gear TECHNOLOGY®

NOV/DEC 2016

BUYERS GUIDE!

GEAR SHOP OF TOMORROW — WHAT'S NEXT?

Revitalizing U.S. Manufacturing

Solutions for all your gear cutting tool needs

Gear cutting tools and services

Star SU offers a wide variety of gear cutting tools and services, including:

- Gear hobs
- Milling cutters
- Indexable Gear Milling Solutions by Sandvik Coromant
- Shaper cutters
- Scudding® cutters
- Shaving cutters
- Chamfer and deburring tools
- Rack and saw cutters
- Master gears
- Ring and plug gauges
- Advanced coatings including ALTENSA and ALCRONA PRO
- Tool re-sharpening

Total tool life cycle management

Control your tool costs and let Star SU manage your tool room. From new tools to design work to re-sharpening and recoating, we have the equipment and resources to help keep your gear cutting operation running smoothly.

SAMPUTENSILI

BOURN&KOCH INC

Phone: 847-649-1450
5200 Prairie Stone Pkwy. • Ste. 100 • Hoffman Estates • IL 60192

PTG-1L

GS 400

Affordable hob sharpening and in-house tool maintenance

Star's PTG-1L linear motor driven machine sharpens both straight and spiral gash hob designs up to 8" OD x 10" OAL. Additionally, it sharpens disk, shank and helical type shaper cutters, Scudding® cutters, and a wide range of round tools, making it a versatile tool room machine.

Shaving cutter and master gear grinding

Designed to grind shaving cutters and master gears, the GS 400 sets new standards for precision, reliability and ease of use. An integrated measuring unit automatically checks the quality of the first tooth ground without unclamping the workpiece.

FFG SICMAT HB SANDVIK Coromant

System technology from one source

www.star-su.com

gear TECHNOLOGY®

NOV/DEC 2016

contents

22 BUYERS GUIDE!

Your comprehensive directory of gear industry suppliers.

features

technical

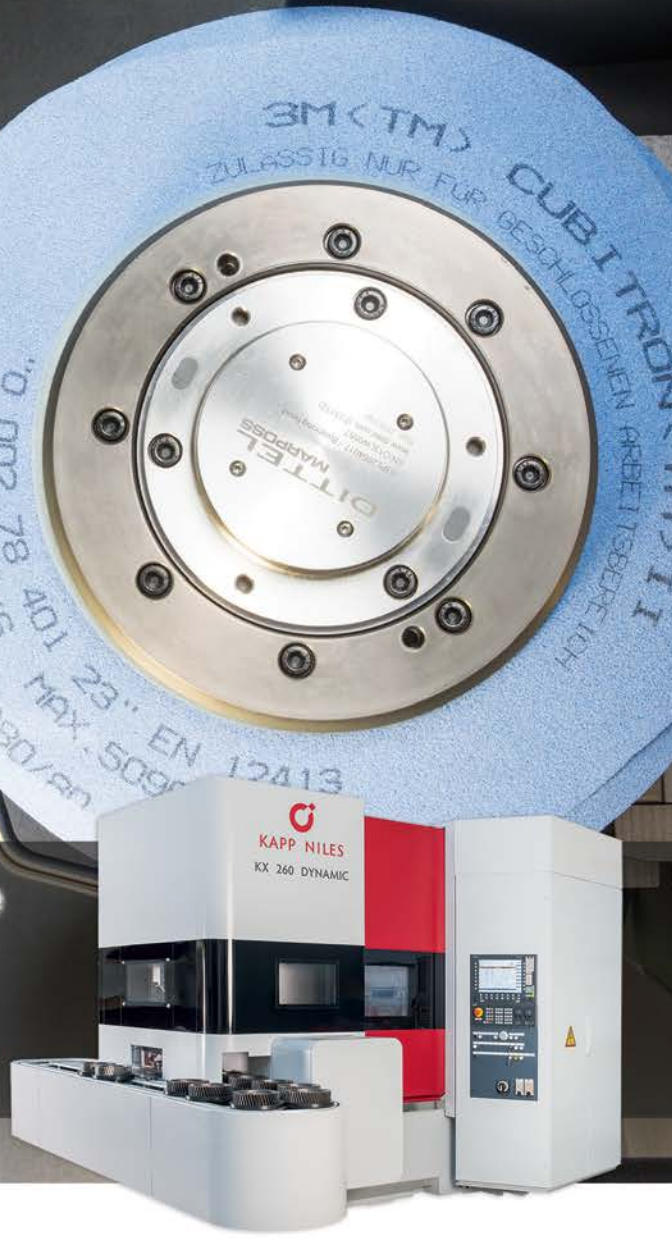
Vol. 33, No. 8 GEAR TECHNOLOGY, The Journal of Gear Manufacturing (ISSN 0743-6858) is published monthly, except in February, April, October and December by Randall Publications LLC, 1840 Jarvis Avenue, Elk Grove Village, IL 60007, (847) 437-6604. Cover price $7.00 U.S. Periodical postage paid at Arlington 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.

What's Up?

KX 260 DYNAMIC Gear Center

A patented design with inverted spindle

- saves on investment
- saves on floor space
- saves on setup time



SEE THE VIDEO!

The KX 260 DYNAMIC gear center's patented design is perfect for the mass production of external planetary gears up to 260 mm. Its inverted "pick-up" spindle provides optimum productivity. Work arbor change and verification is automated, and grinding worm change is semi-automated.

Call our sales office for a quote. (303) 630-1732.

KAPP Technologies
2870 Wilderness Place Boulder, CO 80301
(303) 447-1130 www.kapp-niles.com info-usa@kapp-niles.com

KAPP NILES

gear TECHNOLOGY® Vol. 33, No. 8

departments

Liebherr Performance.

New shaping machine LS 180 F

During the development of the new shaping machine in the 180 mm working range, the focus was on high flexibility and productivity. With the new movable shaping head a variety of different workpieces with different lengths can be machined. Cluster gears can also be easily shaped with this machine in one clamping set-up. This LS 180 F is ideal for every user in gear manufacturing.

- Movable shaping head
- Short setup times thanks to NC axes
- Tool interface: SK 40
- High productivity with 1,500/2,000/3,000 double strokes/min
- Two-track cam system with automatic adjustment
- Very efficient automation

Liebherr Gear Technology, Inc.
1465 Woodland Drive
Saline, Michigan 48176-1259
Phone.: +1 734 429 72 25
E-mail: info.lgt@liebherr.com
www.liebherr.com

LIEBHERR

THE GEAR INDUSTRY'S INFORMATION SOURCE

www.geartechnology.com

Watch Gleason's New Cutter Build Machine in Action

Gleason introduced their latest innovation, the 500CB Cutter Build Inspection Machine at IMTS 2016. The 500CB delivers more accurate and highly automated build, truing and inspection of all types of stick-blade bevel gear cutters. The 500 CB is equipped with a B&R X20 Controller (CPU) running CNC functionality, a compact safelogic controller, X20 I/O, acopos multi servos drives and motors, and a B&R Panel PC for the HMI. Check out the video at *www.geartechnology.com*.

Doosan Provides Gear Hobbing on the Puma 2600LY

The Doosan Puma 2600LY is a high performance turning center. The mill-drill capability of the Y-axis eliminates additional set-ups and maximizes productivity. Check out the video at *www.geartechnology.com*.

GEAR TALK with CHUCK

Gear Talk

Gear Technology technical editor and resident blogger Chuck Schultz weighs in on some important gear topics on the homepage:

In *"Does New Technology Require New Companies?,"* Chuck examines technology trends and asks what 3D printing can achieve in the gear shop.

In *"Non-Traditional Manufacturing,"* Chuck looks at electro-discharge machining (EDM) in gear shops and some other alternative technologies on-hand at IMTS 2016 in Chicago.

Stay Connected

Join the *Gear Technology* Facebook group at *www.facebook.com/groups/210890932629794/*

Follow us on Twitter *twitter.com/#!/Gear_Technology*

Connect with us on LinkedIn *www.linkedin.com/groups/Gear-Technology-Magazine-3893880*

Subscribe Online *www.geartechnology.com/subscribe.htm*

gear TECHNOLOGY

RANDALL PUBLICATIONS LLC
1840 JARVIS AVENUE
ELK GROVE VILLAGE, IL 60007
(847) 437-6604
FAX: (847) 437-6618

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

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

Senior Editor
Jack McGuinn
jmcguinn@geartechnology.com

Senior Editor
Matthew Jaster
mjaster@geartechnology.com

News Editor
Alex Cannella
alex@geartechnology.com

Editorial Consultant
Paul R. Goldstein

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

DESIGN
Art Director
David Ropinski
dropinski@geartechnology.com

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

Materials Coordinator
Dorothy Fiandaca
dee@randallpublications.com

China Sales Agent
Eric Wu, Eastco Industry Co., Ltd.
Tel: (86)(21) 52305107
Fax: (86)(21) 52305106
Cell: (86) 13817160576
eric.wu@eastcotec.com

ON-LINE
Digital Content Manager
Kirk Sturgulewski
kirk@geartechnology.com

CIRCULATION
Circulation Manager
Carol Tratar
subscribe@geartechnology.com

Circulation Coordinator
Barbara Novak
bnovak@geartechnology.com

RANDALL STAFF
President
Michael Goldstein

Accounting
Luann Harrold

BPA WORLDWIDE BUSINESS


Merry Christmas.
From Our Busy Workshops to Yours.
Sorry, Santa. We've been very good this year
but not even our workshops are open on Christmas!
The Holiday Season reminds us to pause and give thanks for
the blessings of great customers, a skilled and dedicated workforce,
and friends and family.
From all of us at Forest City Gear, we wish you
a very Merry Christmas and a joyous and prosperous 2017.
FOREST CITY GEAR
11715 Main Street, Roscoe, IL 61073
815-623-2168
www.forestcitygear.com

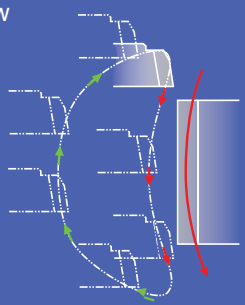
MITSUBISHI
HEAVY INDUSTRIES AMERICA, INC.
Our Technologies, Your Tommorow

A Crowning Achievement In Shaping Technology

ST40A
STseries

Programmable Lead Guide with NC Relieving Delivers Greater Accuracy, Productivity and Ease of Operation.

Mitsubishi Heavy Industries is pleased to introduce the new and enhanced programmable lead guide ST40A machine. Built for precision and performance like the original, the new ST40A is now also equipped with a CNC relieving mechanism, capable of producing gears with taper up to 0.3 degrees and crowning up to 0.070mm. For more information visit **www.mitsubishigearcenter.com** or contact sales at **248-669-6136**.



Our Next Leader

Publisher & Editor-in-Chief
Michael Goldstein

I had the pleasure of sitting down to dinner recently with the new president.

No, not that president! I mean Matt Croson, the new president of the American Gear Manufacturers Association, who started in June and has been busy getting to know the gear industry and AGMA's members.

In our May 2016 issue I reported that the AGMA had hired Matt Croson to replace Joe Franklin, the outgoing AGMA president who was retiring. During his 25-year tenure, Joe Franklin brought a great deal of professionalism to the association, overseeing a period of tremendous growth, not just in membership, but also in AGMA's impact on the industry. Back then, I hadn't yet met Matt, but I was filled with hope and enthusiasm for the possibilities that his leadership might bring.

Over the past months, I've met with Matt on several occasions, and I have to say that I'm even more enthusiastic now that I've gotten to know him. Matt Croson has energy, enthusiasm and vision, and I believe his new ideas and experiences will serve the association well.

We talked a lot about the need for AGMA to stay relevant as the world of manufacturing continues to change. AGMA members are being asked to do more and be more than they've ever done before. Gear manufacturers have to think like systems manufacturers, and they have to compete on a global scale. Gear manufacturers also continue to require education to train the next generation of gear industry professionals.

We also talked a lot about Gear Expo. At our most recent meeting, we were joined by Jenny Blackford, AGMA's vice president of marketing. Jenny has worked very hard over the past several years to grow and improve Gear Expo to be the world gear event it is today.

Over the past several shows, Gear Expo has become more comprehensive, particularly in the number and quality of gear manufacturers who exhibit. Whereas Gear Expo used to be a show whose attendees were primarily gear manufacturers, it's now become a more complete show for the gear industry, and it's become equally valuable for gear buyers and end users. More than 50 gear manufacturers exhibited at the last show.

Both Jenny and Matt confirmed that they were committed to continuing the growth of the show, both in size and concept. As far as I'm concerned, that can only be good for the industry.

Also, Matt made it clear that he's quickly come to understand the importance of AGMA's role in developing standards—the original reason for its formation more than 100 years ago. He sees that as the association's first and foremost responsibility.

Unfortunately, I can't tell you everything I learned from Matt. Many of the specific ideas are currently being discussed by AGMA's board of directors. Ultimately, it's the board who will decide the future direction of the association.

But with Matt Croson's leadership and guidance, I believe that we're all going to be pleased with the direction he's going to take the association, and that our industry stands to benefit from his vision.

