so for cylindrical gears, etc? Any information would be greatly appreciated.

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Expert Answer Provided by: Dr. Hermann J. Stadtfeld, Gleason Corp.

Bevel and hypoid gears commonly use a cantilevering pinion. This means the pinion has, for example, two tapered roller bearings located on the shank — behind the heel — with no bearing support on their toe end. While the ring gear is supported on both sides, this presents a situation that allows the pinion to bend in the plane of the ring gear rotation, and in a plane that is defined by the pinion axis and is perpendicular to the first plane. In other words, a three-dimensional displacement of the pinion vs. the gear takes place during regular operation. This phenomenon increases in severity in cases where the gearbox housing is not of steel, but rather from a material with only a fraction of the modulus of elasticity of steel — such as aluminum alloys. The situation of relative displacement of bevel and hypoid transmissions — even in cases of optimal straddle bearing location — is a magnitude larger than in situations of spur and helical gears because of the three-dimensional force situation.

Cylindrical gears have only one major assembly parameter that is the center distance. There are four assembly parameters for bevel and hypoid gears (Fig. 1). Offset "E" and root angle "Alpha" are given by the gearbox design. The pinion axial position "P" has to be adjusted relative to the bearing shoulder behind the pinion heel to the theoretical value in order to make the crossing point of the axes match the theoretically predetermined position; i.e., the position found in the roll testing machine as the optimal build position — regarding tooth contact and noise. This rather complicated angular configuration with a possible pinion cone "P" optimization and the presence of gearbox tolerances requires an individual adjustment of the gear cone "G". The gear cone adjustment is mainly done to re-establish the desired backlash, which changes if the pinion position should be optimized. In cases where the tooth contact moved too far away from the required position, a pinion cone correction (using bearing shoulder shims of different thickness), in connection with a re-adjustment of the gear cone, must be performed. Because of the high three-dimensional displacements of the pinion position relative to the gear, bevel and hypoid gears receive a combination of length crowning, profile crowning and flank twist (Fig. 2). Modern bevel and hypoid gears even use higher-order corrections with the aim of minimizing the sensitivity regarding contact movement under load while also increasing load-carrying capacity.

Spur and helical gears — in automotive transmissions, for example — are arranged between two parallel shafts. Under load the gears at the end of the shafts might change their center distance by small increments — mostly caused by the transmission housing deformation — while the shaft inclination is still acceptably small. The gears towards the center of the shafts will change their center distance by higher amounts, while the inclination is negligible. The involute profile will prevent edge contact at top and root, if the contact ratio in profile is above 1.00. Load concentration at the ends of the teeth is prevented by the face contact ratio of helical gears. Spur gears are corrected with a first-order end-relief (Fig. 3, left) (in case of hobbing or

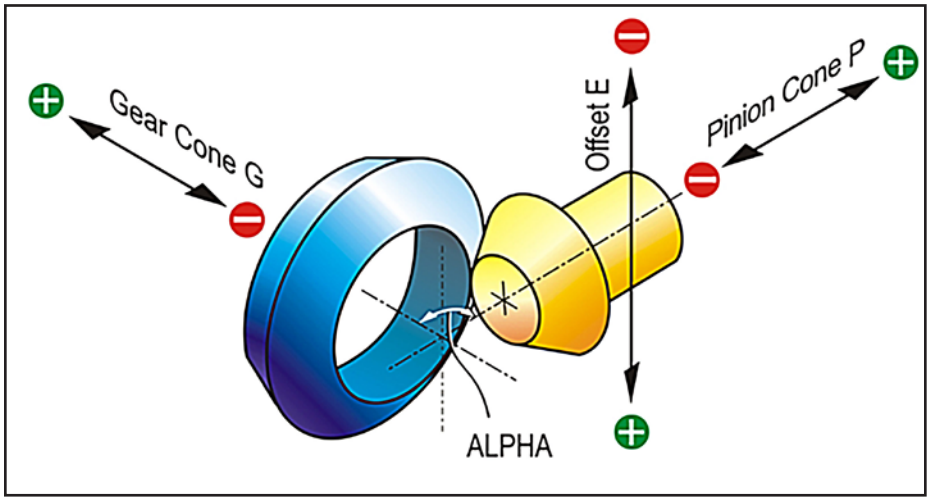

Figure 1 Bevel gearset — axial, vertical and angular adjustments.

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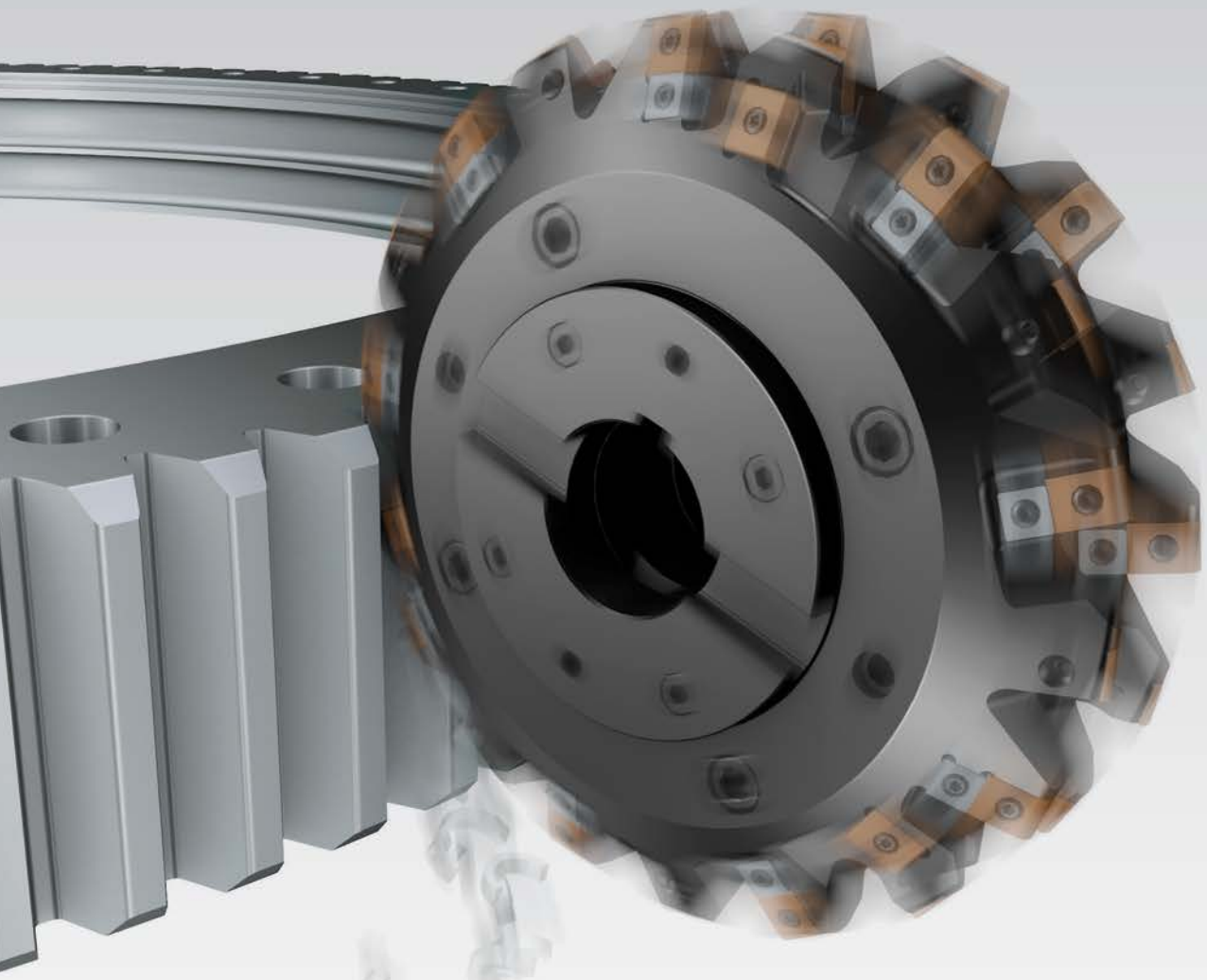

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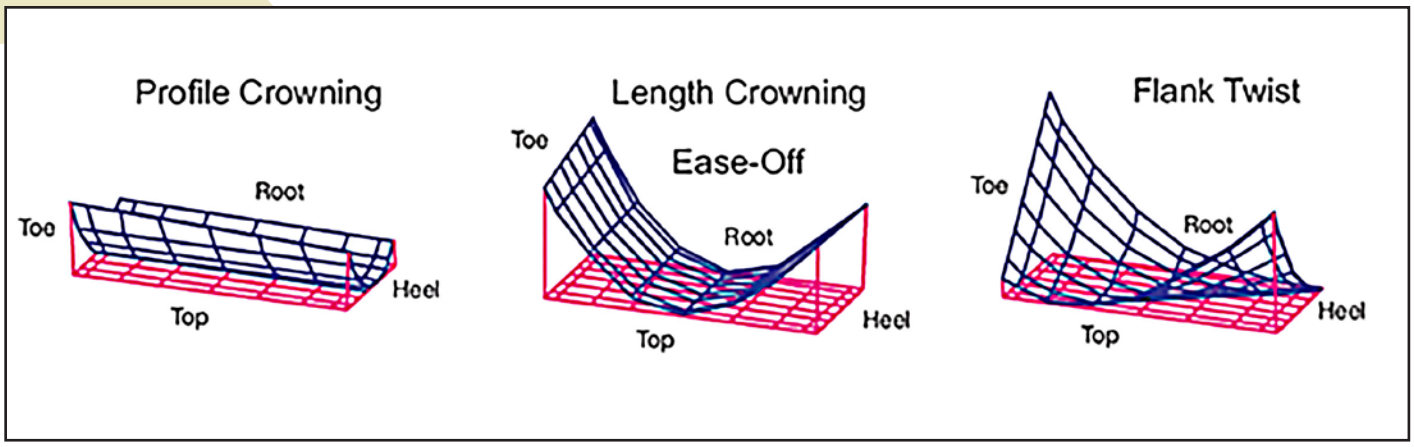


Figure 2 Flank surface modification elements (crowning) used for bevel gears.

shaping) in order to prevent the concentration of load at the tooth ends. More sophisticated is a circular length crowning in connection with a protuberance in the tool profile. A protuberance tool creates a profile relief like that shown in Figure 3 (right). Many helical gears that are ground have this advanced crowning applied. Crowning in face width direction and protuberance are also applied in cases in which the soft manufacturing is the final operation of a cylindrical gear.

Because the cylindrical gear shafts are parallel in the stage of building a gearbox, the gearbox tolerances will basically influence the center distance. Tolerances in milling the bearing journal seats can normally be ignored because they cause only a negligible shaft inclination and generally only result in a center distance variation. Involute gearing is impervious to center distance changes, so the emphasis is on verifying the assembly result in order to maintain the backlash within the required limits. Checking the tooth contact is often not required because there are no significant influences that could greatly influence the contact conditions. Depending on the kind of transmission, the final inspection could still be a backlash and contact pattern check of every gear mesh, or a structure-borne noise analysis of the complete gearbox on a test rig.

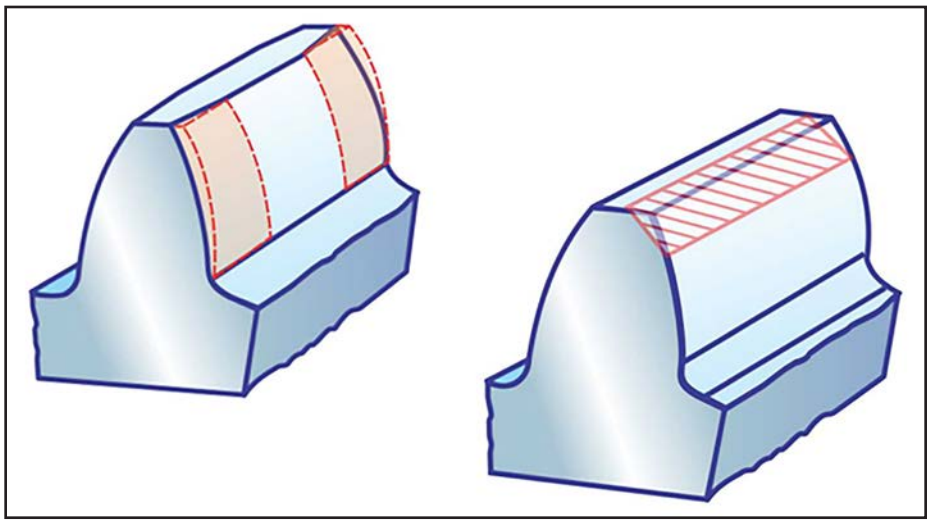
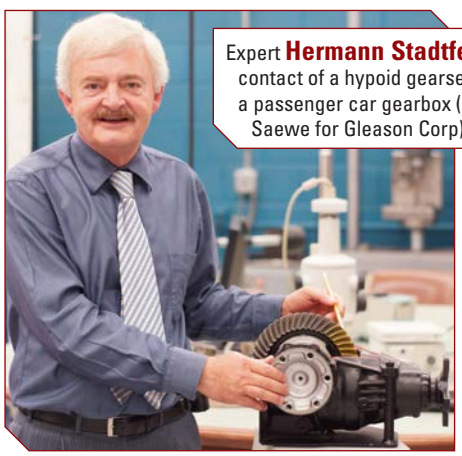


Figure 3 End relief—(left side) and top relief (right side).



Expert **Hermann Stadtfeld** checking tooth contact of a hypoid gearset after assembly in a passenger car gearbox (photo by Jasmin K. Saewe for Gleason Corp).

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Additives: Anti-Wear vs. Anti-Scuff Is One Better?

QUESTION

While I have read a reasonable amount of the literature on the pros and cons of anti-wear and anti-scuff additives, I find that the more I read, the more confused I become. I could use some clarity in my life. Can you help?

Expert response provided by Robert Errichello and Angeline B. Cardis.

Anti-Wear and Anti-Scuff Additives

The natural oxide layer that forms on metals when they are exposed to the atmosphere is the simplest wear protection. Unfortunately, under boundary lubrication, the oxide layer is easily removed under light load, resulting in the risk of metal-to-metal contact.

Anti-wear and anti-scuff additives affect lubricant performance by controlling wear and friction characteristics under boundary lubrication conditions. A properly formulated gear lubricant contains additives that protect gear tooth surfaces at both low and high temperatures. The additives function by one of the following mechanisms:

- Physical adsorption
- Chemical adsorption
- Chemical reaction

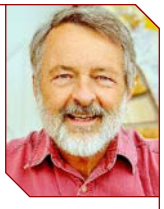
Physical adsorption. Lubricants with polar additives, such as long-chain fatty acids, adsorb to the oxide layers on metal surfaces to form a layer of molecules that reduces friction and wear. These additives are effective at low loads and low temperatures, but lose their effectiveness at temperatures between 80°C and 150°C — depending on the type of additive. They are called lubricity additives and are often used in lubricants for worm gears.

Chemical adsorption. Lubricants with additives such as tricresylphosphate (TCP) or zinc dialkydithiophosphate (ZnDDP) that chemically bond to the oxide layers or metal surfaces provide anti-wear protection that is more durable than that provided by physical adsorption. They are effective at moderate loads and moderate temperatures up to about 200°C. Beyond this temperature, the chemically adsorbed films desorb or are rubbed off and have limited load capacity.

Chemical reaction. Lubricants with anti-scuff additives are designed to react with the parent metal surfaces to provide protection under severe loads and high temperatures where the oxide layers and chemically adsorbed anti-wear films on metal surfaces are disrupted. Anti-scuff additives contain at least one chemically reactive nonmetal such as sulfur or phosphorus that readily reacts with exposed metal surfaces to form a tribofilm with low shear strength. These sacrificial films reduce friction and wear and help prevent scuffing by forming solid films on gear tooth surfaces and inhibiting true metal-to-metal contact. The films of iron sulfide and iron phosphate have high melting points, allowing them to remain on the gear teeth even at high contact temperatures up to about 700°C. The formation and loss of the tribofilms are determined by competition between the opposing processes of chemical reactivity with the metallic surfaces and mechanical removal of the tribofilms caused by the sliding action of the gear teeth. This constitutes a form of mild corrosion, and if the additives are too chemically reactive, they can promote chemical wear and polishing. They can also react unfavorably with other gearbox components such as seals and bearing cages. Therefore, lubricant and additive manufacturers are careful to limit additive reactivity to avoid excessive corrosion.

Distinction between anti-wear and anti-scuff additives. Anti-wear and anti-scuff additives are designed to provide protection over a broad spectrum of operating conditions; both act to protect against adhesive wear that ranges from mild to severe. Mild adhesive wear is confined to the oxide layers of gear tooth surfaces and it always occurs with as-manufactured gear teeth. If the gears are properly run-in, the asperities are smoothed, the wear usually subsides with time, and the wear is considered normal. At the other extreme, scuffing is severe adhesive wear, and it can cause catastrophic damage. Since anti-wear and anti-scuff additives both act in similar ways, it is best to classify them in terms of their activation temperature. Anti-wear additives become effective at relatively low temperatures and become ineffective at moderate temperatures; anti-scuff additives become effective at relatively high temperatures and remain on gear tooth surfaces until they are rubbed off or melt at relatively high temperatures. Therefore, the choice between anti-wear and anti-scuff additives depends on the gear application. Anti-wear additives such as TCP and ZnDDP might be adequate for high-speed, lightly loaded gears that are not subjected to shock loads, whereas slow-speed, highly loaded gears that are subjected to shock loads might require anti-scuff additives such as those containing sulfur and phosphorus — alone, or in combination. In many applications, lubricants with both anti-wear and anti-scuff additives are required to protect against the full range of adhesive wear, but care should be taken to avoid aggressive chemistry that can result in polishing wear, micropitting, or degradation of other components.

Robert Errichello



Angeline B. Cardis

The Pros — And Mostly Cons — Of Fully Ground Root Fillets

QUESTION

For maximum life in carburized and ground gearing, I have been advised that fully grinding a radius into the root gives maximum resistance against fatigue failures. Others have advised that a hobbed and unground radius root form is best. Which is best, and why?

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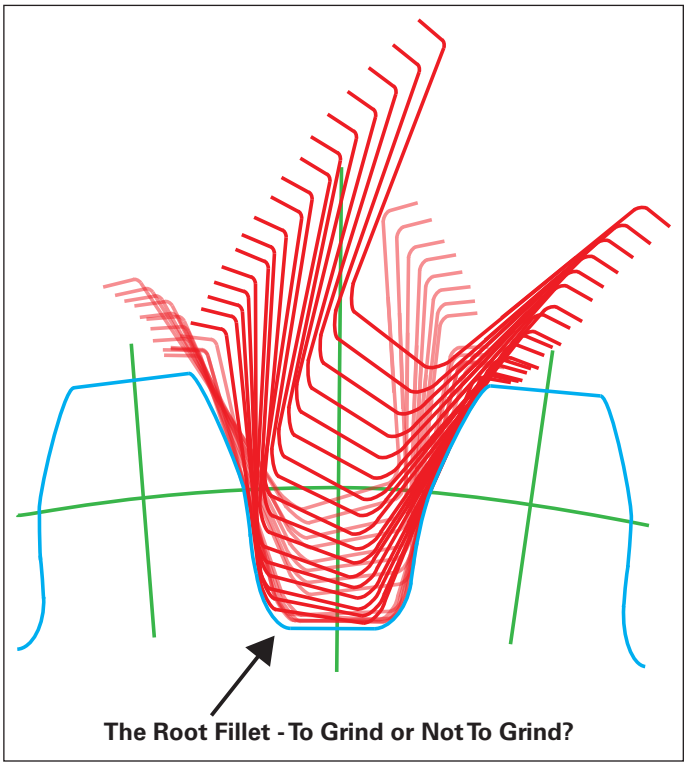
EXPERT ANSWER PROVIDED BY: Robert Errichello, owner/operator of GEARTECH:

It depends on the processing.

With fully ground root fillets, any distortion due to heat treatment must be very carefully controlled, ensuring that stock removed during grinding is minimized and there remains adequate case depth after grinding. This is practical only for small gears and those that are re-heat-quenched. Furthermore, it requires a quench press to adequately control distortion. Generally, grinding is detrimental because it imparts tensile residual stresses. Consequently, root fillets are usually shot peened after they are ground to ensure they have beneficial, compressive residual stresses. In addition, with grinding there is always a risk that the heat associated with grinding might cause tempering or rehardening of the gear tooth surfaces. Therefore, critical gears should be surface-temper-etch-inspected to confirm there are no grind-damaged areas. But this extra processing increases manufacturing costs, rendering ground root fillets practical and cost-effective only for critical gears such as those used in aerospace applications.



The Root Fillet - To Grind or Not To Grind?

Properly processed gears with unground root fillets can have bending fatigue capacity that is nearly the same as aerospace gears that are processed as described above. However, if the gears are gas-carburized, there will be intergranular oxidation (IGO). The IGO must be controlled to Grade 3 requirements according to AGMA 923-B05 to adequately maintain bending fatigue resistance. Furthermore, the root fillets should be shot peened to mitigate the effects of IGO. Alternatively, the gears can be vacuum-carburized to eliminate the IGO. Therefore, for most industrial gears, properly processed gears with unground root fillets are the best choice for reliable and cost-effective gears.

The above discussion applies only to bending fatigue resistance and caution should be exercised regarding shot peening and Hertzian fatigue resistance. The tooth flanks should not be shot peened because their surfaces will be made somewhat harder and rougher, and the flanks might create micropitting on the mating gears. To prevent this problem, the shot peened flanks can be superfinished. Generally, shot peened flanks that are superfinished after shot peening have maximum micropitting and macropitting resistance.

Robert L. Errichello heads his own gear consulting firm, GEARTECH (*geartech@mt.net*), and is founder and creator of GEARTECH software, Inc. He is a technical editor for Gear Technology magazine and STLE Tribology Transactions. Bob is also a recipient of the AGMA TDEC, AGMA E.P. Connell, AGMA Lifetime Achievement, STLE Wilbur Deutch Memorial, and AWEA Technical Achievement Awards.

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Setting Load Parameters for Viable Fatigue Testing of Gears in Powertrain Axles
Part I: Single-Reduction Axles

Ernő Fülöp

This presentation introduces a new procedure that — derived from exact calculations — aids in determining the parameters of the validation testing of spiral bevel and hypoid gears in single-reduction axles.

Introduction

It is generally accepted that a newly developed product is to be tested for conformity — with customer expectations of its design, dimensioning and production for loading and lifetime being met, notwithstanding. As for the axles to be installed in on-road vehicles, further testing is done — regardless of whether the axles meet the safety regulations for on-road traffic. Similarly, the products already in production are subject to tests at certain intervals in order to check the quality of the production process. Tests are generally carried out in a time shorter than the lifetime expected in service, and under higher loading conditions (Ref. 1). When the test procedure is determined, some efficiency and technical aspects are to be considered, such as:

Efficiency:

- Testing should not be over-long, lest it cause delay in marketing of the product and increase the costs of testing
- Testing shall be done with existing equipment; no new, expensive equipment shall be used

Technical:

- In order to simulate the real operational conditions properly, the loading parameters applied during the test shall be determined so that the product shall be subjected to the same damage in a short test time as during actual operation
- Duration of testing shall not be overly shortened or compressed, as this would result in excessively high test loading that would cause extremely large deflections in the product. It would cause extreme conditions that would never occur to such a large extent in real operation, leading as well to unrealistic failures in actual operation.

This study introduces a procedure that helps obtain the exact calculation of the parameters of the validation testing of spiral bevel and hypoid type gears in single-reduction axles.

This procedure does not deal with lifetime testing of other parts in the axle driveline, such as axle shafts, bearings, differential, etc.

Single-reduction axles are usually installed into solo public transport, contact buses and coaches, as well as vans and trucks.

Background

The current study deals with determining the test parameters of bending fatigue and pitting (tooth flank surface fatigue) failure modes (Ref. 2).

Test parameters are defined based on lifetime calculations; the determinant factors in lifetime calculation — namely in determining the number of tolerable tooth loads (N) — are the following: the load level, material grade of the gears (Wöhler curve), and the macro- and micro-geometrical data of toothing.