AGMA Standards Committees Keep Industry in Business

Amir Aboutaleb, Vice President, Technical Services, AGMA

More than 100 years ago, gear manufacturers were facing a significant challenge from industry. The incredible advances in industrialization and transportation that occurred at the turn of the 20th century resulted in incredible growth for gear makers, but there were significant technical issues. "The lack of process and product standardization was a continuing problem in all U.S. industry… the lack of industry-wide gear standards meant there were no standard gear tooth sizes, ratings, quality definition or consistent manufacturing methods" (*Celebrating 100 Years of Gearing*, pg. 22).

Generally, gear companies were making "unique gears to suit particular applications without concern for interchangeability… By 1916, the U.S. government was calling on the gear industry to create standards that would define gear type, tooth size, tolerances (quality) and manufacturing processes. This would minimize the risk of monopoly, and allow for greater availability of interchangeable gears from multiple sources to meet market demands and national security needs" (*Celebrating 100 Years of Gearing*, pg. 22).

Under these industry challenges, AGMA was created, and with it, the AGMA Technical Division.

What does the AGMA Technical Division do? What value does being an AGMA member, and supporting this effort, deliver to industry?

In short, AGMA Technical Division helps the industry deliver state-of-the-art power transmission products to their customers. It does that by bringing together industry experts to collaborate and develop standards that function as a common language for use by the gear manufacturers and users to evaluate various gear products. These standards provide a reference point for the reliability and performance of a product based either on design or application. The standards development process also provides a forum for scientific discussion of product design, materials, and application, which often leads to better product design. In addition, standards are also used as a marketing tool by manufacturers, either in penetrating new markets or protecting established markets.

A brief history of AGMA standards development

Ever since the first AGMA rating standard, developed in 1919 shortly after AGMA's creation, the development of AGMA standards has always been market driven. The AGMA board of directors, in keeping with the increasingly global nature of the gear marketplace, constantly reaffirms the association's long-term commitment in promoting technical excellence through the national and international standards writing process.

In the 1980s, the American National Standards Institute (ANSI) approved AGMA as the accredited national standards development body for gear related standards. Also, AGMA was approved as the administrator of the ANSI Technical Advisory Group which establishes the American national position on international gear standards.

Another milestone was achieved in 1993 when AGMA, through ANSI, was approved as the Secretary of Technical Committee 60 (TC 60), Gears, by the International Standards Organization (ISO) in Geneva, Switzerland. Therefore, AGMA is now responsible for the administration of gear related standards development worldwide.

But how does AGMA really do this?

As noted earlier, the detailed content of AGMA documents (standards and information sheets) are developed by volunteer industry experts acting as committee members. Currently, there are 22 active technical committees with more than 250 industry experts from more than 135 AGMA member companies worldwide. These experts come from not only gear manufacturers, but also users of power transmission equipment, suppliers to the industry, academia and government. The rules under which they operate have been prudently established to obtain a clear consensus among the committee members, and also the public at large, who are given the opportunity to review and constructively critique the content prior to final adoption.

To facilitate its standards development activities, AGMA annually holds approximately 135 committee meetings, of which 70 percent are held via WebEx with the rest held face-to-face at locations easily reachable by a majority of the committee members.

AGMA has always relied on the dedication and valuable contributions of its members participating in technical committees. Our members have found their participation in the technical committees beneficial in more ways than one. Aside from the direct benefit gained through the application of developed standards and information sheets, our members have used their involvement in the committees to interact with and learn from their counterparts from around the industry. Thanks to the internet and the ability to hold virtual meetings, involve-

ONLY THE KLINGELNBERG CAN

Measure smooth surfaces in rough conditions
The only way to do it right – and forget about setup time

KLINGELNBERG

Measurement of surface roughness starts with modules as small as 0.9 mm (DP 29)

Klingelnberg stylus for measuring roughness on small gears (Pat. pending)

NEXT FAIRS:

IMTEX 2017
Hall 3, Booth B-111
January 26 - February 01
Bangalore, India

Measuring surface roughness as part of gear measurement delivers reproducible results in accordance with standards. Only on a Klingelnberg P-Machine can you measure gear surfaces starting from module 0.9 mm (DP 29) using the full CNC-Axis movement – even on the shop floor!

Want to measure surface roughness?
Available for new machines or ask for a retrofit at "only@klingelnberg.com"
www.onlytheklingelnbergcan.com

ment in the activities of these technical committees is no longer geographically bound to a single location. Holding meetings online allows AGMA members from Europe, South America, India and other parts of the world to attend and collaborate with their colleagues on various issues without travel expense or time away from the office.

The current AGMA publication catalog includes 56 Standards and 31 Information Sheets. The catalog also includes four adopted ISO Technical Reports (equivalent to AGMA Information Sheets) and six ISO Standards.

In 2016, these committees and AGMA's Technical Division produced the following updated Information Sheets and Standards:

1. ANSI/AGMA 9005-F16, ***Industrial Gear Lubrication***
2. ANSI/AGMA 9006-A16, ***Flexible Couplings – Basis for Rating***
3. ANSI/AGMA 2002-C16, ***Tooth Thickness and Backlash Measurement of Cylindrical Involute Gearing***
4. ANSI/AGMA 6013-B16, ***Standard for Industrial Enclosed Gear Drives***
5. ANSI/AGMA 6113-B16, ***Standard for Industrial Enclosed Gear Drives [Metric Edition]***
6. ANSI/AGMA 6123-C16, ***Design Manual for Enclosed Epicyclic Gear Drives***

AGMA Welcomes Support

As mentioned earlier, currently more than 135 member companies, consultancies and universities from around the world actively participate on at least one technical committee.

We strive to increase participation on our technical committees to *all* AGMA membership. We invite those members not currently active on an AGMA committee to "dial-in" to an up-coming online meeting and see how easy it is to get involved. As a standards developing organization, we believe increased participation from a large group of diverse companies will improve and ensure wider acceptance of the final product, which is the AGMA standard.

AGMA Welcomes Non-Members to Join AGMA and Drive the Future

AGMA encourages companies to join and actively participate in the standards development process. Members receive all of the standards for free (a value of $3,750 for non-members who pay for the standards via *www.agma.org*).

But most importantly, joining AGMA means you are standing up for the industry and helping ensure another 100 years of technical excellence and advancement for the gear industry. Consensus-driven standards are the most important tool that AGMA delivers to the industry, and we look forward to continuing that tradition with our current members and future members helping to add value.

For more information:

AGMA
1001 N. Fairfax Street
Alexandria, VA 22314-1587
Phone: (703) 684-0211
Fax: (703) 684-0242
tech@agma.org

For Related Articles Search
standards
at www.geartechnology.com

SYNTHETIC GEAR OILS WITH THE POWER TO PROTECT

More and more gear manufacturers are specifying Lubriplate Lubricants for their machinery. Why? With 146 Years of Lubrication Experience, they know Lubriplate has the Quality Products and Services to meet their needs, the needs of their equipment and the needs of their customers.

Products Include:

PGO & PGO-FGL SERIES GEAR OILS

- Ultra High-Performance, Polyalkylene Glycol (PAG)-Based, Gear Lubricants.
- ECO-Friendly - Extended Service Life, Energy Conserving.
- PGO-FGL Series is NSF H1 Registered, NSF/ISO 21469 Certified, Food Grade.

SYN LUBE SERIES GEAR OILS

- High-Performance, 100% Synthetic, Polyalphaolefin (PAO)-Based Fluids.
- Compatible with Petroleum-Based Oils for Easy Conversion.
- Available in ISO Grades 150 through 1000.

SYN LUBE HD SERIES

- Heavy-Duty, Polyalphaolefin (PAO)-Based Synthetic Gear Lubricants.
- Meets AGMA EP (Extreme Pressure) Requirements.
- For Heavy-Duty Applications.

SYNTHETIC WORM GEAR LUBRICANT

- 100% Synthetic, Polyalphaolefin (PAO)-Based Fluid, ISO 460 Grade.
- Formulated Especially for Worm Gear Applications.
- Provides Excellent Oxidation Resistance.

SFGO ULTRA SERIES FOOD GRADE GEAR OILS

- NSF H1 Registered, NSF/ISO 21469 Certified, Food Machinery Grade.
- High-Performance, 100% Synthetic, Polyalphaolefin (PAO)-Based Fluids.
- Provides Excellent Oxidation Resistance.

The Brand OEMs Can Trust When Specifying Lubricants For Their Machinery ✓

To Learn More About These and Lubriplate's Other Lubricants Call 908-489-7355 or visit www.lubriplate.com

"It's the Film" PREVENTS WEAR and CORROSION LUBRIPLATE SUPER-LUBRICATION

Lubriplate® Lubricants

Newark, NJ 07105 / Toledo, OH 43605 / www.lubriplate.com
Contact Ellen Girard, Lubriplate's OEM Marketing Analyst
Tel: 908-489-7355 / E-mail: egirard@lubriplate.com

Backed By: Lubriplate® ESP

Complimentary Extra Services Package

Plant Surveys / Tech Support / Training
Color Coded Lube Charts & Machine Tags
Lubrication Software / Follow-Up Oil Analysis

Power Skiving

FLEXIBLE AND EFFECTIVE PRODUCTION OF INTERNAL GEARS

DR. MARKUS VOS,
MANAGING DIRECTOR,
PITTLER T&S GMBH

The process with the somewhat cumbersome title of "method for cutting gear wheels using a cutting tool similar to a gear wheel with cutting edges on the faces of the teeth" in the patent application more than 100 years ago has matured into one of the most economical gear cutting technologies around — power skiving.

The inventor, Julius Wilhelm von Pittler, intended to use it to make rings with internal gearing. Yet it was only with the technological accomplishments of the 21st century that Pittler T&S GmbH were able to realize gear cutting machines on the basis of the PV series for the efficient production of ring gears, for example. All those years ago, von Pittler was forced to link all machine movements mechanically. It wasn't until intelligent software and a computer-controlled numeric control came along that it was possible to move the five axes extremely precisely and synchronously to one another in an interpolating way. Developments in the tool segment such as more sturdy powder and carbide alloys as well as high-performance coating for tools also played their part.

Due to a lack of efficient production technology for internal gearing, spur gears and external gearing became established in drive engineering in the course of the last 100 years. In the field of internal gearing production, the methods shaping and broaching were the order of the day. Yet this has all changed thanks to the latest developments in the field of power skiving technology. This technology allows manufacturers to get round the disadvantages of the competing processes and benefit from increased flexibility and higher output at the same time.

Production of internal and external gearing in one clamping

Unlike shaping, power skiving is a continual hobbing manufacturing process which avoids the unproductive stroke and removal movement. The advantage: machining time is reduced by at least the factor 3. In addition, power skiving is much more flexible than broaching, because the machine operator can configure the dimensions such as the two-ball dimension using the NC control. Helix angle and the flank shape can also be modified using the NC control. The high adaptive capacity becomes clear when it is born in mind that gearing can be cut both internally and externally.

In the case of external gearing, the technologies of power skiving and hobbing are competing more and more often. Since significantly less space is required for the tool outlet for power skiving, the technology is opening up new possibilities for designing cost-saving gearbox components. Even workpieces with constraining contours can be produced efficiently using this method.

In the past, critics claimed that power skiving was less productive than hobbing. This claim cannot be generalized, however. Because in an optimized process, the main times and tool costs are by all means comparable.

During broaching, component quality is determined mainly by the tool geometry of the broach, and can thus not be influenced during the machining process. The high costs of the tools, set-up, treatment and storage of the broaches is another disadvantage.