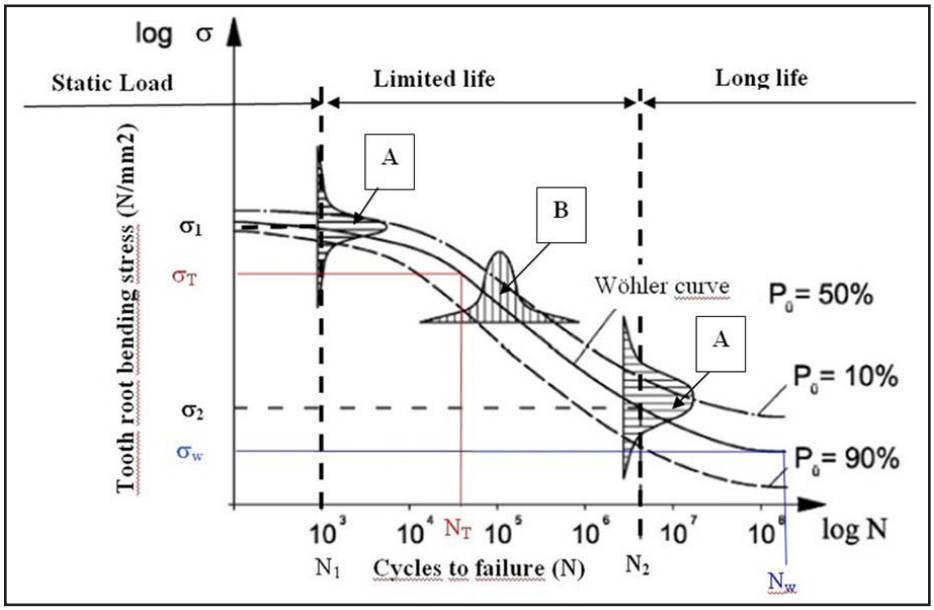

Figure 1 A Wohler Curve diagram showing its three typical sections: Static Load; Limited Life; Long Life.

Table 1 Five Gleason-type bevel gear sets involved in the analysis, each made of case-hardened material 20MnCr5/DIN17210

Gear set	Toothing finishing mode	Tooth profile type	Toothing type	Ratio	Gear outside pitch diameter(mm)
1	Ground	Generated	Hypoid	38/17	285
2	Ground/Waguri	Formate	Spiral	37/17	390
3	Ground	Formate	Hypoid	43/8	420
4	Lapped/5 cut	Formate	Hypoid	41/11	305
5	Lapped/Completing	Formate	Spiral	39/8	400

When the current procedure was developed, we checked the stability of the calculations and whether the procedure properly simulates the influence of various macro- and micro-geometrical dimensions, type of the gears, and the production process applied. For the above reasons, the following five, Gleason-type bevel gear sets were involved in the analysis; each of them is made of case-hardened 20MnCr5/DIN17210.

Bending Fatigue

When we wish to determine the test parameters, we already possess all the macro- and micro-geometrical data of the pinion and gear to be tested, which were determined during designing/dimensioning, using, for example, (Refs. 3 and 4), by applying the loading data and the expected lifetime specified by the customer.

As a starting point, the Wöhler diagram is used, which corresponds to the material grade and heat treatment of the pinion and gearset (Fig. 1).

The Wöhler diagram has three typical sections: *Static Load* (high loading where the gear sets failed in a very short time); *Limited Life* (the load level, where the gear does not fail immediately, but is not suitable for longer service); and *Long life* (load level, which allows long operation).

These three regions are divided by the points (N_1,σ_1) and (N_2,σ_2). For example, for case-hardened material 20MnCr5/DIN17210, at reliability level $P_{\ddot{u}} = 50\%$: ($N_1 = 10^3$, $\sigma_1 = 1{,}570\ N/mm^2$), (Ref. 6) and ($N_2 = 3 \times 10^6$, $\sigma_2 = 430\ N/mm^2$) (Ref. 7).

In Figure 1 the probability density distribution type "A" illustrates that the gear is able to bear the same loading number (N) at various load levels, depending on the reliability level of the material grade ($P\ddot{u} = 10\%$, $P\ddot{u} = 50\%$, $P\ddot{u} = 90\%$).

The probability density distribution type "B" illustrates that at the same load level (σ) the gear is able to bear various loading number (N), depending on the reliability level of the material grade ($P\ddot{u} = 10\%$, $P\ddot{u} = 50\%$, $P\ddot{u} = 90\%$).

Obviously, the pinion and ring gear are dimensioned, and the toothing geometry is determined so that the following condition should be met at working load level:

$$N_w >> N_2 \tag{1}$$

N_w is number of load-cycles-to-failure of the gear tooth in real working load conditions

(N_T) marks the load cycles at each tooth of the pinion and the gear bears during the test. As the test duration is finite, the following condition exists:

$$N_1 < N_T < N_2 \tag{2}$$

N_T is number of load-cycles-to-failure of the gear tooth in test load condition

Reference 1 also refers to the test time being shortened, on the basis of the Miner-defined accumulated damage rule (Ref. 8). In case of a time-varying load, again according to Miner's rule, the failure occurs when:

$$\frac{u_1}{N_1} + \frac{u_2}{N_2} + \frac{u_3}{N_3} + \ldots + \frac{u_i}{N_i} = 1 \tag{3}$$

where:

u_i Number of load cycles supported by the gear tooth during the i^{th} load is acting

N_i Number of load-cycles-to-failure of the gear tooth if only the i^{th} load would be acting

Equation 3 can be arranged in the following form:

$$\frac{u_1}{N_1} + \frac{u_2}{N_2} + \frac{u_3}{N_3} + \ldots + \frac{u_i}{N_i} = \frac{N_w}{N_w} \tag{3'}$$

In case of parts, which are rolling and sliding under loading (e.g., roller bearings, mating gears, etc.), the relation between lifetime and loading is provided by the inverse power law relationship (Ref. 9):

$$N_i = \frac{1}{C \times M_i^k} \tag{4}$$

where:

$M_i\,(Nm)$ Load magnitude; torque transmitted in case of gears

C Constant dependence on material, macro- and micro-geometrical parameters of gear

k Exponent of loading/torque

Generally accepted (k) values:

For ball bearings (Ref. 13) $k = 3.0$

For roller bearings (Ref. 13) $k = 10/3$

For spur gears $k = 4.0$

For spiral bevel and hypoid gears $k = 5.0$ (possibly $k = 5.6$)

Merging the equations (3') and (4):

$$\sum_{i=1}^{m} M_i^5\, u_i = M_w^5 N_w \tag{5}$$

where:

m Number of loads during real operation

$M_w\,(Nm)$ Torque applied in dimensioning the gear

N_w Expected lifetime in working condition

In dimensioning the pinion and ring gear the equivalent torque was applied, which was determined by the following equation:

$$M_w = \sqrt[5]{\frac{\sum_{i=1}^{m} (M_i^5 \times n_i \times t_i)}{\sum_{i=1}^{m} (n_i \times t_i)}} \tag{6}$$

where:

m Number of service modes

$M_i\,(Nm)$ Torque in i^{th} service mode; specified by user

$n_i\,(1/min)$ Pinion rpm in i^{th} service mode; specified by user

$t_i\,(min)$ Duration of i^{th} service mode; specified by user

$M_w\,(Nm)$ Equivalent/dimensioning torque

In dimensioning, at torque (M_w) the number of the tooth loads shall reach the value (N_w). When determining the value (N_w) proceed as follows:

Equivalent rpm, (Ref. 10):

$$n_w = \frac{T_w}{\frac{t_1}{n_1} + \frac{t_2}{n_2} + \ldots + \frac{t_i}{n_i}} \tag{7}$$

where:

$n_w\,(1/min)$ Equivalent rpm

$T_w\,(min)$ Expected lifetime in service conditions; specified by user

$t_i\,(min)$ Duration of i^{th} service mode; specified by user

$$N_w = n_w \times T_w \tag{8}$$

In Equation 5 the following marking is introduced:

$$D_w = M_w^5 N_w \tag{9}$$

where:

D_w Damage frequency the gear bears in real service mode

As mentioned in the introduction, the test shall be carried out so that the toothing of the pinion and ring gear shall be subject to the same damage in a short test time as it would be subject to during actual operation:

$$D_T = D_w \quad (10)$$

where:

D_T Accumulated extensive damage in pinion and ring gear during testing

D_w Accumulated extensive damage in pinion and ring gear during operation

Merging Equations 5 and 10:

$$\sum_{i=1}^{m} M_{Ti}^{kT} N_{Ti} = M_w^5 N_w \quad (11)$$

where:

t Number of service modes during testing ($t = 1, 2, \ldots$)

k_T Torque exponent in test service mode

The curve of the Wöhler diagram shows that the curve $\sigma(N)$ has different slopes in sections *Limited Life* and *Long Life*. As the test service mode is situated in the interval of *Limited Life*, while the real service mode is situated in the interval of *Long Life,* then:

$$k_T \neq k_w = 5 \quad (12)$$

During the dimensioning, using *FEA T900, Release 8.18*, macro- and micro-geometrical dimensions of the pinion and ring gear are determined, so the number of tooth loads (N_w) shall be reached under the loading (M_w).

None of the parameters on the left side of Equation 11 is known; this study is especially aimed at determining these parameters.

The person who works out the test makes his decision whether he wants to carry out the test at one or several load levels.

The important things here are the experience of the test engineer, technical capabilities of the test equipment, etc.

First, the test procedure at one load level is introduced, and then the test procedure at several levels will be presented.

Testing at one load level

Step 1: Taking into account the heat loss capability of the product during the test; the proper lubrication; and possibilities of the test equipment, the test rpm (n_T) is chosen. Based on economical efficiency, a duration (t_T) for the test is chosen. Thus, the number of tooth loads during the test can be calculated:

$$N_T = n_T \times t_T \quad (13)$$

Step 2: Using the macro- and micro-geometrical data of the pinion and ring gear to be tested, and using the *FEA T900, Release 8.18* software, the value (M_T) is determined so that lifetime of the gear shall be (N_T).

Step 3: In case of single-step testing, Equation 11 can be set up as follows:

$$M_T^{kT} \times N_T = M_w^5 \times N_w \quad (14)$$

Based on Equation 14, the value (k_T) can be determined as a function of the optional chosen (N_T) and the values (M_T) already determined. As in the interval (N_1, N_2), any value (N_T) can optionally be chosen; different values of (k_T) are produced for each chosen value of (N_T).

Step 4: Depending on the loading in service, a pinion and ring gear set with the same macro- and micro-geometry can have various lifetimes (N_w). Based on the above, a work diagram (N_w, k_T, N_T) can be determined for any gear set; e.g. — Figure 2, which was determined for gear set No. 5.

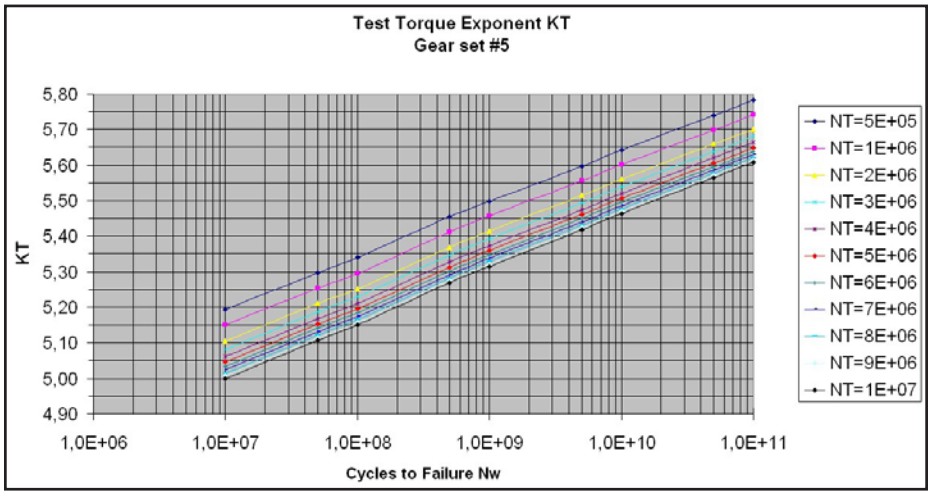

Figure 2 A working diagram for Gear set No. 5.

How to Use the Work Diagram

a. The values (M_w) and (N_w) used in designing the particular gear set are known
b. We want to test in duration (t_T), at rpm (n_T) → $N_T = t_T \times n_T$ load cycles
c. In Figure 2, the value (k_T) is obtained from intersection point of (N_w) and (N_T)
d. Based on Equation 14 the value (M_T) is determined
e. Using a 3-D model of the axle, the magnitude of the deflections occurring under loading (M_T) is checked with FEA analysis

If deflections are not too high, testing can be carried out with the parameters (M_T), (n_T) and (t_T) — determined as described above

If deflections are too high, the values (t_T) and (n_T) shall be increased and then the points (*b*, *c*, *d*, *e*) are to be repeated

In Figure 2 it can be observed that if the number of the test loads is equal to the number of the loads in service ($N_T = N_w = 1{,}0E+07$), then ($k_T = k_w = 5$), this confirms that the work diagram is correct.

Note: Figure 2 was determined in case of $K_W = 5$. If the previous test results confirm that the material grade used and the production accuracy requires other value of (k_w) in the particular case, (e.g. — $k_w = 5.3$), then Figure 2 must be rebuilt.

B. Testing at several load levels (determining test cycle)

In many cases this test method is preferred, as the changing service load conditions are better modeled by this testing mode.

But in this case, we start from the previously determined work diagram (Fig. 2) typical to the particular gear set as follows:

x. Values (N_w) and (D_w) are known from the gear set dimensioning phase.

y. As presented above, based on Miner's rule, the damage suffered in various service modes can be accumulated linearly. Consequently, the value (D_w) can also be divided linearly.

Service modes of real operation are divided into two groups: *Primary* and *Secondary* service modes.

$$D_w = \sum_{i=1}^{u} D_{wi} + D_{ws} \quad (15)$$

where:

u Number of primary service modes, in general $u = 4, 5, \ldots$

$D_{wi} = M_{wi}^5 N_{wi}$ Damage number of i^{th} primary service mode

D_{ws} Accumulated damage number of secondary service modes; negligible

z. Using Equations 7 and 8, equivalent load numbers N_{ws} of secondary service modes are determined

z. Using the work diagram in Figure 2 typical to the particular gearset, the above points (*b*, *c*, *d*, *e*) are separately carried out with the value pairs (D_{wi}, N_{wi}). As a result of the above, we get to the parameters (M_{Tu}, N_{Tu}), of the stepped test load process (u), namely: the equivalent (M_{Tu}, n_{Tu}, t_{Tu}).

After the test with (u) and steps with the parameters (M_{Tu}, n_{Tu}, t_{Tu}) are carried out, the axle will be damaged to exactly the same extent as it would suffer in real service mode.

Tooth Flank Surface Fatigue (Pitting)

Surface fatigue mainly results from loading (torque, rpm, time); material grade of the gear; the flank topography; and on the quality of production (surface roughness, surface harness).

On each gear set involved in this study we have investigated what torque level is required at the same value (N_T) to induce bending fatigue or pitting by using FEA analyzing software (Ref. 5) and macro- and micro-geometry of the gear set (Fig. 3).

The diagram (Fig. 3) shows that significantly higher torque is required to have pitting than to have damage (bending fatigue) occurring. In other words, during the test bending fatigue appears earlier than pitting. For this reason, in every case the test parameters of bending fatigue shall be used. The same is established in Reference 10 as well.

Note: It might happen that during the test, pitting appears earlier than bending fatigue, if:

Test torque (M_T) is too high and point-surface-origin macro-pitting appears on the pinion root due to extreme deflections (Ref. 11).

For some design errors, convexity of the tooth surfaces is too high; the designer has not adhered to the recommended values (Ref. 12).

For some production errors, the tooth surface roughness is of poor quality, and metal to metal contact is allowed between the mating tooth surfaces, which can lead to local seams.

The oil quality is not proper, too much low viscosity at the testing temperature.

Influence of Macro- and Micro-Geometry of Toothing on the Test Torque Exponent

We have already mentioned the influence of macro- and micro-geometry of the toothing on the value of the test torque exponent, (k_T). In order to demonstrate this effect the following process is carried out for each pinion and gear set shown in the Table 1:

a. Optional value of (N_w) was chosen (e.g. — $N_w = 5 \times 10^9$). By using software (Ref. 5), the value of service torque (M_w) was determined, at this load the pinion and gear set will withstand the load cycles ($N_w = 5 \times 10^9$).

b. Optional value of (N_T) was chosen (e.g. — $N_T = 2 \times 10^6$). By using *FEA T900, Release 8.18* software, the value of test torque (M_T) was determined, at this load the pinion and gear set will withstand the load cycles ($N_T = 2 \times 10^6$).

c. Based on the diagram (Fig. 2) typical to the particular gear set, the value (k_T) was determined by means of the values (N_w) and (N_T).

Results are presented in Fig. 4:

The diagram in Figure 4 shows that macro- and microgeometry of the toothing has significant effect on the value of test torque exponent, (k_T), and hereby on determination of the test parameters. It means that the above process is gear-specific, namely the diagram as in Figure 2 shall separately be determined for each pinion and gear set. The results shown in Figure 4 reflect the cumulated effects of macro- and micro-geometry.

The diagram in Figure 4 confirms that the value of *k* added in (Ref. 9) depends not only on the material grade, but on macro- and micro-geometrical data of toothing as well, as each gear involved in the current study was made of material 20MnCr5/DIN17210.

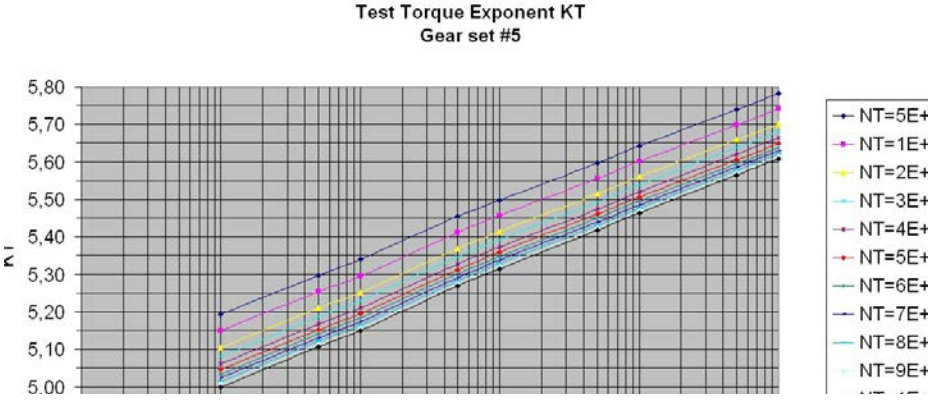

Figure 3 Bending-pitting test torque results obtained with Gear set No. 5.

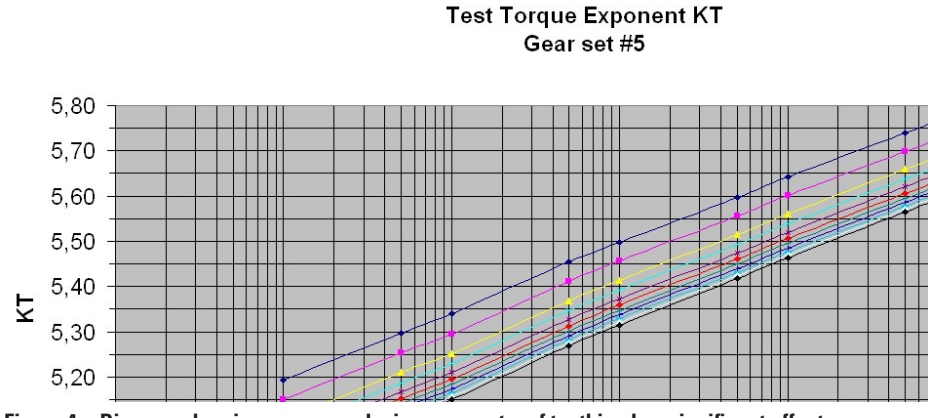

Figure 4 Diagram showing macro- and micro-geometry of toothing has significant effect on value of test torque exponent (k_T), and thus on determination of test parameters.

Higher Influence of High Loads on Damage

There are several studies referring to high loads causing extremely high damage (Refs. 1 and 11). A pinion and gear dimensioned to known parameters (M_w, N_w) can be tested for longer (high value N_T), or shorter (low value N_T) test time. In order to satisfy Equation 14, the lower the value (N_T), the higher the value (M_T) should be.

So, the low values (N_T) mean high values (M_T).

If the conjugate values (K_T,N_T,N_w) in diagram seen in Figure 2 are shown so that the relation (K_T,N_T) is shown at various constant value (N_w), we get to the following diagram:

The diagram in Figure 5 shows that the lower the value (N_T) is, i.e. — the higher the loading (M_T) is, the higher is the exponent (k_T) — which confirms that the high load will really cause extremely high damage due to two reasons: 1) high (M_T) value and 2) higher torque exponent value (k_T).

Conclusions

A procedure is introduced allowing the determination of validation test parameters of spiral bevel and hypoid gears in single-reduction axles.

The study represents that various torque exponents shall be used in sections *Limited Life* and *Long Life* of the Wöhler diagram, when accumulated damage number is calculated. By its structure, the work diagram (Fig. 2) allows determination of the value (k_T).

The procedure takes into account the material grade of gears and macro- and micro-geometrical data of toothing.

The above procedure assures that during the test the gear set shall be subject to the same damage as will be subject to in real service; *realistic* character of testing is provided.

Test parameters resulting from application of this procedure are typical to the particular gear set only. Thus the test parameters determined are always *gear-set-specific*.

In case of the same gear set, quality of material and production always show certain scattering. That's why it is practical to carry out the validation test on at least three sets. The set of values (N_T) obtained as a result of testing shall be processed by means of some statistical method (e.g., Weibull analysis).

In the interval of *Limited Life,* the value (k_T) varies with the number of test tooth loads (N_T), which is a function of the applied load level in case of the particular toothing geometry. This result refers to the non-linear damage model (Ref. 14). The diagram in Figure 5 confirms that the high load causes high damage not only by itself, but due to the higher exponent (k_T) as well.

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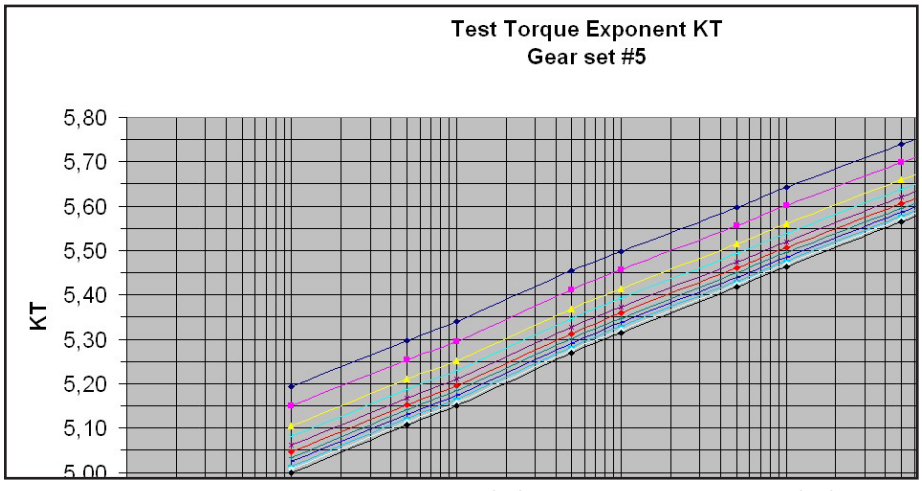

Figure 5 Diagram showing that the lower the value (N_T), i.e. — the higher the loading (M_T) — the higher the exponent (k_T); this confirms that the high load will cause extremely high damage due to two reasons: 1) high (M_T) value and 2) higher torque exponent value (k_T).

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First International Involute Gear Comparison

F. Härtig and K. Kniel

Measurement institutions of seven different countries — China, Germany, Japan, Thailand, Ukraine, United Kingdom and the U.S. — participated in the implementation of the first international comparison of involute gear measurement standards. The German metrology institute Physikalisch-Technische Bundesanstalt (PTB) was chosen as the pilot laboratory as well as the organizer. Three typical involute gear measurement standards provided by the PTB were deployed for this comparison: a profile, a helix and a pitch measurement standard. In the final analysis, of the results obtained from all participants, the weighted mean was evaluated as reference value for all 28 measured parameters. However, besides the measurement standards, the measured parameters, and, most importantly, some of the comparison results from all participants are anonymously presented. Furthermore, mishandling of the measurement standards as occurred during the comparison will be illustrated.