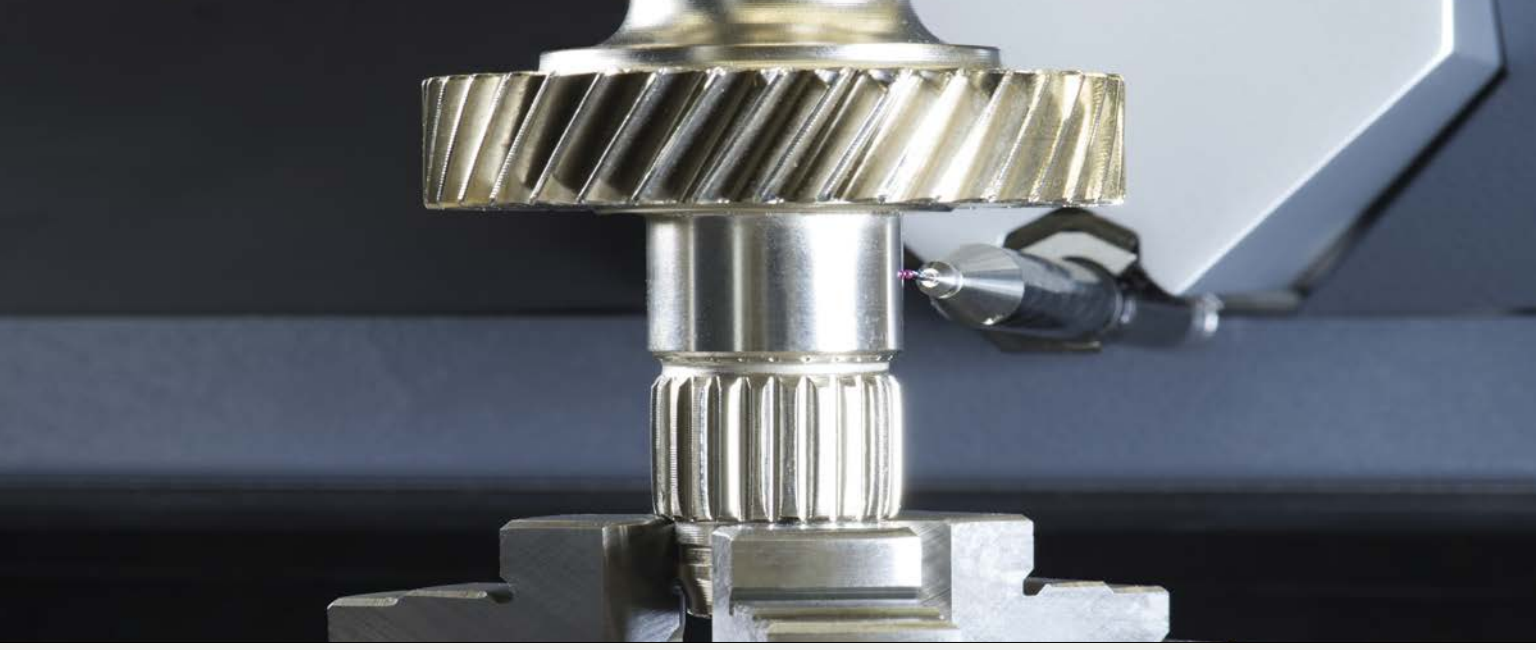
Tool change saves costs

With the PV range, Pittler T&S offers a whole series of machines using power skiving technology. This covers the whole workpiece diameter range from 30 to 1,250 mm. All the machines have 5 axes and a tool magazine for simple and fast tool change.

Alongside the pure tool management of different skiving wheels, the tool change includes tactile measuring sensors and other metal-cutting tools. This allows the cutting process to be divided into roughing and finishing.

A roughing tool with standard indexable inserts removes more than 90 percent of the material. This goes decidedly easy on the finishing tool, which creates the involute contour and results in lower tool costs.

A further advantage of the tool magazine of the Pittler PV range is the complete machining option for workpieces. This means procurement and transport to other machines is no longer required. Reclamping faults are avoided. Further advantages: processing and delivery times are sped up, the complexity of workpiece handling is reduced, intermediate storage is not required and manufacturing structures are flexible rather than rigid.



GEAR MEASUREMENT… EXACTLY

Mahr's Class 1 Universal Gear Testers provide fast, accurate analysis for a wide range of gear and gear tool applications on gears with OD's up to 600 mm (23.6 in). The GMX systems incorporate a high-accuracy scanning probe head, automatic tailstock and powerful controller to make them an excellent solution for both universal and specialized gear manufacturing processes. They also feature ultra-high precision spindles, originally used in the renowned Mahr Formtester series, to allow very accurate form measurements to be made as well. Equipped for both stand-alone shop floor and gear lab applications, Mahr's GMX systems can also be fully networked for fast and efficient transfer of measuring results and machine corrections.

Dimensional Metrology Solutions for:

AEROSPACE · AUTOMOTIVE · ELECTRONICS · ENERGY · MACHINE TOOL · MEDICAL · OPTICS

Mahr

EXACTLY

1-800-343-2050

www.mahr.com

Request our gear measurement white paper **orders@mahr.com**

▲ MARGEAR GMX 400 W

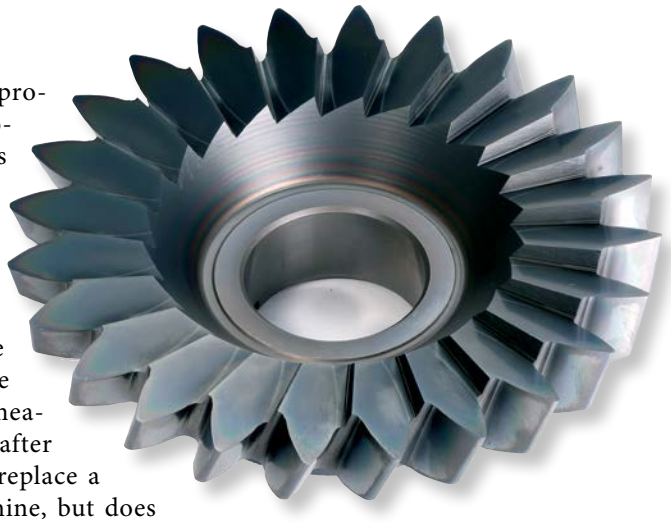
SURFACE MEASUREMENT · SHAFT MEASUREMENT · HEIGHT MEASUREMENT · CALIPERS & MICROMETERS · INDICATORS & COMPARATORS · AIR GAGING · SNAP GAGES · FORM MEASUREMENT · PRECISION LENGTH MEASUREMENT

Economic production of crowned tooth flanks

Unlike the methods already described, power skiving influences the straightness of the tooth flanks. If both flanks are cut offset, the result is crowned tooth flanks. This allows the contour to be corrected on the one hand, and new geometries to be created on the other. This cannot be done more efficiently by any other manufacturing method.

Simplified user interface

The power skiving machines from Pittler T&S are all constructed with the very latest control technology on the basis of Siemens 840D SL. This allows the machine to be used as a 5-axis machining center with *ShopMill*. In addition, a suitable post-processor makes free-form surfaces with milling possible. The company, based in southern Hesse, equips the machines with a special user interface for power skiving. This allows an employee with basic knowledge to produce gearing. The NC program is generated automatically. The data is requested with the aid of a graphic interface. The data is also transferred to an automatic measuring program which checks the quality of the gearing. This means the measuring sensor can measure the result directly after machining. It does not replace a gearing measuring machine, but does provide a first quick check of the quality achieved and is thus an important aid during process run-in.



Clamping technology with DVS system

Concentricity is essential for component quality, particularly where thin-walled ring gears are being machined. This is why Pittler T&S got together with SWS Spannwerkzeuge GmbH, an associated company within the DVS Technology Group, to develop a special diaphragm chuck as well as special chucks using the hydro expansion principle for this application. This DVS system solution permits sensitive clamping without warping the component.

For more information:
DVS Technology America Inc.
Phone: (734) 656-2080
www.dvs-technology.com

Sandvik Coromant

INTRODUCES GRADE ISO H05 AND H15 APPLICATIONS

To help manufacturers enjoy benefits such as reduced cycle times and greater tool life when performing hard part turning, Sandvik Coromant has strengthened its existing offer in the ISO H05 to H15 application area with the introduction of two new grades, CB7105 and CB7115. The grades will be of particular benefit to those machining transmission components for the automotive industry, where lower cost per part can be achieved.

With CB7105, Sandvik Coromant has created a grade for hard part turning that offers enhanced crater wear resistance in comparison with existing solutions, while CB7115 is designed to provide users with better fracture resistance than today's available grades. These benefits equate to higher speed and improved edge line toughness, respectively.

Hard part turning is usually a finishing or semi-finishing process where typical machining challenges include high surface and dimensional tolerance demands, along with competitive tool life. CB7105 and CB7115 have been developed to tackle these challenges through the application of a high performing PCBN grade material and coating as well as appropriately adjusted edge preparation on the inserts. In combination with high quality control during insert manufacturing, this results in a number of end user benefits.

"CB7105 allows machine shops to achieve lower cost per part when used as part of a high speed machining strategy," states Torbjörn Ågren, product manager, turning at Sandvik Coromant. "Alternatively, users of this grade can benefit from longer tool life at lower speeds. CB7115 is also designed to deliver lower cost per component, typically though the adoption of one-cut strategies at higher speeds."

A case in point saw one trial site increase production of case-hardened 16MnCrS5 (HRc 57-62) automotive components by at least 15 percent after switching to CB7105 and CB7115. In fact, the CB7115 surpassed 600 components (at 0.15 minutes time-in-cut) with predictable surface generation and a lower Rz value. The cutting speed was 170 m/min (557 ft/min), while feed rate was 0.22 mm/rev (0.008 inch/rev) with a cutting depth of 0.15 mm (0.006 inch).

CB7105 and CB7115 offer updated PCBN material, edge preparations and improved edge-line quality to ensure better and more predictable tool life and edge-line security.

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

Traub

TNL18 AUTOMATIC LATHE OFFERS IMPROVED DYNAMICS

The Traub TNL18 series Swiss-style automatic lathes perform even more dynamically with an enhanced CNC control, axis amplifier, and more dynamic drives, resulting in significantly improved accelerations and top speeds. In extensive tests, the developers made sure that the mechanical conditions of the machine harmonize with the new dynamics.

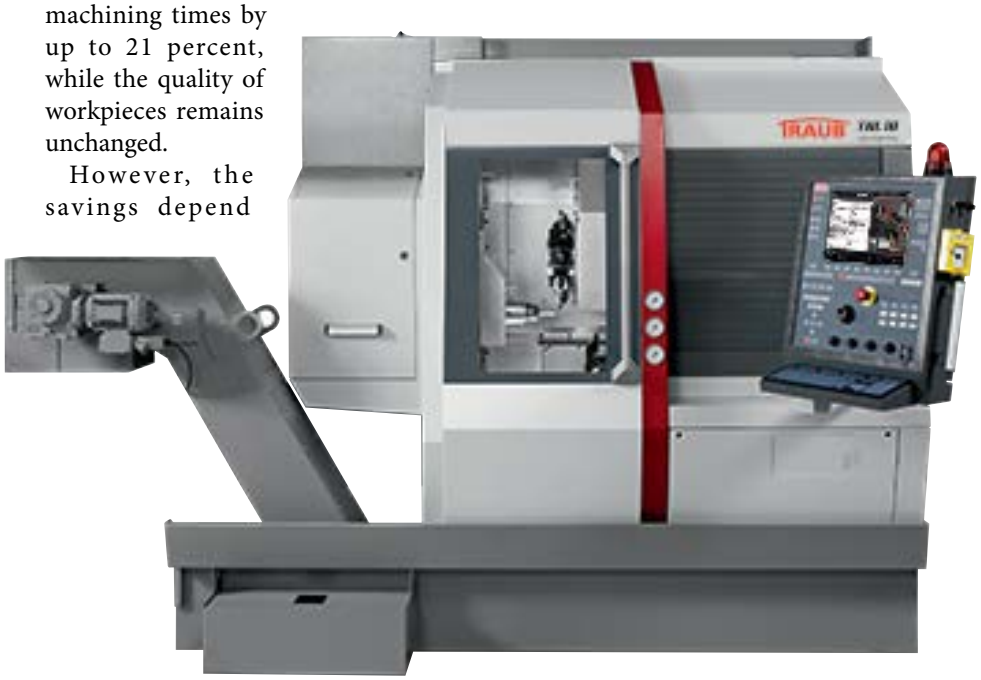
The TNL18 includes an optimized drivetrain which will benefit all machines in the Traub sliding/fixed headstock automatic lathe range: the TNL18-7B with its seven linear axes and the B-axis on the upper turret; the TNL18 9 with autonomous counter spindle and nine linear NC axes; the Traub TNL18-9P, optimized for series production.

The rugged mechanical construction of the Traub TNL18 machines effectively handle the new accelerations which are up to 25 percent faster than the previous TNL18. Better acceleration and optimized NC programs can reduce machining times by up to 21 percent, while the quality of workpieces remains unchanged.

However, the savings depend also on the complexity of the workpiece. While for a "simple" shaft that is machined mostly at constant cutting speeds and with only a few tool changes, the savings are about five percent, it is completely different for a dental implant with numerous different turning, drilling and milling operations. Besides reduced secondary times, the shorter acceleration and deceleration processes allow significantly higher feed rates for these complex cutting contours, resulting in the said 21 percent time savings.

Even if the user does not implement such cycle time-related optimization measures, he still benefits from the new powertrain. A much higher contour accuracy is possible, and on components with high precision requirements, this can be of great benefit if it reduces the number of measurement processes required.

For more information:
Index Traub
Phone: (317) 770-6300
www.indextraub.com



Gleason

INTRODUCES 300GMSL MULTI-SENSOR INSPECTION MACHINE

Gleason recently introduced its latest innovation in gear inspection technology with the 300GMSL Multi-Sensor Inspection Machine; providing the capabilities of four instruments on one platform.

Designed for manufacturers of automotive, aircraft and other like-sized gears, the 300GMSL offers a single, compact, reliable and easy-to-operate inspection solution to apply the most desirable gear measurement and analysis methods for both R&D and production applications.

An extremely versatile platform, the 300GMSL is capable of performing tactile probing to support traditional gear feature data collection on spur and helical gears, spiral and straight bevel gears up to 300 mm in diameter. In addition, the platform supports non-contact, laser, full form scanning for a wide range of workpieces to support gear development efforts where large amounts of data need to be collected faster than possible with conventional tactile probing. Optional features include surface finish measurement and Barkhausen Noise Analysis; to further improve throughput while reducing cost of ownership and floor space requirements.