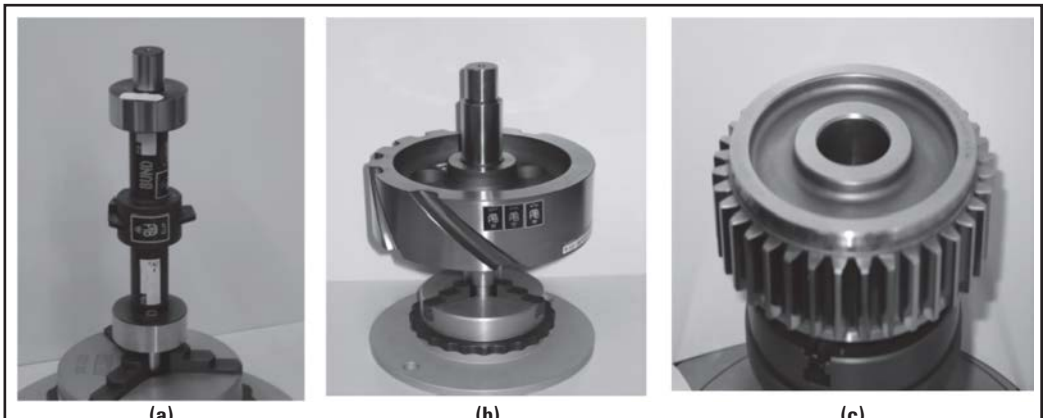
Background

International comparisons are required to ensure the compatibility and reliability of measurement results among different countries. In the field of high accurate involute gear metrology which is of enormous economic importance, no international comparison measurement has been conducted so far. Therefore, it was imperative to organize this comparison among five national metrology institutes (Germany (PTB), China (NIM), Japan (AIST), Thailand (NIMT), Ukraine (NSC)), one designated institute (United Kingdom (NGML)) and one competent measurement institutes (U.S. (Y12)). The rules of the comparison following internationally agreed documents published by the Bureau international des Poids et Mesures (BIPM) (Ref. 1) which task is to ensure world-wide conformity of measurements and their traceability to the International System of Units (SI). The BIPM does this with the authority of the Convention of the Metre, a diplomatic treaty between 55 nations. The terminology and symbols used in this paper follow actual documents of the BIPM and the International organization for Standardization (ISO) (Refs. 2–5).

This first comparison was initiated by the PTB. Following the regional meeting in 2007, the Technical Committee of Length (TC-L) of EURAMET (Ref. 6) decided to implement this comparison as regional comparison with the involvement of other non-European participants. The PTB was chosen as pilot laboratory and organizer for the intercomparison. The choice of measurement standards to be used, parameters to be measured, potential participants and time schedule were all decided at the subsequent meetings, while the protocol adopted was later communicated to all participants. Three involute gear measurement standards which are typically used in industry were chosen for this comparison. Each participant was allocated equal amount of specified time to carry out the measurements before the measurement standards had to be sent to the next participant. The measurement comparison was implemented from July 2008 to September 2010.

The measurement standards deployed for this comparison represents the three most typically measurement standards in industry for involute gear metrology: profile, helix and pitch measurement standard (Fig. 1). These measurement standards were developed by the PTB and manufactured from high-alloy steel more than 30 years ago. The choice of helix, profile and pitch measurement standards for this measurement comparison and their suitability were based on a number of factors. Among them are the measurement accuracies and long history of measurement stability which have been observed by the PTB since the time they were manufactured. Furthermore, geometrical parameters of these measurement standards are other important attributes for their choice. Particularly their reference bands and flanks possessed significantly small form and roughness errors. All participants were asked to measure each of the measurement standards and to evaluate their results according to References 7–10.

Profile measurement standard. Figure 1a shows the involute profile measure-



(a) (b) (c)

Figure 1 (a) Profile measurement standard; (b) Helix measurement standard; (c) Pitch measurement standard.

ment standard. In a classical design it consists of two base discs each of d_b 49,997 mm and one centered, involute shape. Table 1 delineates gear parameters that are necessary to measure the profile measurement standard on a coordinate measuring machine (CMM) or other gear measuring machines (GMM). The following typical measurement parameters for the profile evaluation were chosen according to (Refs. 7–9):

- Profile slope deviation $f_{H\alpha}$ in µm
- Profile form deviation $f_{f\alpha}$ in µm
- Profile total deviation F_α in µm

Table 1 Parameters of the three measurement standards

Measurement Standard	Gear Parameter	Value			
Profile	Pressure angle α_n	20°			
	Helix angle β	0°			
	Normal module m_n	2.9559134 mm			
	Face width b	3,2 mm			
	Number of teeth z	18			
Helix	Helix angle β	0°	15°	30°	45°
	Face width b	75 mm	75 mm	75 mm	75 mm
	Transversal module m_t	4 mm	4 mm	4 mm	4 mm
	Number of teeth z	50	50	50	50
Pitch	Pressure angle α_n	20°	20°	20°	20°
	Normal module m_n	4 mm			
	Number of teeth z	37			
	Tip diameter d_a	156 mm			
	Facewidth b	32 mm			
	Pressure angle α_n	20°			

Measurement Procedure

This profile measurement standard was measured along the surface of left flank at the centre of the tooth. The measurement points were selected equidistance over the length of roll. A spherical stylus tip of 8 mm in diameter was chosen for the measurement because it offers guaranteed comparability while being observed since the profile measurement standard has been acquired, and secondly, it enables reduction of the influence of form errors on the flank surface. The evaluated parameters were measured within the following limits:

- Start of profile evaluation (expressed in length of roll): 1 mm
- End of profile evaluation (expressed in length of roll): 18 mm

Measurement References

The reference axis of the measurement standard was numerically determined. For this purpose, the reference bands of approximately 50 mm in diameter of the profile measurement standard were probed in the centre of the discs. In each of the transverse planes at least 36 points at equally spaced distances were measured over the circumference. Through the points, a circle was fitted in accordance with the least squares method and the centre was defined. The axis of the gear measurement standard was defined from the centres of the two circles. The reference point for the height of the profile measurement was determined at the top of the tooth, 2 mm from the tip circle in the direction of the reference axis.

Helix measurement standard. Figure 1b presents a classical helix measurement standard; it embodies four different helix angles (0°, 15°, 30°, 45°), left hand as well as right hand. The measurements were performed only on the right flank. The corresponding gear parameters are listed in Table 1. The following typical measurement parameters for the helix evaluation were chosen according to (Refs. 7–9):

- helix slope deviation $f_{H\beta}$ in µm
- helix form deviation $f_{f\beta}$ in µm
- helix total deviation F_β in µm

Measurement Procedure

The helix measurements were performed on a measurement cylinder at $d_M = 204$ mm. The diameter of the stylus sphere used is approximately 8.0 mm. The evaluation is conducted at the range of $L_\beta = 70$ mm.

Measurement References

The reference axis of the measurement standard was numerically determined. For this purpose, the two reference cylinders of the gear measurement standard were probed. The measurement points were arranged in two end face planes. The end face planes were located at a distance of 43 mm from the lateral surface of the cylinders with 30 mm in diameter. In each of these transversal planes at least 36 points, which were distributed equally spaced over the circumference, were recorded. Through the points, a circle was fitted in accordance with the least squares method. The axis of the gear measurement standard was defined from the centres of the two circles.

Pitch measurement standard. Figure 1c illustrates the pitch measurement standard. The specified gearing parameters embodied in the measurement standard are delineated in Table 1. The following typical measurement parameters for the pitch evaluation were chosen according to (Refs. 7 and 10):

- Cumulative pitch deviation F_P in µm (left and right flank)
- Single pitch deviation f_P in µm (left and right flank)

Measurement Procedure

The pitch measurement standard was mounted on the measuring machine by fixing it with an internal three-jaw chuck at the inner side of the hollow shaft. The pitch was measured in a single-flank mode. The diameter of stylus sphere used was 3.0 mm, while the diameter of the measurement circle was $d_m = 148$ mm.

References

The reference axis of the measurement standard was numerically determined. For this purpose, two circles at two different locations in the bore were measured — one at 10 mm from the reference surface (upper side) of the gear measurement standard, the other at 40 mm. In each case at least 36 points — distributed and equally spaced over the circumference — were recorded. Through these points a circle was fitted in accordance with the least squares method and the center was determined. The axis of the gear measurement standard was defined from the center of each of the two circles.

Measurement and handling instructions. Taking into account the geometrical parameters of each measurement standard, as well as the technical description with all measurement procedures, all valid guidelines and standards for the comparison were prepared and distributed to all participants. Lengths

are required to be measured traceable to the latest realization of the meter as set out in the current "Mise en Pratique" (Ref. 11), irrespective of the instrument used. The measurement of the temperature is based on use of the international temperature scale of 1990 (ITS-90). Similarly, the uncertainty of measurement is estimated according to the ISO Guide to the Expression of Uncertainty of Measurement (Ref. 12).

The procedures for the packaging and handling of the measurement standards were also stated in the technical description adopted for the comparison. The measurement standards were sent to the participants in a customized, self-containment case designed for safe transportation. In addition, the case prevents surface scratches and contamination to the measurement standards. The packaging cases are all portable enough to be sent by any courier services.

Similarly, recommendations on physical inspections of the measurement standards both prior to and after measurement were given to the participants. The circulation of the measurement standards was carried out in a loop among the partners. Each partner was given sufficient time to conduct the measurements before sending the measurement standards to the next partner.

Evaluation of reference values and comparison. The reference values must be determined on the basis of the received measurement results. The guidelines — as laid down by the BIPM — allow the use of different methods for the evaluation of reference values. These methods include simple mean, weighted mean, and median. For the sake of consistency one method — the weighted mean $x_{ref,w}$ (Eq. 1) — was chosen as an appropriate method. It considers the n measurement values x_i and the corresponding, expanded measurement uncertainties U_i, which ultimately reflect the measurement condition and competence of each of the participating laboratories.

$$x_{ref,w} = \sum_{i=1}^{n} \frac{x_i}{U_i^2} \cdot \frac{1}{\sum_{i=1}^{n} \frac{1}{U_i^2}} \quad (1)$$

The calculation of the reference value for each measurand (*Ed.'s Note: A physical quantity, property, or condition that is measured.*) was generally based on all submitted measurement results, with the exception of three helix measurands. Following a request by one participant for these measurands, their measurement results were not considered for calculating the corresponding reference values. Nevertheless, according to the regulations of MRA guidelines for CIPM, key comparisons of the measurement results are presented in the final report.

A check for statistical consistency of the results with their associated uncertainties can be made by calculation of the normalized error E_n for each laboratory and for each measurand. The E_n value indicates if the measurement value and its corresponding measurement uncertainty are comparable to the results of the other NMIs. This means that the E_n value is the internationally agreed upon parameter that shows whether the individual value x_i — together with its determined expanded measurement uncertainty U_i, and the expanded measurement uncertainty of the corresponding reference value $U_{ref,\,w}$ — are reliable in comparison with the calculated reference value $x_{ref,\,w}$. The absolute value IE_nI must be less than 1 to meet this quality criterion for indicating that the laboratory is capable of obtaining a qualified result.

According to publications and guidelines, there are slightly different approaches for the calculation of the E_n value; they concern the use of:

Standard measurement uncertainty or the expanded measurement uncertainty

Arithmetic operator in the denominator ("+" or "-")

Due to prior agreement with the EURAMET TC-L (Ref. 6) and other experts and guidelines for measurement uncertainty evaluation (Refs. 13–15), the E_n value was calculated according to the approach shown in Equation 2:

Table 2 Overview of the comparability of the measurement results; grey-colored cells indicate where comparability factor E_n is not fulfilled

		a	b	c	d	e	f	g
profile	$f_{H\alpha}$	0.14	0.06	0.17	0.51	0.32	0.71	1.53
	$f_{f\alpha}$	0.14	0.09	0.16	0.00	0.14	0.07	0.21
	$F\alpha$	0.05	0.02	0.18	0.07	0.09	0.32	0.14
helix 0°	$f_{H\beta}$	0.06	0.46	0.17	0.21	0.38	1.09	no results
	$f_{f\beta}$	0.35	0.03	0.33	0.26	0.43	0.27	
	F_β	0.36	0.01	0.25	0.23	0.32	0.20	
helix 15° left hand	$f_{H\beta}$	0.25	0.50	0.13	0.43	0.30	0.48	
	$f_{f\beta}$	0.07	0.17	0.25	0.14	0.15	0.04	
	F_β	0.39	0.44	0.11	0.22	0.40	0.38	
helix 15° right hand	$f_{H\beta}$	0.36	0.18	0.03	0.41	0.18	0.50	
	$f_{f\beta}$	0.02	0.10	0.32	0.23	0.39	0.52	
	F_β	0.35	0.02	0.08	0.43	0.13	0.29	
helix 30° left hand	$f_{H\beta}$	1.34	0.77	0.34	1.04	0.39	0.60	
	$f_{f\beta}$	0.10	0.10	0.54	0.48	0.21	0.33	
	F_β	0.52	0.69	0.04	0.69	0.62	0.76	
helix 30° right hand	$f_{H\beta}$	1.24	0.18	0.07	0.65	1.18	0.73	
	$f_{f\beta}$	0.14	0.16	0.47	0.19	0.19	0.10	
	F_β	0.25	0.20	0.07	0.45	0.91	0.69	
helix 45° left hand	$f_{H\beta}$	4.06	0.14	0.03	1.63	0.98	1.70	
	$f_{f\beta}$	0.50	0.37	0.43	0.12	0.04	0.24	
	F_β	1.18	0.19	0.09	1.44	1.00	1.57	
helix 45° right hand	$f_{H\beta}$	0.44	0.15	0.09	0.79	0.24	0.56	
	$f_{f\beta}$	0.01	0.36	0.08	0.74	0.22	0.10	
	F_β	0.22	0.33	0.05	0.05	0.35	0.02	
pitch left flank	F_P	1.56	0.13	0.32	0.13	0.39	0.06	2.21
	f_P	0.36	0.08	0.03	0.01	0.20	0.07	1.00
pitch right flank	F_P	0.28	0.08	0.12	0.01	0.16	0.22	1.38
	f_P	0.19	0.12	0.09	0.03	0.16	0.15	0.43
$\sum E_n>1$		5	0	0	3	2	3	(4+21)

$$E_n(k=2)=\frac{1}{k}\frac{x_i-x_{ref}}{\sqrt{\left|u_i^2-u_{ref}^2\right|}}=\frac{x_i-x_{ref,w}}{\sqrt{\left|u_i^2-u_{ref,w}^2\right|}} \quad (2)$$

wherein is

$$U_{ref,w}(k=2)=2\cdot\frac{1}{\sum_{i=1}^{n}\frac{1}{U_i^2}}$$

As recommended by the WG-MRA "Guidance Document" GD-1 (Ref. 15), the calculation of the E_n value was based on the expanded measurement uncertainty. Moreover, in a case of correlation between the participant measurement results and the weighted mean reference value, the measurement uncertainty contributions in the denominator must be subtracted.

Measurement Results and Analysis

The total measured parameters for all the measurement standards (profile, helix and pitch) — 28 — were analyzed and evaluated. E_n values for each participant were evaluated (Table 2). The cells of the measurement parameters are highlighted in grey when the IE_nI factor is greater than 1.

The most relevant values that indicate the geometrical competence and correct evaluation of each participant are the results of the slope error for profile and helix measurements, and the total error for pitch measurements. The robustness of the slope evaluation for profile and helix measurements is based on the regression algorithm where a single outlier has only a small effect. However, for form and total errors the influence of a single outlier is immense. Yet for pitch measurement evaluation, the probability that an outlier influences the value of the total pitch error is much smaller, as it appears in single pitch error.

Table 2 shows that the magnitude of the evaluated E_n- values based on the participant results is, in some cases, considerably high, meaning the results were either too far from the reference value and/or the estimated measurement uncertainties were underestimated; neither of these cases is acceptable.

However, profile and pitch show more consistency, as compared to helix measurement parameters. The discrepancy of the helix results is more pronounced at higher angle of the helix; this effect cannot be sufficiently explained at this stage, as only one flank (helix angle 45° left) is affected. One possible assumption is that such a discrepancy could be caused by the geometrical errors of the measuring system.

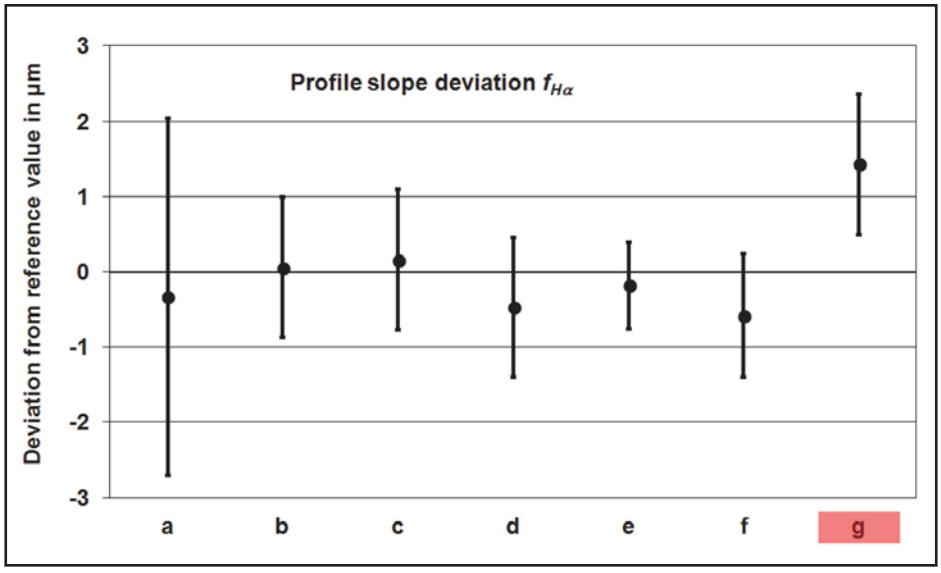


Figure 2 Slope deviations of the profile measurement s.

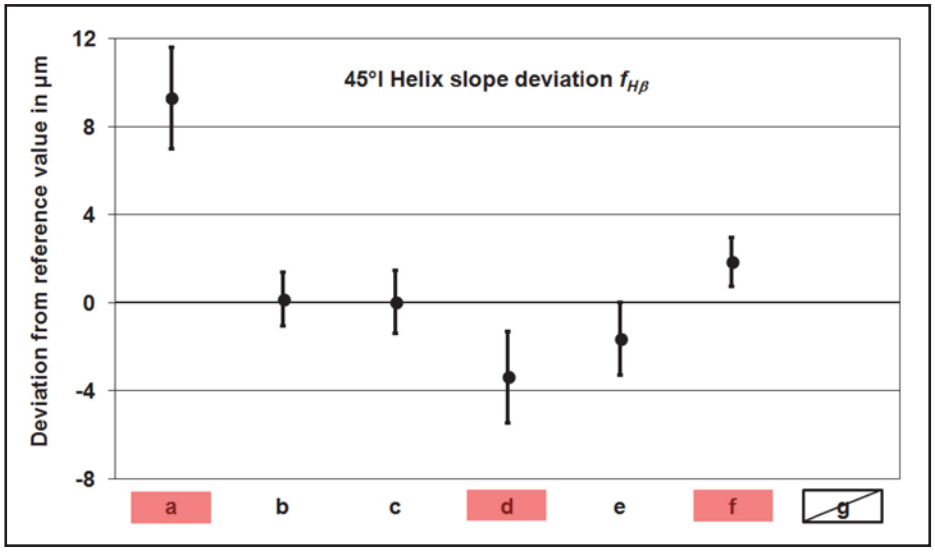


Figure 3 Slope deviations of the helix measurements — 45° left hand, right flank.

Figures 2 and 3 show results for the profile slope, and the 45° left-hand, helix slope, deviations, respectively. The error bars represent the combined, expanded measurement uncertainties U_i^* based on the quadratic sum of the single standard measurement uncertainty u_i of each participant, and the standard measurement uncertainty of the respective reference value $u_{ref,w}$ (Eq. 3).

$$U_i^*=2\cdot\sqrt{\left|u_i^2-u_{ref,w}^2\right|} \quad (3)$$

Participants who don't fulfil the comparability value are highlighted; participants who don't measure the respective measure and are crossed out.

In case of the profile slope deviation, most of the measurement values disperse in the limit of 1 µm with the exception of one particular measurement. Moreover, it shows that the measurement uncertainties from most of the participants were adequately estimated within the optimum range.

Figure 3 shows results of the helix measurements at the right flank of the left-hand 45° helix. It could be seen that the values and the estimated measurement uncertainties do not overlap sufficiently to fulfil the E_n criterion for three participants. The range of results is approximately 12 µm; this value is five times greater that the allowed tolerance accura-

cy grade, according to ISO 1328-1 (Ref. 7) of the quality requirement.

Damage to the measurement standards. Despite the precautionary measures that emphasized good handling of the measurement standards by all partners, all measurement standards suffered a number of surface damages. Moreover, instead of the customized case provided by the pilot institute, one particular partner used a completely unsuitable package case with the intention of reducing the shipping cost by reducing packaging dimension and weight. The consequences of such negligence are highly visible (Fig. 4). This example should serve to re-emphasize the importance of maintaining good care of a measurement standard as "a master piece."

When the measurement standards were returned to PTB, they were re-measured and evaluated. Fortunately, the results were almost unchanged; most of the damage was found outside the surfaces to be measured. One future recommendation: more attention and emphasis should be given to safety and handling.

Figure 4 Damages inflicted on the measurement standards surface.

Summary and Outlook

- The first international comparison for involute gears — organized by EURAMET — has been successfully implemented.
- The results presented here show that the criteria for comparability were fulfilled; however, discrepancies in the values of the compared measurement parameters of some participants were sizable and fell below the expectations.
- The mishandling of the measurement standards by one participant demonstrated the need to improve the metrological skills of this particular institute.
- In summary, the comparison shows that some participants are able to calibrate gear measurement standards with the required level of competencies. Contrarily, some participants were unable to adequately demonstrate the level of competence required in terms of their measurement values, as well as in the stated measurement uncertainties.
- Caveats aside, the comparison has been accepted for registration as a Supplementary Comparison and will be published on the BIPM key comparison database (KCDB) (Ref. 16).

Acknowledgements. *The pilot institute expresses gratitude for the support of EURAMET and the Consultative Committee for Length (CCL) of the BIPM that made the comparison a success. Also, we would like to acknowledge the internal support from PTB, as well as colleagues from the coordinate metrology department who have contributed in ensuring prompt control and analysis of the participant results. Most importantly, we express our thanks to all participants in the comparison for the scientific and financial commitment that contributed to the success of the comparison. It is a great step forward in a positive direction.*

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Bernhard Kapp

(1921-2014)

Dr.-Ing. E. H. Bernhard Kapp, a passionate entrepenuer and founder of the Kapp Group, passed away on July 13, 2014 at the age of 93. His inventiveness and leadership spanned over 50 years in the machine tool industry. Following five years in the military and completing his studies, Dr. Kapp started his professional life at the firm Waldrich in Coburg as a design engineer. He became a shareholder and general manager of the company at the age of 29. He successfully led this company for 27 years with his brother-in-law Otto Waldrich. Also at this time, in 1953 he founded his own company, Kapp & Co in Coburg, motivated by the urge to create something of his own, and to generate jobs. Today the Kapp Group is among the world's leading manufacturers of machine tools for hard and soft finishing of gears and profiles with 850 employees worldwide and facilities in Germany, USA, Brazil, Japan and China.

Dr. Kapp firmly believed qualified educational support and technical training is the most important investment for the future. With this philosophy he started an apprenticeship workshop within his manufacturing facility in Coburg. Dr. Kapp's expertise and leadership was also in demand by other companies. Numerous national and international companies and institutions have named him to their management and supervisory boards including the German Trade Fair and Exhibition AG, Gildemeister, Fiat, Krupp Hoesch, Iveco, Internazionale Holding Fiat, Werner & Pfleiderer, Trumpf, the Ifo Institute, the Fraunhofer Society and the University of Coburg. Dr. Kapp's ideals continue to flourish today, with the success of the Kapp Group under the leadership of his son, Martin Kapp. The machine tool and gear industries have lost a revered man, and true pioneer with the passing of Dr. Bernhard Kapp.