The 300GMSL can be used for research and development applications such as rapid prototyping and reverse engineering. It is also well suited for normal production operations requiring high-speed topography inspection as well as increased non-gear inspection capabilities and the ability to inspect soft, compliant materials such as plastic gears.

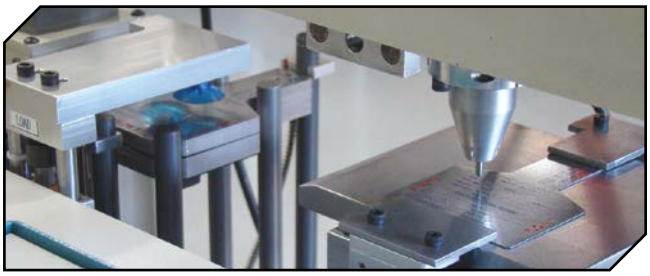
The optional Advanced Operator Interface puts a number of powerful tools right at the operator's fingertips including video telephony, note pad and voice mail messaging capability along with QR/bar code reading. The user-friendly, fully Windows compatible *GAMA* application software suite provides users a highly intuitive interface with simple input screens for programming workpiece data.

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

Kwik Mark Inc.

OFFERS AUTOMATIC NAME TAG FEEDER/MARKER

The new Tag Master 3 feeder was developed to eliminate the problematic tag feeding issues of escaping tags from the bottom of the magazine. The tags are transferred from the top to eliminate the jamming; scratching and other problems associated with bottom feed "coin changer" type escapements. This also means thickness tolerance; sharp edges, etc. are no longer issues. Available with Print Queue Driver; allowing multiple users to download job menus, variables, quantities, etc.



For more information:
Kwik Mark Inc.
Phone: (815) 363-8268
www.kwikmark.com

Kennametal

MILL 4-11 DESIGNED FOR SMALLER MACHINING CENTERS

The issue with many square shoulder indexable milling cutters is the stair-step effect they leave on workpiece walls.

Two years ago, Kennametal introduced a double-sided 90° milling platform that eliminates this issue while providing manufacturers a cost-effective machining solution to boot. The Mill 4 Series of indexable shoulder mills is now a proven performer, offering high metal removal rates, excellent tool life, and surface finish that frequently eliminates semi-finishing operations—and in some cases, can even be used as a finishing cutter, reducing reliance on expensive solid carbide end mills.

Kennametal is expanding its game-changing Mill 4 family with a new cutting tool, the Mill 4-11. Designed for smaller machining centers, the Mill 4-11 accommodates 40-taper CAT and BT, HSK50, and similarly-sized spindles. Due to its free-cutting capabilities, it is ideal for successful metal removal in less-than-rigid setups and on light-duty machine tools, multitaskers and live-tool lathes.

Tim Marshall, senior global product manager for indexable milling, said the Mill 4-11 enjoys the same strong insert design as its larger cousin, the Mill 4-15, but is 24 percent shorter and 34 percent narrower. With an 11 mm (0.433 in.) maximum cut length, this addresses the needs of those job shops and manufac-

turers producing smaller parts and part features while still offering high metal removal rates and excellent tool life.

"What's unique about it is the step down," said Marshall. "Because of the insert design and precision, there's very little mismatch between passes—for example, using a 63 mm diameter tool (2.48 in.) and our SGE geometry, we were able to achieve less than 8 µm (0.00003 in.) deviation between successive 6 mm (0.236 in.) deep passes. One of our largest automotive customers completely eliminated a finishing operation on a steel alloy housing because of it, saving them many thousands of dollars annually."

Scott Etling, director of global product management for indexable milling, said the Mill 4-11 platform offers a full complement of grades and geometries. "KCPM40 is our go-to grade for most steel applications and our newest KCSM40 is our first choice in aerospace and medical machining. Of course we have cast iron and aluminum grades, and a variety of edge preps and corner radii up to 1.6 mm (0.062 in.) as well," he added.

The Mill 4-11 is also easy to use. Each insert is securely locked in place with a single M3 screw, and marked with a series of dimples to indicate geometry and insert style. Marshall recommends customers keep the tool clean and the screws lubricated with a small amount of grease, and says it's a good idea to mount all of the inserts with the dimples or markings facing the same direction. "This improves accuracy during indexing, no matter whose cutting tools you're using," he added.

The cutter has uneven pocket spacing designed to break up machine harmonics and reduce chatter. Because of its complex insert geometry and positive placement in the pocket, it has an effective radial rake angle between 1° to 11°, depending on the cutter diameter, and an axial rake angle of 3°, this despite the Mill 4-11's double-sided design.

When taking cuts up to approximately 6.5 mm (0.255 in.) axial engagement, the cutter is essentially "stepless," although Marshall said cuts up to 11 mm deep (0.433 in.) are possible while still maintaining square, smooth walls. Best of all, it removes material quickly. "We've performed extensive testing," Marshall said. "Time and again we beat the competition, in some cases by 35 percent greater metal removal rates and 40 percent or longer tool life. It's quite simply a great addition to our portfolio."

For more information:
Kennametal
Phone: (724) 539-5000
www.kennametal.com

Liebherr

OFFERS NEW TECHNOLOGY FOR INTERNAL GEAR TOOTH PROFILE GRINDING

Liebherr has added a new internal gear tooth profile grinding technology, based on its proven OPAL grinding technology, to its portfolio. This involves a belt-drive spindle, which can be fitted to the standard GH 4.0 grinding head as well as to the new GH 5.0 and GH 6.0 grinding heads. Initially the internal gear grinding arm will be available in two different sizes, while others are to follow shortly. Custom internal gear grinding arms can be developed to match customer workpieces on request.

"The switch over is really simple. Changing between external and internal gears takes a maximum of half an hour," Dr. Hansjörg Geiser, head of the gear cutting machinery development and design engineering team, explains. "You detach the external gear grinding disk or worm, hang the internal gear grinding arm on the hardened stop bars to ensure repeat accuracy and fix it in place with a handful of screws, then tension the belt-drive disk and the belt and attach the cover. Internal gears can then be ground using a grinding disk of 100 or 125 millimeters in diameter—an innovation at Liebherr." The external gear grinding head does not have to be touched, and external gear grinding quality is again the same as before once the internal gear grinding arm has been detached.

IG Opal 4.0 is the name of this innovation that functions at a maximum spindle speed of 12,000 rpm. A larger version, the IG Opal 4.1, featuring a maxi-

mum grinding disk diameter of 125 millimeters, is also already available. Both arms were successfully tested using CBN and corundum disks. Where dressable grinding disks are used, the internal gear grinding arm travels up to the grinding dresser that is also used for external gear grinding.

All internal gear grinding arms are modelled in 3D and can be used in very confined spaces. "Collision inspections are simple and extremely reliable," emphasizes Andreas Mehr, who is responsible for grinding and shaping technology development and consultancy at Liebherr-Verzahntechnik GmbH. "Small-diameter internal gear teeth can therefore also be machined quickly and easily. Colleagues at Liebherr-Aerospace, which uses Liebherr gear cutting machinery to manufacture their own components, have confirmed this to us." The aerospace engineering specialist is one of three first buyers of this new technology. As in the case of external gears, this new internal gear teeth technology works with a multi-rib grinding disk system that can rough- and finish-grinding. That is particularly important to users, who regard speed and costs as important, for instance customers from the aerospace industry. Grinding disks made of dressable corundum or electroplated CBN can be used in conjunction with the spindle. These are also manufactured at Liebherr's plant in Ettlingen (Germany).

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

About This Directory

The 2016 *Gear Technology* Buyers Guide was compiled to provide you with a handy resource containing the contact information for significant suppliers of machinery, tooling, supplies and services used in gear manufacturing.

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

But Wait! Where are the Gear Manufacturers Listed?

If you are looking for suppliers of gears, splines, sprockets, gear drives or other power transmission components, see our listing of this issue's power transmission component advertisers on page 68. In addition, you will find our comprehensive directory in the December 2016 issue of *Power Transmission Engineering* as well as in our online directory at *www.powertransmission.com*.

Handy Online Resources

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

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

How to Get Listed in the Buyers Guide

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

CUTTING TOOLS

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

2L Inc.
www.2Linc.com

300 Below, Inc.
www.300below.com

A.L. Tooling cc
www.altooling.co.za

ANCA, Inc.
www.anca.com

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

Acedes Gear Tools
www.acedes.co.uk

Addison & Co. Ltd.
www.addison.co.in

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

Advico
www.advico.co.uk

Ajax Tool Supply
www.ajaxtoolsupply.com

Alliance Broach & Tool
www.alliancebroach.com

Allied Machine & Engineering Corp.
www.alliedmachine.com

American Broach & Machine Co.
www.americanbroach.com

Anderson Cook Inc.
www.andersoncook.com

Apex Broaching Systems
www.apexbroach.com

Ash Gear & Supply
www.ashgear.com

Banyan Global Technologies LLC
www.banyangt.com

Broach Masters/Universal Gear Co.
1605 INDUSTRIAL DRIVE
AUBURN CA 95603
Phone: (800) 563-3442
Fax: (530) 885-8157
sales@broachmasters.com
www.broachmasters.com
SEE OUR AD P51

Broaching Machine Specialties
www.broachingmachine.com

Canada Broach
www.canadabroach.com

Capital Tool Industries
www.capital-tool.com

Carbide Tool Services, Inc.
www.carbidetool.com

Carborundum Universal Ltd.
www.cumiabrasives.com

Century Precision Co., Ltd.
www.cty.co.kr

Ceramtec North America
www.ceramtec.

Cold Forming Technology
www.coldformingtechnology.com

Colonial Tool Group
www.colonialtool.com

Comco Inc.
www.comcoinc.com

Continental Diamond Tool Corporation
www.cdtusa.net

D.C. Morrison Company
www.dcmorrison.com

DK Surface Hardening
7427 W. 90TH ST.
BRIDGEVIEW IL 60455
Phone: (708) 233-9095
Fax: (708) 233-9366
contactus@dksurfacehardening.com
www.dksurfacehardening.com
SEE OUR AD P48,59

DTR Corp. (formerly Dragon Precision Tools)
1865A HICKS ROAD
ROLLING MEADOWS IL 60008
Phone: (847) 375-8892
Fax: (224) 220-1311
alex@dragon.co.kr
www.dragon.co.kr
SEE OUR AD P37

DVS Technology America Inc.
44099 PLYMOUTH OAKS BLVD. SUITE 102
PLYMOUTH, MI 48170
Phone: (734) 656 2080
sales.america@dvs-technology.com
www.dvs-technology.com
SEE OUR AD P21

Dathan Tool & Gauge Co. Ltd.
www.dathan.co.uk

Diametal AG
www.diametal.ch

Dianamic Abrasive Products Inc.
www.dianamic.com

ESGI Tools Pvt. Ltd.
www.esgitools.com

Eltool Corp.
www.eltool.com

Eltro Services, Inc.
www.eltroservices.com

Emuge Corp.
www.emuge.com

Engineered Tools Corp.
www.engineeredtools.com

Engis Corporation
www.engis.com

Fässler by Daetwyler Industries
www.faessler-usa.com

Fangyuan Ringlike Forging & Flange Co., Ltd.
www.steelforging.net

Federal Broach & Machine
www.federalbroach.com

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

Friedrich Gloor Ltd.
www.gloorag.ch

Fuji Machine America Corp.
www.fujimachine.com

Galaxy Sourcing Inc.
www.galaxysourcing.com

Gear Quality Inc.
donald_griffin@comcast.net

General Broach Company
www.generalbroach.com

German Machine Tools of America
www.gmtamerica.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Cutting Tools Corporation
1351 WINDSOR RD.
LOVES PARK IL 61111
Phone: (815) 877-8900
Fax: (815) 877-0264
gctc@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P56–57

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P56–57

Goldstein Gear Machinery LLC
1840 JARVIS AVE.
ELK GROVE VILLAGE IL 60007
Phone: (847) 437-6605
Fax: (847) 437-6618
michael@goldsteingearmachinery.com
www.goldsteingearmachinery.com
SEE OUR AD P62,110

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

Greg Allen Company
www.gallenco.com

Guardair Corporation
www.guardair.com

Guven Bronz Metal
www.guvendokum.com

Hanik Corporation
www.hanikcorp.com

Hanro Tools Incorporation
www.hanrotools.com

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

Huff Carbide Tool
www.huffcarbide.com

Ingersoll Cutting Tools
www.ingersoll-imc.com

International Tool Machines (ITM)
www.itmfl.com

Interstate Tool Corp.
itctoolcorp.com

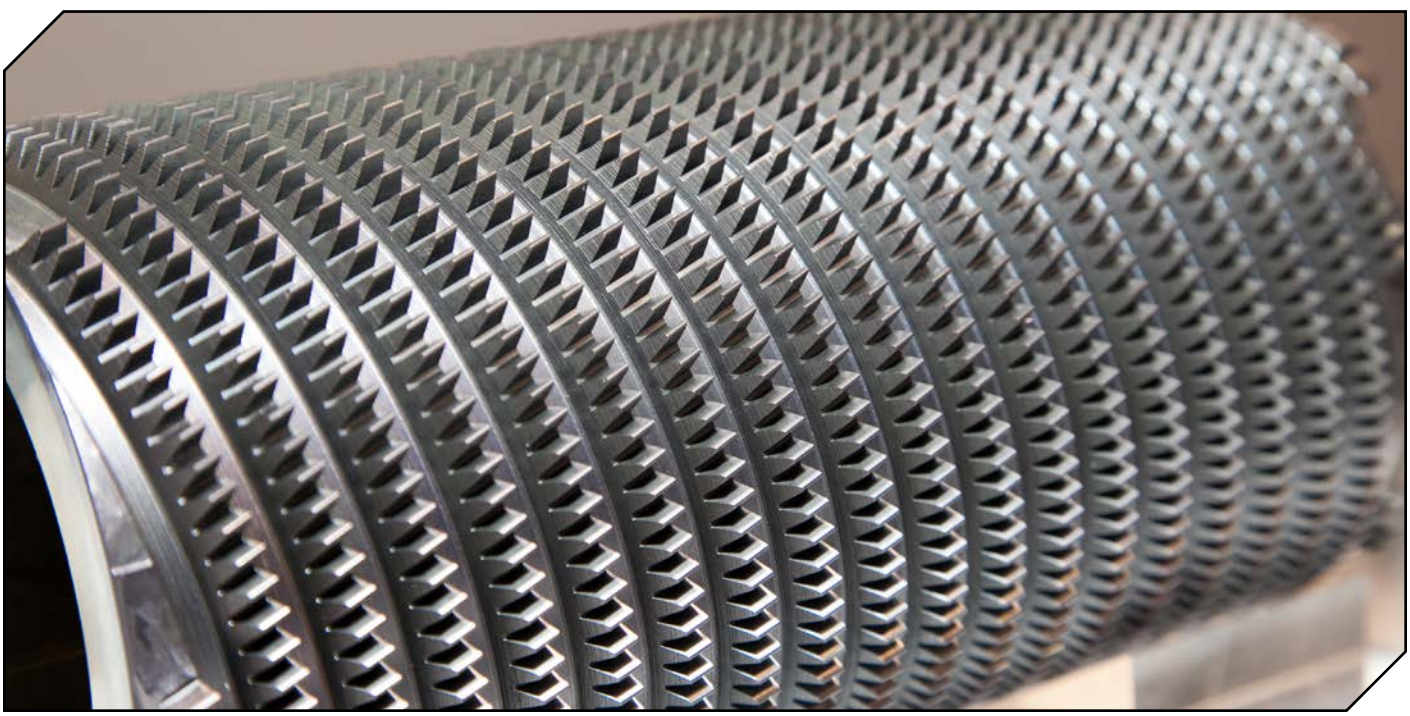
Kennametal Inc.
www.kennametal.com

Khemka Broach & Spline Gauge
www.khemkabroach.com

Kinefac Corporation
www.kinefac.com

Kingsford Broach & Tool Inc.
www.kingsfordbroach.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11



Klingelnberg America Inc.
118 E. MICHIGAN AVENUE, SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

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

Koepfer America
635 SCHNEIDER DRIVE
SOUTH ELGIN IL 60177
Phone: (847) 931-4121
Fax: (847) 931-4192
sales@koepferamerica.com
koepferamerica.com
SEE OUR AD P59

LMT USA
www.lmt-fette.com

Lalson Tools Corporation
www.lalsoncuttingtools.com

Leistritz Corporation
www.leistritzcorp.com

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

Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
SEE OUR AD P5

Longevity Coatings
www.longevitycoatings.com

Luren Precision Chicago
707 REMINGTON RD., SUITE 1
SCHAUMBURG IL 60173
Phone: (847) 882-1388
Fax: (847) 882-1933
sales@lurenusa.com
lurenusa.com
SEE OUR AD P31

Machine Tool Solutions, Inc.
machtoolinc.com Maheen Enterprises
www.maheenbroaches.com

Maxwell Tools Co. USA
www.maxwelltools.com

Maxwell Tools Company
www.maxwelltools.com

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
SEE OUR AD P8

Mitsubishi Materials USA
www.mmus.com

Modern Gearing
www.moderngearing.com

Mutschler Edge Technologies
mutschleredgetech.com

Nachi America Inc.
www.nachiamerica.com

Norton | Saint-Gobain
www.nortonindustrial.com

ORT Italia
www.ortitalia.com

Ohio Broach & Machine Co.
www.ohiobroach.com

PDM Engineering Pvt. Ltd.
www.pdmengg.net

Parker Industries Inc.
www.parkerind.com

Philadelphia Carbide Co.
www.philacarbide.com

Pinpoint Laser Systems
pinpointlaser.com

Pioneer Broach Co.
www.pioneerbroach.com

PlasmaRoute CNC
www.cncplasmacutterinc.com

Polygon Solutions
www.polygonsolutions.com

QC American
www.qcamerican.com

R.A. Heller
www.raheller.com

Roto-Flo/U.S. Gear Tools
www.roto-flo.com

Russell Holbrook & Henderson
www.tru-volute.com

S.S.Tools
www.sstools.net

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

SWG Solutions
www.swgsolutions.com

Saazor
www.saazor.de

Samputensili S.p.A.
www.samputensili.com

Sandvik Coromant
www.sandvik.coromant.com

Schnyder SA
JAKOBSTRASSE 52
CH-2504 BIEL
SWITZERLAND
Phone: +(41)(32) 344-0406
Fax: +(41)(32) 344-0404
george.boon@schnyder.com
www.schnyder.com
SEE OUR AD P4

Seco Tools Inc.
www.secotools.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Shape-Master Tool Company
www.shapemastertool.com

Slater Tools Inc.
www.slatertools.com

Slone Gear International, Inc.
www.slonegear.com

Star Cutter Co.
www.starcutter.com

Star SU LLC
5200 PRAIRIE STONE PARKWAY, SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-1,P58

Steelmans Broaches Pvt. Ltd.
www.steelmans.com

Sunnen Products Company
www.sunnen.com

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

TSA America, LLC
www.tsageartools.com

Techcellence
www.broachindia.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

U.S. Gear Tools
www.usgeartools.com

United Broach Company
www.unitedbroach.net

United Tool Supply Ltd.
www.unitedtoolsupply.com

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

Vargus USA
www.vargususa.com

Walter USA, LLC
www.walter-tools.com

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

West Michigan Spline, Inc.
www.westmichiganspline.com

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

Yash International
www.yashtools.com

GEAR BLANKS & RAW MATERIAL

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

300 Below, Inc.
www.300below.com

A. Finkl & Sons Co.
www.finkl.com

Accurate Specialties Inc.
www.accuratespecialties.com

Aksan Steel Forging
www.aksanforging.com

All Metals & Forge Group, LLC
75 LANE RD
FAIRFIELD NEW JERSEY 07004
Phone: (973) 276 5000
Fax: (973) 276 5050
info@steelforge.com
www.steelforge.com
SEE OUR AD P1724,49

American Friction Welding
www.teamafw.com

Anihas Castings
www.anihas.com

ArcVac ForgeCast Ltd.
www.arcvacsteel.com

BGH Specialty Steel Inc.
www.bgh.de

Bhandari Precision Forgings Pvt. Ltd.
www.bhandariforgings.com

Bharat Forge Ltd.
www.bharatforge.com

Bohler High Performance Metals Pvt. Ltd.
www.bohlerindia.com

Bohler-Uddeholm Corporation
www.bucorp.com

Boltex Manufacturing
www.boltex.com

Brooker Bros. Forging Co.
www.brookerbrosforgings.com

C.E. Sweeney & Associates
www.castingsandforgings.com

Canton Drop Forge
www.cantondropforge.com

Castalloy
www.castalloycorp.com

Celanese
www.celanese.com

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

Concast Metal Products
www.concast.com

Cornell Forge
www.cornellforge.com

Crucible Industries LLC
www.crucible.com

DSM Engineering Plastics
www.dsm.com

Dayton Forging and Heat Treating
www.daytonforging.com

Deco Products Company
www.decoprod.com

DuPont
plastics.dupont.com

Dura-Bar
www.dura-bar.com

Earle M. Jorgensen Co.
www.emjmetals.com

ElectroHeat Induction
www.electroheatinduction.com

Ellwood City Forge
www.ellwoodcityforge.com

Erasteel Inc.
www.erasteel.com

Excel Gear
11865 MAIN STREET
ROSCOE IL 61073
Phone: (815) 623-3414
Fax: (815) 623-3314
Chinn@excelgear.com
www.excelgear.com

SEE OUR AD P12

Fangyuan Ringlike Forging & Flange Co., Ltd.
www.steelforging.net

Fomas USA
www.fomasgroup.com

Forging Solutions LLC
www.forging-solutions.com

Fox Valley Forge
www.foxvalleyforge.com

Fuji Machine America Corp.
www.fujimachine.com

Galaxy Sourcing Inc.
www.galaxysourcing.com

Gear Quality Inc.
donald_griffin@comcast.net

Guven Bronz Metal
www.guvendokum.com

Hanro Tools Incorporation
www.hanrotools.com

Hunan Standard Steel Co. Ltd.
www.hu-steel.com

Hunter Chemical LLC
www.hunterchem.com

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

Intech Corporation
www.intechpower.com

Interstate Tool Corp.
itctoolcorp.com

Lafert North America
www.lafertna.com

Lalson Tools Corporation
www.lalsoncuttingtools.com

Larson Forgings
www.larsonforge.com

Lefere Forge
www.lefereforge.com

Mackeil Ispat & Forging Ltd.
mackeilforgings.com

Maguire Technologies
www.maguiretech.com

Martin Tool & Forge
www.martinsprocket.com

Masternet Ltd.
www.masternetltd.com

Maxwell Tools Co. USA
www.maxwelltools.com

CATEGORY LISTINGS

McInnes Rolled Rings
1533 EAST 12TH STREET
ERIE PA 16511
Phone: (800) 569-1420 or (814) 459-4495
Fax: (814) 459-8443
sales@mcrings.com
mcinnesrolledrings.com
SEE OUR AD P18,26

McKees Rocks Forgings
www.mckeesrocksforgings.com

Midwest Themal-Vac Inc.
www.mtvac.com

Moore-Addison Precision Plastic Blanking
www.mooreaddison.com

Mosey Manufacturing Co. Inc.
www.moseymfg.com

National Bronze & Metals, Inc.
www.nbmmetals.com

National Bronze Mfg. Co.
www.nationalbronze.com

Ovako AB
www.ovako.com

PC Forge
www.pcforge.ca

PCK Buderus India
www.pck-buderus.com

Parag Casting Co.
www.paragcasting.com

Patriot Forge
www.patriotforge.com

Penticton Foundry Ltd.
www.pentictonfoundry.com

Perry Technology Corporation
P.O. BOX 21
120 INDUSTRIAL PARK ROAD
NEW HARTFORD CT 06019
Phone: (860) 738-2525
Fax: (860) 738-2455
dseger@perrytechnology.com
www.perrygear.com
SEE OUR AD P61

Presrite Corporation
3665 E. 78TH STREET
CLEVELAND OH 44105
Phone: (216) 441-5990
Fax: (216) 441-2644
www.presrite.com
SEE OUR AD P61

QSC Forge & Flange
www.qscforge.com

QuesTek Innovations LLC
www.questek.com

Ralf Schaffer
www.specialsteel-forgings.com

Reade Advanced Materials
www.reade.com

Renishaw Inc.
www.renishaw.com

Rewitec GmbH
www.rewitec.com

Rotek Incorporated
www.rotek-inc.com

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

Schmiedewerke Groeditz GmbH
www.stahl-groeditz.de

Scot Forge
www.scotforge.com

Sedlock Companies
www.sedlockcompanies.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Sensor Products Inc.
www.sensorprod.com

Shree Krishna Auto Indsutries
www.shreekrishnaauto.com

Southwest Metal Products Ltd.
www.southwestmetal.com

Spectrum Machine Inc.
www.spectrummachine.com

Steuby Manufacturing Company, Inc.
www.steubymfg.com

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

TimkenSteel Corporation
www.timkensteel.com

UMC - United Metals Co.
www.umcmetals.com

United Cast Bar, Inc.
www.unitedcastbar.com

Viking Forge
www.viking-forge.com

Walker Forge
www.walkerforge.com

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

Welland Forge
www.wellandforge.com

Willman Industries Inc.
www.willmanind.com

Yarde Metals
www.yarde.com

Yash International
www.yashtools.com

ARROW GEAR COMPANY

ARROW VISION

SEE IT IN YOUR RESULTS

ARROW GEAR'S COMMITMENT TO QUALITY

WHEN FAILURE ISN'T AN OPTION

When you're hovering at 5,000 feet, gearbox failure is simply not an option. In fact, few applications demand the quality and precision crucial to the helicopter industry.