Sandvik

CELEBRATES GRAND OPENING OF U.S. HEADQUARTERS

Sandvik, Inc. celebrated the grand opening of its new U.S. headquarters in Fair Lawn, New Jersey. The 100,000 square foot facility contains a combination of modern office space, extensive meeting facilities and a state of the art Productivity Center and Aerospace Application Center for customer training, engineering and process development. Among the many attending the event were Congressman Scott Garrett, Mayor John Cosgrove and Sandvik CEO Olof Faxander. Garrett praised Sandvik's continued commitment to the community and local economy since the 1950's and presented the company with a Certificate of Congressional Recognition. Cosgrove recognized the company with a Proclamation declaring July 1, 2014 "Sandvik, Inc. Day."

"This is an important milestone and I am so pleased to commend Sandvik on this outstanding accomplishment," Garrett said. "With its customer-centric approach to business and commitment to innovation, Sandvik has been a vital asset to New Jersey and the surrounding communities." Mayor Cosgrove added, "Sandvik is a well-known and well respected business entity that gives back to the Fair Lawn community."

In design and construction of the new building Sandvik made energy efficiency and sustainability a priority. Over 75 percent of all waste generated from the construction was diverted from landfills by reusing, recycling, and repurposing materials. Furthermore, Sandvik donated the majority of the furnishing and equipment from previous headquarters to local charities, schools, and fire departments throughout the community. "Fair Lawn and New Jersey have been home to Sandvik for nearly 60 years. Like our beloved red oak in front of the main entrance, Sandvik looks forward to being part of the Fair Lawn community for many years to come," states Askin.

Mitutoyo America

OPENS HOUSTON SOLUTION CENTER

Mitutoyo America Corporation is pleased to announce the opening of a new M3 Solution Center in the south central United States region, located in Houston, Texas. This new, 8,000 sq. ft. center is conveniently located minutes from the George Bush Intercontinental Airport. Customers can schedule appointments for product demonstrations and acquire assistance with measuring solutions and application challenges. "Our goal is to provide timely metrology solutions to our customers, in a region that is home to a booming oil industry. The benefit of opening this new M3 Solution Center is the acces-

sibility in offering experienced metrology specialists to our customers that could provide up to date and knowledgeable metrology information for any situation they may encounter," says Alan Jackson, regional sales manager, South Central region. For more information, visit *www.mitutoyo.com.*

Timken

COMPLETES SPINOFF OF TIMKENSTEEL CORP.

The Timken Company recently announced that it has completed its spinoff of TimkenSteel Corporation, which begins trading as an independent public company tomorrow on the New York Stock Exchange under the symbol "TMST."

"The spinoff offers exceptional opportunity to drive value for both The Timken Company and TimkenSteel Corporation, their respective employees and shareholders," said **Richard G. Kyle,** president and chief executive officer of The Timken Company. "We offer congratulations to Tim Timken and the entire TimkenSteel team on their launch as an independent steel company, and wish them every success in advancing their leadership position as a special bar quality steelmaker. At the same time, we extend a special thanks to Timken associates for their hard work and commitment in successfully facilitating the separation."

Timken announced in September 2013 that it planned to separate its steel business in a tax-free spinoff to Timken shareholders. This spring, the Timken board of directors declared a distribution of all outstanding common shares of TimkenSteel Corporation through a dividend. At the close of business on June 30, Timken shareholders received one common share of TimkenSteel Corporation for every two common shares of Timken they held as of the close of business on June 23, 2014.

TIMKEN

After the spinoff, The Timken Company will continue to focus on its bearings business as well as power transmission products and related services, which include gearboxes, chain, lubrication systems, transmissions, and other related rebuild and maintenance services. "We are committed to creating value

for our customers and our shareholders," said Kyle. "The separation is now behind us and we are focused on growing our business in targeted markets across the world."

VDMA Machine Vision Board

WELCOMES NEW MEMBERS

Donato Montanari, general manager of the Machine Vision Business Unit of Datalogic Automation in Italy, and **Lou Hermans,** COO at CMOSIS in Belgium were recently elected by the VDMA Machine Vision members to strengthen the board of the VDMA Machine Vision unit. The election was conducted as a result of the decision taken at the last Members' Assembly of VDMA Robotics + Automation with regard to the opening of the association to European members. "Becoming a member of VDMA is natural for CMOSIS since we already have a very good working relationship with many members of its Machine Vision Group. There is a big potential for stepping up the technological leadership of our group if we work closely together, and VDMA Machine Vision provides an excellent platform for us to do so," said Hermanns.

Montanari added: "I would like to thank the VDMA and its members for the opportunity of serving on the board. As a non-German member, I will make it my first goal to increase the number of non-German companies in the association. I am convinced that European companies can bring a different and complementary perspective to the machine vision industry."

According to the results of the recent VDMA Machine Vision Market Survey, the industry turnover of the machine vision industry in Germany increased its turnover by 8% in 2013 reaching the mark of 1.6 billion euro. The growth impetus came mostly from exports: While domestic turnover stagnated, exports from Germany went up by 15% in 2013. The export share rose from 55% to a new all-time high of 58%. Due to a very favorable order intake in the first five months of this year, the German machine vision suppliers are expected to expand their sales volume by 10% in 2014 exceeding a sector turnover

of close to 1.8 billion Euro. According to the latest VDMA market survey, the sector turnover in Europe grew even by 10%, with a further growth expectation of 12% in 2014.

Mazak

SOUTHWEST EVENT FOCUSES ON LEAN MANUFACTURING

Mazak invited manufacturers to its Discover More with Mazak event in July at the company's Southwest Technology Center in Houston, Texas. Attendees had the opportunity to learn how to shorten lead times, increase part quality and boost profitability using the company's highly versatile machine tools and applications expertise. The company demonstrated the latest multi-tasking, five-axis, milling and turning processes on Mazak machines including the Integrex i-300S multi-tasking machine that employs a second spindle to efficiently produce medium to large complex parts; the Quick Turn Nexus 550 MY turning center that features milling capability and Y-axis functionality to process long, large-diameter parts in single setups; the

Orbitec 20 large part machining center that can perform a variety of operations on difficult-to-rotate workpieces in a single setup; and the space-saving Vertical Center Universal 400A 5X that uses a five-axis rotary/tilt table.

Applications engineers were also available to discuss new ways attendees can streamline their operations. For example, Mazak machines can perform multiple processes in a single setup, which helps minimize material handling and work-in-process inventory. Also, the company's user-friendly CNC technology gives operators the flexibility to change setups on Mazak machines very quickly. Furthermore, the company encouraged attendees to present their part-production challenges so its engineers could offer solutions for overcoming such difficulties.

H-D Advanced Manufacturing

ACQUIRES SUNGEAR, INC.

H-D Advanced Manufacturing Company (H-D) has acquired Sungear, Inc. (Sungear), a manufacturer of high precision gears and assemblies for the aerospace industry. Sungear is the

fourth acquisition completed under the H-D platform, joining Overton Chicago Gear Corporation, a manufacturer of large, high-precision gears and gearboxes, Innovative Mechanical Solutions (iMECH), a manufacturer of highly engineered, custom bearings for the directional drilling motor industry and Leading Edge Heat Treating Services Ltd., a provider of heat treating solutions.

Headquartered in San Diego, CA, Sungear manufactures complex, high quality, precision gear components for many of the world's leading aerospace suppliers. The company's loose gearing and gear assembly products perform critical functions in engine starters, auxiliary power units and other applications. Sungear manufactures products for both OEM and aftermarket applications across a broad range of commercial and defense platforms. Sungear's current President, Roger Gizicki, will continue to lead Sungear within H-D's gearing division.

"The addition of Sungear's expertise and reputation for quality with some of the world's largest aerospace customers advances H-D's goal of becoming a leading global manufacturer of mission-critical products across a wide range of industries," said H-D CEO, Chris DiSantis.

"After over 30 years of growth and relationship development as a family-owned business, I am thrilled to lead Sungear in its next chapter as a part of H-D," said Gizicki. "We are eager to partner with H-D and its tremendous financial, operational and business development resources that can help us take Sungear to new heights for our customers."

Trescal

ANNOUNCES ACQUISITION STRATEGY IN NORTH AMERICA

Trescal, the international specialist in calibration services, today announces the acquisition of US company Master Metrology, Inc. and Gefran's Italian metrology assets. Respectively, based in Towson (Maryland, USA) and Provaglio d'Iseo (Italy) and A2LA and Accredia accredited. With an annual turnover of $2 million and 16 employees including 7 engineers, Master Metrology increases Trescal's growing presence in the US and also broadens its technical offer, notably in the dimensional and torque domains.

Gefran's Italian metrology laboratory, with annual sales of €800,000 and 5 employees including 4 engineers, will be merged with Trescal's existing laboratory in Brescia, growing its lab-based offer in Italy's humidity, temperature and climatic chamber calibration sector, within laboratory and on site. The deals were completed with the support of Trescal's majority shareholder, Ardian, the premium independent private investment company. They are the fifth and the sixth build-up transactions executed following Ardian's acquisition of Trescal in July 2013.

Guillaume Caroit, General Secretary of Trescal Group, said: "These acquisitions fit perfectly with our development strategy, both in the US where we hope to achieve a leading position in the next two years and also in Europe, where our ambition is to extend the technical offer to our clients. We are working on two or three build-up to be closed before the end of the year."

Raymond Wood, Founder and President of Master Metrology added: "Master Metrology is one of a number of fast growing companies that are contributing to the resurgence of Maryland manufacturing. The acquisition by Trescal expands our market-leading position and gives our customers access to greater technical capability across a broader geographic footprint." Thibault Basquin, Managing Director in the Mid Cap Buyout team at Ardian, said: "Trescal's ambitious international growth strategy reflects both the strength of Trescal's management team and the level of support which Ardian always gives its portfolio companies."

PMA

EXPECTS SLIGHT DOWNTURN IN METALFORMING BUSINESS CONDITIONS

According to the June 2014 Precision Metalforming Association (PMA) Business Conditions Report, metalforming companies expect a slight downturn in business conditions during the next three months. Conducted monthly, the report is an economic indicator for manufacturing, sampling 124 metalforming companies in the United States and Canada.

The June report shows that 31% of participants predict that economic activity will improve during the next three months (down from 33% in May), 54% expect that activity will remain unchanged (down from 60% last month) and 15% believe that economic activity will decline (up from 7% in May).

Metalforming companies also forecast a dip in incoming orders during the next three months, with 37% predicting an increase in orders (compared to 43% in May), 45% expecting no change (up from 43% in May) and 18% predicting a decrease in orders (up from 14% in May).

Current average daily shipping levels declined in June. Thirty-five percent of participants report that shipping levels are above levels of three months ago (down from 45% in May), 46% report that levels are the same as three months ago (up from 40% last month), and 19% report a decrease in shipping levels (up from 15% in May).

Adcole Corp.

NAMES REECE PRESIDENT AND CEO

Adcole Corporation, a manufacturer of special purpose machines for measuring engine components such as camshafts, crankshafts, and pistons, as well as sun angle sensors for space satellites has appointed **Brook Reece** president and CEO. Adcole was founded in 1957 by Addison D. Cole who was president and CEO for 57 years, retired at age 95, and sold the business to Artemis Capital Partners. Terms of the purchase were not disclosed. Reece previously served as vice president sales at Adcole Corporation for 20 years and is uniquely qualified to lead the company. "Our heritage is one of innovation and trusted accuracy and our vision is to be the most trusted and valued name in the space and industrial metrology industries. We are presently on an extremely fast product development track in response to the rapid technological changes in engine development. Innovation is our heritage and central to our future business strategy," he said.

Sandvik

SUPPORTS HURCO CHIPMAKER CHALLENGE

Hurco recently announced that Sandvik Coromant will donate $1,000 worth of tooling to the champion of the Chipmaker Challenge, a contest designed to highlight manufacturing entrepreneurism, which will be held at the International Manufacturing Technology Show Tuesday (IMTS), Sept. 9, at 1:30 p.m. at the Hurco booth (S-8619). The winner will walk away with their choice of a brand new Hurco VMX42i CNC mill or TM8i lathe in addition to the Sandvik Coromant tooling of their choice. "The idea of the Chipmaker Challenge evolved as we discussed ways to add some excitement to IMTS and get publicity for the entrepreneurs in our industry who do remarkable things each and every day," said Joe Braun, general manager of Hurco North America. "Our customers are competitive, proud of the businesses they've built, and the products they make. We decided to model the Chipmaker Challenge after the television show Shark Tank in order to create an exciting, competitive, entertaining event that showcases manufacturing entrepreneurs and highlights the hi-tech aspect of manufacturing in this country."