For more than 60 years, Arrow Gear has remained an industry leader by consistently supplying aerospace gears that meet the most demanding quality requirements. Today, our products can be found in critical in-flight applications around the world. It's no wonder that top suppliers of civilian and military helicopters trust in Arrow for the gears that keep them flying. Because especially in aerospace, quality is crucial.

See it in Your Results.
Call 630-969-7640 or visit arrowgear.com

2301 CURTISS STREET, DOWNERS GROVE, IL 60515 | 630-969-7640 | ARROWGEAR.COM

GEAR MACHINES

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

ANCA, Inc.
www.anca.com

Abtex Corp.
www.abtex.com

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

Acme Manufacturing Co.
www.acmemfg.com

Advico
www.advico.co.uk

Affolter
www.rotectools.com

Alliance Broach & Tool
www.alliancebroach.com

American Broach & Machine Co.
www.americanbroach.com

Anderson Cook Inc.
www.andersoncook.com

Apex Broaching Systems
www.apexbroach.com

Banyan Global Technologies LLC
www.banyangt.com

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

Bates Technologies, LLC
www.batestech.com

Becker GearMeisters, Inc.
www.maagmachines.com

Bourn & Koch Inc.
www.bourn-koch.com

Breton USA
www.bretonusa.com

Broaching Machine Specialties
www.broachingmachine.com

C & B Machinery
www.cbmachinery.com

CNC Center
www.cnccenter.com

CNC Machining by American Swiss Products
www.americanswiss.com

Capital Tool Industries
www.capital-tool.com

Chamfermatic Inc.
www.chamfermatic.com

Clemco Industries Corp.
www.clemcoindustries.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Colonial Tool Group
www.colonialtool.com

Comco Inc.
www.comcoinc.com

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

D.C. Morrison Company
www.dcmorrison.com

DMG MORI USA
www.dmgmori-usa.com

DVS Technology America Inc.
44099 PLYMOUTH OAKS BLVD. SUITE 102
PLYMOUTH, MI 48170
Phone: (734) 656 2080
sales.america@dvs-technology.com
www.dvs-technology.com
SEE OUR AD P21

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

Dianamic Abrasive Products Inc.
www.dianamic.com

Donner+Pfister AG
KIRCHWEG 5
CH-8855 WANGEN-NUOLEN
SWITZERLAND
Phone: +(41) 55 440 20 32
Fax: +(41) 55 440 29 80
info@dpag.ch
www.dpag.ch
SEE OUR AD P4

Drake Manufacturing Services Co., LLC
www.drakemfg.com

Dreamtec Consulting LLC
www.dreamtec.us

EMAG L.L.C.
www.emag.com

Electronics Inc.
www.electronics-inc.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Abrasives
www.engineeredabrasives.com

Engis Corporation
www.engis.com

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

Fässler by Daetwyler Industries
www.faessler-usa.com

FFG - Modul
www.star-su.com

Fassler by Daetwyler Industries
www.fassler-usa.com

Federal Broach & Machine
www.federalbroach.com

Fellows Machine Tools
www.bourn-koch.com

Felsomat USA Inc.
www.felsomat.com

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

Fuji Machine America Corp.
www.fujimachine.com

Gear Consulting Group
www.gearconsultinggroup.com

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

Gehring L.P.
www.gehring.de

General Broach Company
www.generalbroach.com

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

German Machine Tools of America
www.gmtamerica.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P56–57

Gleason Works Rochester
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 256-6776
rewanow@gleason.com
www.gleason.com
SEE OUR AD P56–57

Goldstein Gear Machinery LLC
1840 JARVIS AVE.
ELK GROVE VILLAGE IL 60007
Phone: (847) 437-6605
Fax: (847) 437-6618
michael@goldsteingearmachinery.com
www.goldsteingearmachinery.com
SEE OUR AD P62,110

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

Greg Allen Company
www.gallenco.com

HÖFLER - A Brand of KLINGELNBERG
www.hofler.com

Haas Multigrind LLC
www.multigrind.com

Hamai Co. Ltd.
www.hamai.com

Hanik Corporation
www.hanikcorp.com

Hanro Tools Incorporation
www.hanrotools.com

Hans-Juergen Geiger Maschinen-Vertrieb GmbH
JAMES-WATT-STRASSE 12
D-72555 METZINGEN
GERMANY
Phone: +(49) 7123-18040
Fax: +(49) 7123-18384
geiger@geiger-germany.com
www.geiger-germany.com
SEE OUR AD P36

Hartech
www.hartech.com.tw

Havlik International Machinery Inc.
www.havlikinternational.com

Heller Machine Tools
www.heller-machinetools.com

IMEXSU Group
www.imexsu.com

ITW Heartland
www.itwheartland.com

Index Corporation
www.indextraub.com

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

International Tool Machines (ITM)
www.itmfl.com

Involute Gear & Machine Company
www.involutegearmachine.com

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

JRM International, Inc
www.jrminternational.com

James Engineering
www.james-engineering.com

Kapp Technologies
2870 WILDERNESS PLACE
BOULDER CO 80301
Phone: (303) 447-1130
Fax: (303) 447-1131
sales-USA@kapp-niles.com
www.kapp-usa.com
SEE OUR AD P3,59

Khemka Broach & Spline Gauge
www.khemkabroach.com

Kinefac Corporation
www.kinefac.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE, SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

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

Koepfer America
635 SCHNEIDER DRIVE
SOUTH ELGIN IL 60177
Phone: (847) 931-4121
Fax: (847) 931-4192
sales@koepferamerica.com
koepferamerica.com
SEE OUR AD P59

Lambda Technologies
www.lambdatechs.com

Leistritz Corporation
www.leistritzcorp.com

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

Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
SEE OUR AD P5

Luren Precision Chicago
707 REMINGTON RD., SUITE 1
SCHAUMBURG IL 60173
Phone: (847) 882-1388
Fax: (847) 882-1933
sales@lurenusa.com
lurenusa.com
SEE OUR AD P31

MPT Manufacturing Process Technologies
www.mptinc.com

Machine Tool Builders
www.machinetoolbuilders.com

Mazak Corporation
www.mazakusa.com

Meccanica Nova Corporation
www.novagrinders.com

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

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
SEE OUR AD P8

Mutschler Edge Technologies
mutschleredgetech.com

Nachi America Inc.
www.nachiamerica.com

Nagel Precision
www.nagelusa.com

Normac, Inc.
www.normac.com

ORT Italia
www.ortitalia.com

Ohio Broach & Machine Co.
www.ohiobroach.com

Okuma America Corporation
www.okuma.com

PTG Holroyd
www.holroyd.com

Parker Industries Inc.
www.parkerind.com

Pegard Productics Division HARO
harotechnologies.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
SEE OUR AD P25

Phoenix Inc.
www.phoenix-inc.com

Pioneer Broach Co.
www.pioneerbroach.com

PlasmaRoute CNC
www.cncplasmacutterinc.com

Power Inverter Inc.
www.powerinverter.org

Precision Finishing Inc.
www.precisionfinishinginc.com

Preco Inc.
www.precolaser.com

Prime Technologies
www.gear-testers.com

QC American
www.qcamerican.com

Röders GmbH
www.roeders.de

Ravjeet Engineering Specialty Ltd.
www.ravjeet.com

Redin Production Machine
www.redinmachine.com

Reishauer AG
INDUSTRIESTRASSE 36
CH-8304 WALLISELLEN
SWITZERLAND
Phone: +(41) 44-832-22-11
Fax: +(41) 44-832-23-90
info@reishauer.com
www.reishauer.com
SEE OUR AD P41

Reishauer Corporation
1525 HOLMES ROAD
ELGIN IL 60123
Phone: (847) 888-3828
Fax: (847) 888-0343
usa@reishauer.com
www.reishauer.com
SEE OUR AD P41

Roberts Sinto Corp.
www.robertssinto.com

Rotek Incorporated
www.rotek-inc.com

Roto-Flo/U.S. Gear Tools
www.roto-flo.com

Russell Holbrook & Henderson
www.tru-volute.com

SETCO Precision Spindles
www.setcousa.com

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

Saacke North America, LLC
www.saacke-usa.com

Samputensili S.p.A.
www.samputensili.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

SerWeMa GmbH & Co. KG
www.serwema.de

Star Cutter Co.
www.starcutter.com

Star SU LLC
5200 PRAIRIE STONE PARKWAY, SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-1,58

Steelmans Broaches Pvt. Ltd.
www.steelmans.com

Stenhoj Broaching Machines
www.stenhoj.dk

Sunnen Products Company
www.sunnen.com

Surface Finishing Equipment Co.
www.sfecindia.net

Surplex GmbH
www.surplex.com

TECO Werkzeugmaschinen GmbH & Co.
www.teco-germany.com

Tianjin No.1 Machine Tool Works
www.tmtw.com

Toolink Engineering
www.toolink-eng.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

U.S. Gear Tools
www.usgeartools.com

Ultramatic Equipment Co.
ultramatic-equipment.com

Vermont Machine Tool
www.vermontmachinetool.com

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

WardJet
www.wardjet.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Westminster Machine Tools Ltd.
www.wmtg.co.uk

Wheelabrator
www.wheelabratorgroup.com

Willrich Precision Instrument Company
willrich.com

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

Yieh Chen Machinery
www.yiehchen.com

GRINDING WHEELS & ABRASIVE TOOLS

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

2L Inc.
www.2Linc.com

3M Abrasives
www.3m.com/Abrasives

Abtex Corp.
www.abtex.com

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

Ajax Tool Supply
www.ajaxtoolsupply.com

Alliance Broach & Tool
www.alliancebroach.com

Banyan Global Technologies LLC
www.banyangt.com

Bates Technologies, LLC
www.batestech.com

Brighton Laboratories
www.brightonlabs.com

CGW - Camel Grinding Wheels
www.cgwcamel.com

Carborundum Universal Ltd.
www.cumiabrasives.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Comco Inc.
www.comcoinc.com

Continental Diamond Tool Corporation
www.cdtusa.net

DTR Corp. (formerly Dragon Precision Tools)
1865A HICKS ROAD
ROLLING MEADOWS IL 60008
Phone: (847) 375-8892
Fax: (224) 220-1311
alex@dragon.co.kr
www.dragon.co.kr
SEE OUR AD P37

DVS Technology America Inc.
44099 PLYMOUTH OAKS BLVD. SUITE 102
PLYMOUTH, MI 48170
Phone: (734) 656 2080
sales.america@dvs-technology.com
www.dvs-technology.com
SEE OUR AD P21

DiaTech Tools India Pvt. Ltd.
www.diatechtools.com

Diametal AG
www.diametal.ch

Diamond Abrasive Products
www.diamondabrasiveproducts.com

Dianamic Abrasive Products Inc.
www.dianamic.com

Dr. Kaiser Diamantwerkzeuge
www.drkaiser.de

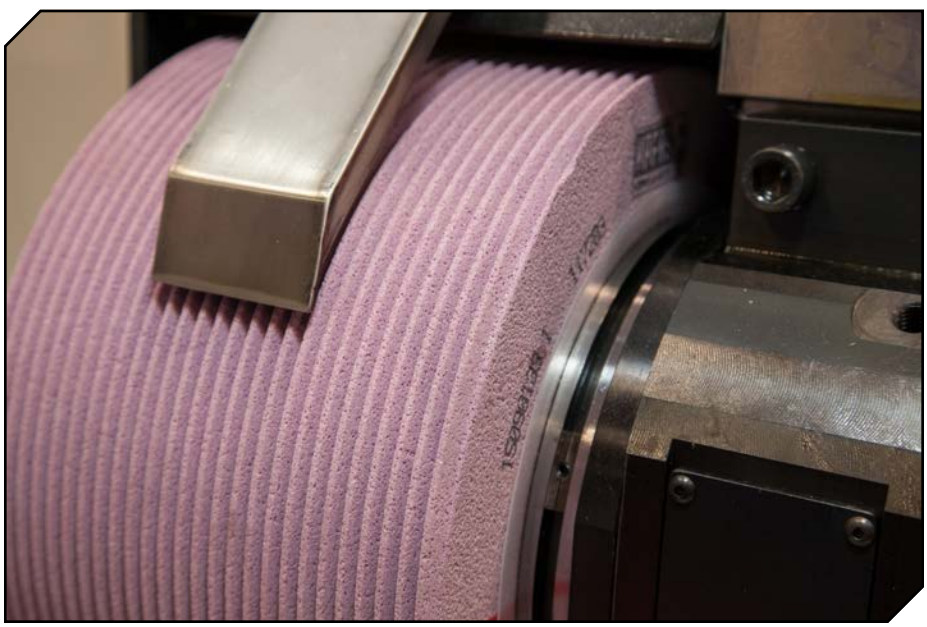
ESGI Tools Pvt. Ltd.
www.esgitools.com

Engis Corporation
www.engis.com

Fässler by Daetwyler Industries
www.faessler-usa.com

FFG - Modul
www.star-su.com

Fassler by Daetwyler Industries
www.fassler-usa.com



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

Gear Technology
www.geartechnology.in

Gehring L.P.
www.gehring.de

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Cutting Tools Corporation
1351 WINDSOR RD.
LOVES PARK IL 61111
Phone: (815) 877-8900
Fax: (815) 877-0264
gctc@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P56–57

Graff Diamond Products
www.graffdiamond.com

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

Greg Allen Company
www.gallenco.com

Hanro Tools Incorporation
www.hanrotools.com

Hermes Abrasives Ltd.
www.hermesabrasives.com

Huff Carbide Tool
www.huffcarbide.com

IMEXSU Group
www.imexsu.com

Interstate Tool Corp.
itctoolcorp.com

Involute Gear & Machine Company
www.involutegearmachine.com

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

JRM International, Inc.
www.jrminternational.com

Kapp Technologies
2870 WILDERNESS PLACE
BOULDER CO 80301
Phone: (303) 447-1130
Fax: (303) 447-1131
sales-USA@kapp-niles.com
www.kapp-usa.com
SEE OUR AD P3,59

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE, SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

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

Koepfer America
635 SCHNEIDER DRIVE
SOUTH ELGIN IL 60177
Phone: (847) 931-4121
Fax: (847) 931-4192
sales@koepferamerica.com
koepferamerica.com
SEE OUR AD P59

Lambda Technologies
www.lambdatechs.com

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

Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
SEE OUR AD P5

Longevity Coatings
www.longevitycoatings.com

Luren Precision Chicago
707 REMINGTON RD., SUITE 1
SCHAUMBURG IL 60173
Phone: (847) 882-1388
Fax: (847) 882-1933
sales@lurenusa.com
lurenusa.com
SEE OUR AD P31

Marposs Corporation
www.marposs.com

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

Modern Gearing
www.moderngearing.com

Mutschler Edge Technologies
mutschleredgetech.com

Nagel Precision
www.nagelusa.com

Norton | Saint-Gobain
www.nortonindustrial.com

Osborn International
www.osborn.com

PTG Holroyd
www.holroyd.com

Particular Technology, Inc.
www.particulartechnology.com

Philadelphia Carbide Co.
www.philacarbide.com

Precision Spindle & Accessories Inc.
www.precisionspindleinc.com

QC American
www.qcamerican.com

Radiac Abrasives
www.radiac.com

Ravjeet Engineering Specialty Ltd.
www.ravjeet.com

RedLine Tools
www.redlinetools.com

Redin Production Machine
www.redinmachine.com

Reishauer AG
INDUSTRIESTRASSE 36
CH-8304 WALLISELLEN
SWITZERLAND
Phone: +(41) 44-832-22-11
Fax: +(41) 44-832-23-90
info@reishauer.com
www.reishauer.com
SEE OUR AD P41

Reishauer Corporation
1525 HOLMES ROAD
ELGIN IL 60123
Phone: (847) 888-3828
Fax: (847) 888-0343
usa@reishauer.com
www.reishauer.com
SEE OUR AD P41

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

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

Samputensili S.p.A.
www.samputensili.com

Schnyder SA
JAKOBSTRASSE 52
CH-2504 BIEL
SWITZERLAND
Phone: +(41)(32) 344-0406
Fax: +(41)(32) 344-0404
george.boon@schnyder.com
www.schnyder.com
SEE OUR AD P4

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

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

Special Cutting Tools
www.specialcuttingtools.net

Star Cutter Co.
www.starcutter.com

Star SU LLC
5200 PRAIRIE STONE PARKWAY, SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-1,58

Steelmans Broaches Pvt. Ltd.
www.steelmans.com

Stella Keramik GmbH
www.stella-gruppe.de

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

Sunnen Products Company
www.sunnen.com

Suresh Mehta Associates
www.sureshmehta.com

Toolink Engineering
www.toolink-eng.com

Ultramatic Equipment Co.
ultramatic-equipment.com

Vargus USA
www.vargusa.com

Weldon Solutions
www.weldonsolutions.com

Yash International
www.yashtools.com

HEAT TREATING EQUIPMENT & SUPPLIES

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

300 Below, Inc.
www.300below.com

AFC-Holcroft
www.afc-holcroft.com

ALD-Holcroft
www.ald-holcroft.com

Abbott Furnace Company
www.abbottfurnace.com

Advanced Nitriding Solutions
www.ans-ion.net

Aichelin Heat Treatment Systems, Inc.
www.aichelinusa.com

Ajax Tocco Magnethermic
1745 OVERLAND AVE NE
WARREN OH 44483
Phone: 330-372-8511
Fax: 330-372-8608
sales@ajaxtocco.com
www.ajaxtocco.com
SEE OUR AD P58

Aksan Steel Forging
www.aksanforging.com

Ambrell Precision Induction Heating
www.ambrell.com

Avion Manufacturing Company Inc.
www.avionmfg.com

Bega Special Tools
www.bega.nl

Bodyhardchem
www.bodyhardchem.com

Byington Steel Treating
www.byingtonsteel.com

C.I. Hayes
www.cihayes.com

C.I. Hayes, A Gasbarre Furnace Group Company
www.cihayes.com

Cascade TEK
www.cascadetek.com

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

Contour Hardening, Inc.
www.contourhardening.com

DAM GmbH
www.stopoffpaints.com

Davron Technologies
www.davrontech.com

Duffy Company, The
www.duffycompany.com

ECM USA
9505 72ND AVE. SUITE 400
PLEASANT PRAIRIE WI 53158
Phone: (262) 605-4810
info@ecm-usa.com
www.ecm-usa.com
SEE OUR AD P29,32

EFD Induction Inc.
www.efdinduction-usa.com

East Coast Induction
www.eastcoastind.com

Eldec Induction USA, Inc.
www.eldec-usa.com

ElectroHeat Induction
www.electroheatinduction.com

Eltro Services, Inc.
www.eltroservices.com

Euclid Heat Treating
www.euclidheattreating.com

FPM Heat Treating
www.fpmht.com

Flame Treating & Engineering
www.flametreating.com

Flame Treating Systems, Inc.
www.flametreatingsystems.com

Fredericks Company - Televac
www.frederickscompany.com

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

GH Induction Atmospheres
www.gh-ia.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works Rochester
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 256-6776
rewanow@gleason.com
www.gleason.com
SEE OUR AD P56–57

Goldstein Gear Machinery LLC
1840 JARVIS AVE.
ELK GROVE VILLAGE IL 60007
Phone: (847) 437-6605
Fax: (847) 437-6618
michael@goldsteingearmachinery.com
www.goldsteingearmachinery.com
SEE OUR AD P62,110

Grieve Corporation, The
www.grievecorp.com

Hanro Tools Incorporation
www.hanrotools.com

Heatbath/Park Metallurgical
www.heatbath.com

Heavy Carbon Co., LLC
www.heavycarbon.com

HighTemp Furnaces Limited
www.hightemp-furnaces.com

Houghton International
www.houghtonintl.com

IHI Ionbond Inc.
ionbond.com

Induction Tooling, Inc.
www.inductiontooling.com

Inductoheat Inc.
www.inductoheat.com

Inductotherm Corp.
www.inductotherm.com

Ionitech Ltd.
www.ionitech.com

J.L. Becker, A Gasbarre Furnace Group Company
www.jlbecker.com

Khemka Broach & Spline Gauge
www.khemkabroach.com

Koncar Termotehnika d.o.o.
koncar-termotehnika.hr

Lucifer Furnaces, Inc.
www.Luciferfurnaces.com

Machine Tool Solutions, Inc.
machtoolinc.com

Metallurgical High Vacuum Corp.
www.methivac.com

Mindon Engineering
www.mindon-eng.com

National Heat Treat
nationalheattreat.com

Nisha Engineers (India)
www.nishagroup.com

Nitrex Inc. - Chicago Operations
www.nitrex.com

Nitrex Inc. - Indiana Operations
www.nitrex.com

Nitrex Inc. - Michigan Operations
www.nitrex.com

Nitrex Inc. - West Coast Operations
www.nitrex.com

Nitrex Metal Inc.
www.nitrex.com

PC Forge
www.pcforge.ca

PhoenixTM
www.phoenixtm.com

Pillar Induction
www.pillar.com

Plus Furnace
www.plusfurnace.com

Preco Inc.
www.precolaser.com

Premier Furnace Specialists Inc.
www.premierfurnace.com

Pro-Beam USA
www.pro-beam.com

Pyromaitre
www.pyromaitre.com

Radyne Corporation
www.radyne.com

Regal Products, Inc.
www.regalproducts.com

Roberts Sinto Corp.
www.robertssinto.com

Rubig US, Inc.
www.rubig.com

SMS Elotherm North America
www.techinduction.com

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

Seco/Warwick Corp.
www.secowarwick.com

Seco/Warwick Europe S.A.
www.secowarwickeurope.com.pl

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Sinterite, A Gasbarre Furnace Group Company
www.sinterite.com

Solar Manufacturing
1983 CLEARVIEW ROAD
SOUDERTON PA 18964
Phone: (267) 384-5040
Fax: (267) 384-5060
info@solarmfg.com
www.solarmfg.com
SEE OUR AD P34

Stack Metallurgical Services, Inc.
www.stackmet.com

Surface Combustion
www.surfacecombustion.com

TM Induction Heating
www.tminductionheating.com

Thermal Spray Coatings - A&A Coatings
www.thermalspray.com

Welland Forge
www.wellandforge.com

ZRIME
www.zrime.com.cn

Zion Industries
www.zioninduction.com

HEAT TREATING SERVICES

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

300 Below, Inc.
www.300below.com

Accu-Temp Heat Treating
www.accutempheat.com

Accurate Steel Treating, Inc.
www.accuratesteeltreating.com

Advanced Heat Treat Corp.
www.ahtweb.com

Advanced Nitriding Solutions
www.ans-ion.net

Aichelin Heat Treatment Systems, Inc.
www.aichelinusa.com

Ajax Tocco Magnethermic
1745 OVERLAND AVE NE
WARREN OH 44483
Phone: 330-372-8511
Fax: 330-372-8608
sales@ajaxtocco.com
www.ajaxtocco.com
SEE OUR AD P58

Akron Steel Treating Company
www.akronsteeltreating.com

Aksan Steel Forging
www.aksanforging.com

ALD Thermal Treatment, Inc.
2656 24TH STREET
PORT HURON MI 48060
Phone: (810) 357-0685
Fax: (810) 357-0699
sales@aldtt.net
www.aldtt.net
SEE OUR AD P34,60

American Metal Treating Co.
www.americanmetaltreating.com

American Metal treating, Inc.
www.americanmetaltreatinginc.com

Ampere Metal Finishing
www.amperemetal.com

Applied Process
12238 NEWBURGH ROAD
LIVONIA MI 48150
Phone: (734) 464-8000
Fax: (734) 464-6314
info@appliedprocess.com
www.appliedprocess.com
SEE OUR AD P58

Applied Thermal Technologies
www.appliedthermaltechnologies.com

Avion Manufacturing Company Inc.
www.avionmfg.com

BG&S Peening and Consulting LLC
www.peeningconsultants.com

BOS Services Company
www.bosheattreating.com

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

Best Technology Inc.
www.besttechnologyinc.com

Bluewater Thermal Solutions
www.bluewaterthermal.com

Bodycote Thermal Processing - Highland Heights
www.bodycote.com

Bodycote Thermal Processing - Melrose Park
www.bodycote.com

Bodyhardchem
www.bodyhardchem.com

Boltex Manufacturing
www.boltex.com

Braddock Metallurgical
www.braddockmt.com

Burlington Engineering, Inc
www.burlingtoneng.com

Byington Steel Treating
www.byingtonsteel.com

CST-Cincinnati Steel Treating
www.steeltreating.com

California Surface Hardening, Inc.
www.calflamehardening.com

Calumet Surface Hardening
calsurhardening@att.net

Cambridge Heat Treating Inc.
www.cambridgeheattreating.com

Cascade TEK
www.cascadetek.com

Certified Steel Treating
www.certifiedsteeltreat.com

Chicago Flame Hardening
www.cflame.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Complete Heat Treating
www.completeht.com

Continental Heat Treating, Inc.
www.continentalht.com

Contour Hardening, Inc.
www.contourhardening.com

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

Cryoplus Inc.
www.cryoplus.com

Dayton Forging and Heat Treating
www.daytonforging.com

Detroit Steel Treating Co.
www.detroitsteeltreating.com

Duffy Company, The
www.duffycompany.com

ECM USA
9505 72ND AVE. SUITE 400
PLEASANT PRAIRIE WI 53158
Phone: (262) 605-4810
info@ecm-usa.com
www.ecm-usa.com
SEE OUR AD P29,32

EFD Induction Inc.
www.efdinduction-usa.com

ERS Engineering Corp.
www.ersengine.com

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

Eldec Induction USA, Inc.
www.eldec-usa.com

ElectroHeat Induction
www.electroheatinduction.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Heat Treat, Inc.
www.ehtinc.com

Erasteel Inc.
www.erasteel.com

Euclid Heat Treating
www.euclidheattreating.com

Extremeion Hard Carbon
www.CarbonRaptor.com

FPM Heat Treating
www.fpmht.com

Felsomat USA Inc.
www.felsomat.com

Flame Metals Processing Corporation
www.flamemetals.com

Flame Treating & Engineering
www.flametreating.com

Flame Treating Systems, Inc.
www.flametreatingsystems.com

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

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

General Surface Hardening Inc.
www.gshinc.net

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works Rochester
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 256-6776
rewanow@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gozuk Co.LTD
www.vfds.org