August 26–28—International Gear Conference 2014. Lyon-Villeurbanne, France. Mechanical transmission components are present in every industrial sector and range from nano-gears to large gearboxes. Increasing competitive pressure and environmental concerns have provided an impetus for cleaner, more efficient and quieter units. Moreover, the emergence of relatively new applications in wind turbines, hybrid transmissions and jet engines has led to even more severe constraints. The main objective of this conference is to provide a forum for the most recent advances, addressing the challenges in modern mechanical transmissions. Topics include gear noise, gear design, gear materials, gear failure, lubrication, gearbox efficiency and more. For more information, visit *http://int-gearconf14.sciencesconf.org*.

September 8–10—Gear Failure Analysis Seminar. Big Sky Resort, 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. A gear failure analysis expert will use lectures, slide presentations, hands-on workshops with failed gears and Q&A sessions to give 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 and will help you solve everyday problems whether you are a gear engineer, user, researcher, maintenance technician, lubricant expert or manager. The course manual offers more than 100 color photos, dozens of illustrations, a textbook and failure atlas that will become a permanent reference source. For more information, visit *www.agma.org*.

September 8–13—IMTS 2014. The International Manufacturing Technology Show (IMTS) is the largest manufacturing technology show in the Western Hemisphere. IMTS 2012 drew more than 100,000 industry decision-makers in areas like metal cutting, tooling, metal forming, abrasives, controls, CAD-CAM, EDM, gear generation, industrial automation and more. The IMTS conference brings the industry together to discuss new opportunities and network with the manufacturing community. Other highlights include the Smartforce Student Summit, Exhibitor Workshops, the Emerging Technology Center and IMTSTV. IMTS is co-located with Industrial Automation North America and Motion, Drive & Automation North America. For more information, visit *www.imts.com*.

September 16–20—AMB 2014. Stuttgart, Germany. AMB, the international exhibition for metalworking, has increased the number of exhibitors in 2006, 2008, 2010 and 2012. All global market and technology leaders will be represented in Stuttgart. Exhibitors from over 30 nations present their new products and services in the area of machines and tools for metalworking. The trade show features more than 105,000 square meters of exhibition space, clear, structured hall divisions, and optimal accessibility. Special programs during AMB include Art Meets Technology, Metalworking Innovation Tour, WorldSkills Germany, Career Walk and more. The topics will extend from solving economic problems to searching for production or sales partners. For more information, visit *www.messe-stuttgart.de*.

October 6–8—Furnaces North America 2014. Nashville Renaissance & Convention Center, Nashville, TN. Heat treating specialists from around the world will gather to discuss the latest emerging technologies in heat treating and furnace equipment. FNA will feature 170 suppliers representing every major area of heat treating. The conference includes five technical tracks with 40 learning sessions. Visitors and exhibitors will have the chance to meet and discuss opportunities in three networking sessions. For more information, visit *www.furnacesnorthamerica.org*.

October 8–10—RMGFS 2014. Boulder, CO. The Rocky Mountain Gear Finishing School (RMGFS) is the premier gear finishing school in the western United States. Kapp-Niles presents this multi-layered program designed to optimize learning and strengthen your understanding of gear finishing processes no matter your experience level. Participants study the underlying principles and mechanics of different gear finishing processes, apply them through practical sessions on a Kapp-Niles machine, and take part in group workshops for more in-depth discussions. Kapp encourage attendees to bring applications to the school for small group, or one-on-one discussions. Presenters include Jim Buschy, Bill Miller, Dwight Smith, Paul Brazda, Michael Ruppert, Sascha Ungewiss, Thomas Schenk, Nidam Meharzi, Eric Dixon and Hans-Helmut Rauth. For more information, visit www.kapp-usa.com.

October 22–23—WZL Gear Conference USA. Gleason Corporation, Rochester, New York. For more than 50 years the annual WZL Gear Conference in Aachen, Germany, has been fostering technical collaboration and communication among the members of the WZL Gear Research Circle. The two-day conference is devoted exclusively to the presentation of the latest research in gear design, manufacturing and testing. Additionally, the software resources of the WZL Gear Research Circle are available for examination, including solutions for gear design and manufacturing process development. With up to 300 participants from Europe and overseas, the WZL Gear Conference is one of the largest annual events dedicated to gear technology in Europe. Nine years ago exclusive contents of the Aachen gear conference were first presented in the United States. The Fifth WZL Gear Conference - USA is being hosted by Gleason Corporation and will provide the opportunity for North American companies to connect with WZL and learn about current research activities. The conference fee is $260 per attendee. For more information, visit *www.wzl.rwth-aachen.de*.

October 27–30—Gear Dynamics and Gear Noise Course. Ohio State University. The Gear Dynamics and Gear Noise Short Course has been offered for 35 years and is considered extremely valuable for gear designers and noise specialists who encounter gear noise and transmission design problems. Attendees will learn how to design gears to minimize the major excitations of gear noise: transmission error, dynamic friction forces and shuttling forces. Fundamentals of gear noise generation and gear noise measurement will be covered along with topics on gear rattle, transmission dynamics and housing acoustics. This four-day course includes extensive demonstrations of specialized gear analysis software in addition to the demonstrations of many Ohio State gear test rigs. A unique feature of the course is the interactive workshop session (on Day 3) that invites attendees to discuss their specific gear and transmission noise concerns. The roundtable discussions on Day 4 are intended to foster interactive problem solving discussions on a variety of topics. Cost is $1,950 per person. For more information, visit *www.nvhgear.org*.

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SALLY RIDE SCIENCE:
CREATIVITY, COLLABORATION AND FUN

Founded in 2001 by Dr. Sally Ride, America's first woman in space, Sally Ride Science offers programs and professional development for upper-elementary and middle school students on science and technology topics. The goal is to provide tools for college and career readiness that can build students' passion for STEM fields and careers. Former astronaut Wendy Lawrence will deliver a keynote address during the Smartforce Student Summit at IMTS 2014. The presentation will take place Wednesday September 10th in Chicago.

The Smartforce Student Summit is held in conjunction with IMTS and gives students a first-hand, interactive view of manufacturing technology, in addition to promoting careers in the industry. During IMTS 2012—less than two months after Ride's losing battle to pancreatic cancer—more than 9,300 students and educators from 17 states attended the Smartforce Student Summit before touring the trade show.

"One of the primary issues facing U.S. manufacturing is a lack of workers who have the required advanced and high-technology skills necessary in industry today. The Smartforce Student Summit is a great way to educate students, teachers and parents about the career opportunities in manufacturing," said Greg Jones, vice president - Smartforce Development, AMT. "Additionally, it's imperative to generate interest among girls and young women for careers in STEM fields, including manufacturing. Dr. Flammer is a natural fit for bringing this message to the attendees at the Smartforce Student Summit."

Sally Ride Science incorporates career-focused instruction through teacher training programs, books and eBooks (e.g., the Cool Careers and Key Concepts in Science series), and various events and services. The company shows students that science is creative, collaborative, fascinating and fun. "I am very much looking forward to speaking at the Smartforce Student Summit, and—on behalf of the entire team at Sally Ride Science—I thank AMT for the invitation," said Lawrence. "Like Sally Ride Science-a company I have worked with closely over many years-I am very passionate about building student interest in STEM. I can't emphasize enough how important it is for employers and industry groups like AMT to share that mission as well."

"A focus of my keynote will be on the lasting impact teachers—and anyone, really, such as the STEM professionals at the Summit—can have on students when they expand STEM topics 'beyond the classroom' and connect them to careers. Once students can envision themselves as a marine biologist, engineer, astronaut, or other STEM professional, there is really no stopping them. Introducing students to the wide array of women and men working in STEM—whether through in-person contacts or through Sally Ride Science books, products and programs—is the best way to build student interest in STEM fields."

Long an advocate for improved science education, Ride co-wrote seven science books for children, and also initiated and directed NASA-funded education projects designed to fuel middle school students' fascination with science, including Sally Ride EarthKAM and GRAIL MoonKAM. Sally Ride Science works with numerous public and private partners, including ExxonMobil, NASA, the Office of Naval Research, Northrop Grumman, Deloitte and others. Since 2005, Sally Ride Science has trained over 10,000 teachers who have reached almost 1.5 million students with instruction that emphasizes career connections to STEM. For more information visit *www.sallyridescience.com* and *www.amtonline.org*.

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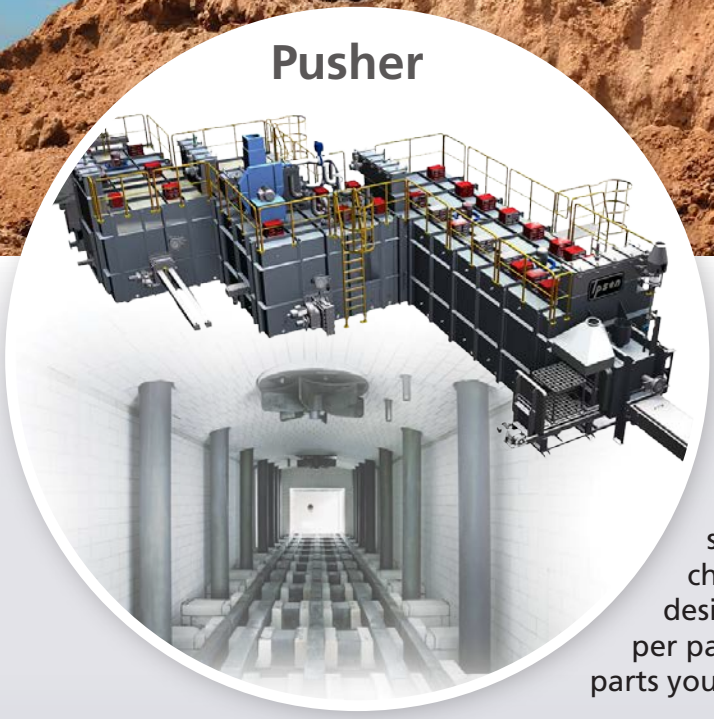

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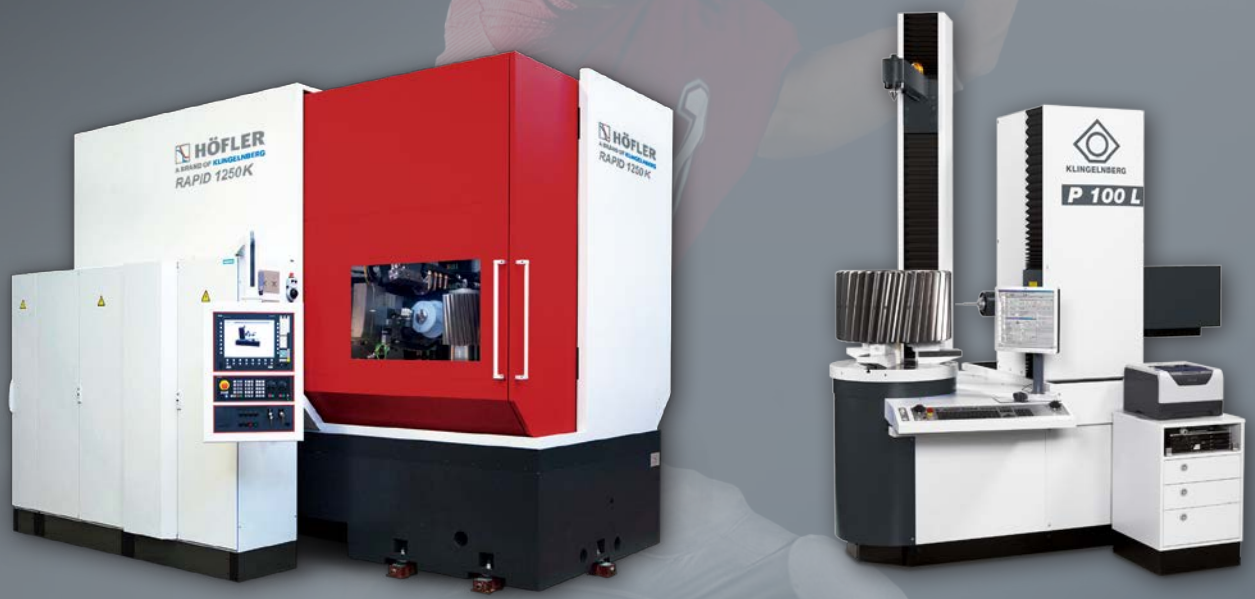

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