Härterei Reese Bochum GmbH
www.hardening.com

Heat Treating Services Corporation of America
www.htsmi.com

Hi TecMetal Group
www.htg.cc

HighTemp Furnaces Limited
www.hightemp-furnaces.com

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

Hudapack Metal Treating
www.hudapack.com

IHI Ionbond Inc.
ionbond.com

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

Induction Hardening Specialists
inductionhardeningspecialists.com

Induction Resources
inductions@aol.com

Induction Services, Inc.
www.inductionservicesinc.com

Induction Tooling, Inc.
www.inductiontooling.com

Inductoheat Inc.
www.inductoheat.com

Industrial Metal Finishing, Inc.
www.indmetfin.com

Ionic Technologies Inc.
www.ionic-tech.com

Ionitech Ltd.
www.ionitech.com

Irwin Automation Inc.
www.irwinautomation.com

Khemka Broach & Spline Gauge
www.khemkabroach.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Kowalski Heat Treating
www.khtheat.com

Lalson Tools Corporation
www.lalsoncuttingtools.com

Lambda Technologies
www.lambdatechs.com

Mackeil Ispat & Forging Ltd.
mackeilforgings.com

Magnum Induction
www.magnuminduction.com

McLeod and Norquay Ltd.
www.mcleodandnorquay.com

Metal Improvement Company www.metalimprovement.com

Metallurgical Processing, Inc.
www.mpimetaltreating.com

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

Metlab
www.metlabheattreat.com

Mid-South Metallurgical
www.midsouthmetallurgical.com

Midwest Themal-Vac Inc.
www.mtvac.com

Nachi America Inc.
www.nachiamerica.com

National Heat Treat
nationalheattreat.com

Nisha Engineers (India)
www.nishagroup.com

Nitrex Inc. - Chicago Operations
www.nitrex.com

Nitrex Inc. - Indiana Operations
www.nitrex.com

Nitrex Inc. - Michigan Operations
www.nitrex.com

Nitrex Inc. - Nevada Operations
www.nitrex.com

Nitrex Inc. - West Coast Operations
www.nitrex.com

Nitrex Metal Inc.
www.nitrex.com

Nitrex Metal Technologies Inc.
www.nitrexmetaltech.com

Oerlikon Balzers - PPD Division
www.oerlikon.com

Ohio Vertical Heat Treat
www.ov-ht.com

Ovako AB
www.ovako.com

PC Forge
www.pcforge.ca

Paulo
www.paulo.com

Penna Flame Industries
www.pennaflame.com

Penticton Foundry Ltd.
www.pentictonfoundry.com

Peters Heat Treating
www.petersheattreat.com

Pillar Induction
www.pillar.com

Precision Finishing Inc.
www.precisionfinishinginc.com

Precision Heat Treating
precisionheat@tulsacoxmail.com

Precision Heat Treating Co.
www.precisionheat.net

Precision Heat Treating Corporation
www.phtc.net

Precision Pump and Gear Works
www.ppg-works.com

Precision Thermal Processing
www.precisionthermal.com

Preco Inc.
www.precolaser.com

Pro-Beam USA
www.pro-beam.com

Progressive Heat Treating Co.
www.pecgears.com

R & R Heat Treating
rrheattreat@verizon.net

Rex Heat Treat
www.rexht.com

Rockford Heat Treaters
www.rockfordheattreaters.com

Rotek Incorporated
www.rotek-inc.com

Rubig US, Inc.
www.rubig.com

SMS Elotherm North America
www.techinduction.com

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

SWD Inc.
www.swdinc.com

Sedlock Companies
www.sedlockccompanies.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Solar Atmospheres
1969 CLEARVIEW ROAD
SOUDERTON PA 18964
Phone: (800) 347-3236
Fax: (215) 723-6460
info@solaratm.com
www.solaratm.com

SEE OUR AD P35,36

Specialty Heat Treating
www.specialtyheat.com

Specialty Steel Treating Inc.
www.specialtysteeltreating.com

Spectrum Thermal Processing
www.spectrumtp.com

Stack Metallurgical Services, Inc.
www.stackmet.com

Sun Steel Treating Inc.
www.sunsteeltreating.com

Super Systems Inc.
www.supersystems.com

Thermal Braze, Inc.
thermalbrazeinc@att.net

Thermetco Inc.
www.thermetco.com

Thermex Metal Treating Ltd.
www.thermexmetal.com

Thermtech
www.thermtech.net

TimkenSteel Corporation
www.timkensteel.com

Treat All Metals, Inc.
www.treatallmetals.com

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

VaporKote, Inc.
www.vaporkote.com

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

Welland Forge
www.wellandforge.com

Willman Industries Inc.
www.willmanind.com

ZRIME
www.zrime.com.cn

Zion Industries
www.zioninduction.com

INSPECTION EQUIPMENT

All of the suppliers listed here are broken down by category (bore gages, master gears, spline gages, CNC gear measuring systems, CMMs, non-destructive testing equipment, roll testers, etc.) at *www.geartechnology.com*.

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

ABTech Inc.
www.abtechmfg.com

ACO Mold Co.LTD
www.acomold.com

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

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

Advico
www.advico.co.uk

Ajax Tool Supply
www.ajaxtoolsupply.com

Aksan Steel Forging
www.aksanforging.com

Alliance Broach & Tool
www.alliancebroach.com

American Stress Technologies, Inc.
www.astresstech.com

Andec Mfg. Ltd.
www.andec.ca

Anthony Best Dynamics Ltd
www.abd.uk.com

Ash Gear & Supply
www.ashgear.com

Avalon International Corporation
www.avalongateway.com

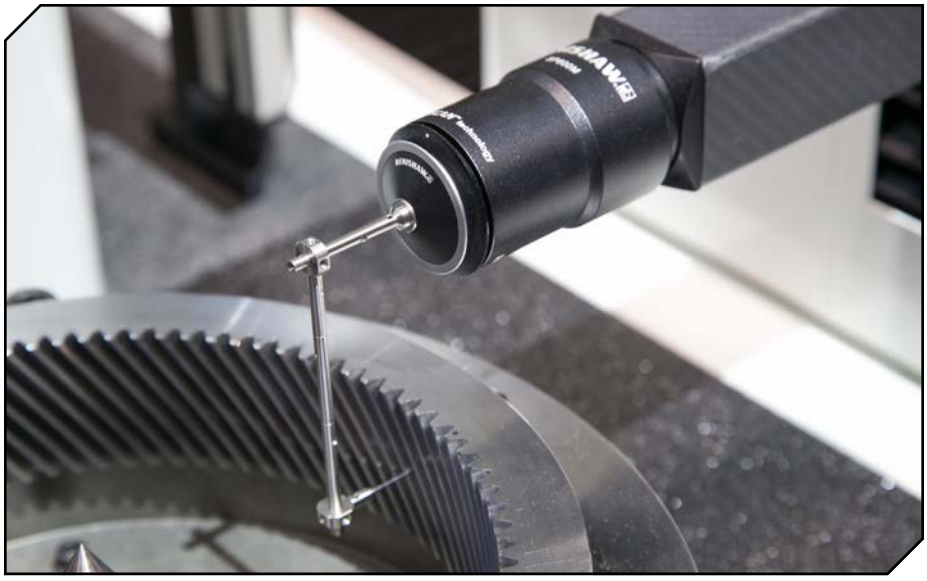
Becker GearMeisters, Inc.
www.maagmachines.com

Big C Dino-Lite Scopes
www.dinolite.Borescopes-R-www.borescopesrus.com

Bourn & Koch Inc.
www.bourn-koch.com

Broach Masters/Universal Gear Co.
1605 INDUSTRIAL DRIVE
AUBURN CA 95603
Phone: (800) 563-3442
Fax: (530) 885-8157
sales@broachmasters.com
www.broachmasters.com
SEE OUR AD P51

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



CNC Center
www.cnccenter.com

CNC Machining by American Swiss Products
www.americanswiss.com

Capital Tool Industries
www.capital-tool.com

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

Celanese
www.celanese.com

Certified Comparator Products (CCP)
www.certifiedcomparator.com

Comtorgage Corporation
www.comtorgage.com

Coord3 Metrology LLC
www.coord3-cmm.com

Datapaq Inc.
www.datapaq.com

Donner+Pfister AG
KIRCHWEG 5
CH-8855 WANGEN-NUOLEN
SWITZERLAND
Phone: +(41) 55 440 20 32
Fax: +(41) 55 440 29 80
info@dpag.ch
www.dpag.ch
SEE OUR AD P4

Drewco Workholding
www.drewco.com

Dyer Company
dyergage.com

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

Euro-Tech Corporation
www.eurotechcorp.com

FARO Technologies, Inc.
www.faro.com

FPM Heat Treating
www.fpmht.com

Flame Treating & Engineering
www.flametreating.com

Flexbar Machine Corporation
www.flexbar.com

Foerster Instruments Incorporated
140 INDUSTRY DRIVE
PITTSBURGH PA 15275
Phone: (412) 788-8976
Fax: (412) 788-8984
sales@foerstergroup.com
foerstergroup.com
SEE OUR AD P62

Fredericks Company - Televac
www.frederickscompany.com

Frenco GmbH
www.frenco.de

Fuji Machine America Corp.
www.fujimachine.com

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

Gear Consulting Group
www.gearconsultinggroup.com

Gear Technology
www.geartechnology.in

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

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Metrology Systems
300 PROGRESS ROAD
DAYTON OH 45449
Phone: (937) 859-8273
Fax: (937) 859-4452
gleason-metrology@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P56–57

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P56–57

Goldstein Gear Machinery LLC
1840 JARVIS AVE.
ELK GROVE VILLAGE IL 60007
Phone: (847) 437-6605
Fax: (847) 437-6618
michael@goldsteingearmachinery.com
www.goldsteingearmachinery.com
SEE OUR AD P62,110

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

Greg Allen Company
www.gallenco.com

HITEC Sensor Solution, Inc.
www.hitecorp.com

Hanik Corporation
www.hanikcorp.com

Hanro Tools Incorporation
www.hanrotools.com

Hexagon Metrology
www.hexagonmetrology.com

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

Hydra-Lock Corporation
www.hydralock.com

ITW Heartland
www.itwheartland.com

Innovative Analytical Solutions
www.steelanalyzer.com

Interstate Tool Corp.
itctoolcorp.com

Involute Gear & Machine Company
www.involutegearmachine.com

Kapp Technologies
2870 WILDERNESS PLACE
BOULDER CO 80301
Phone: (303) 447-1130
Fax: (303) 447-1131
sales-USA@kapp-niles.com
www.kapp-usa.com
SEE OUR AD P3,59

Khemka Broach & Spline Gauge
www.khemkabroach.com

KlingelnbergAG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE, SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Koepfer America
635 SCHNEIDER DRIVE
SOUTH ELGIN IL 60177
Phone: (847) 931-4121
Fax: (847) 931-4192
sales@koepferamerica.com
koepferamerica.com
SEE OUR AD P59

LDB Corporation
ldbcorp.com

Lambda Technologies
www.lambdatechs.com

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

MDM-Mecatronics
www.mdm-mecatronics.com

MPT Manufacturing Process Technologies
www.mptinc.com

Magnetic Inspection Laboratory
www.milinc.com

Maheen Enterprises
www.maheenbroaches.com

Mahr Federal Inc.
1144 EDDY STREET
PROVIDENCE RI 02905
Phone: (800) 343-2050
Fax: (401) 784-3246
orders@mahr.com
www.mahr.com
SEE OUR AD P15

Marposs Corporation
www.marposs.com

Miller Broach
www.millerbroach.com

Mitutoyo America Corporation
www.mitutoyo.com

The Modal Shop
www.modalshop.com

Modern Gearing
www.moderngearing.com

Mutschler Edge Technologies
mutschleredgetech.com

Nachi America Inc.
www.nachiamerica.com

Newage Testing Instruments
www.hardnesstesters.com

Ono Sokki Technology, Inc.
www.onosokki.net

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

PCE Instruments
www.pce-instruments.com/english

Parker Industries Inc.
www.parkerind.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
SEE OUR AD P25

Phase II
www.phase2plus.com

Pinpoint Laser Systems
pinpointlaser.com

Pioneer Broach Co.
www.pioneerbroach.com

PlasmaRoute CNC
www.cncplasmacutterinc.com

Precision Devices, Inc.
www.predev.com

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

Prime Technologies
www.gear-testers.com

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

Promess Inc.
www.promessinc.com

Proto Manufacturing
12350 UNIVERSAL DRIVE
TAYLOR MICHIGAN 48180
Phone: (313) 965-2900
Fax: (734) 946-0974
info@protoxrd.com
www.protoxrd.com
SEE OUR AD P19

Quality Solutions
www.qs-hardnesstester.com

Quality Vision Services (QVS)
www.qvsi.com


GearScan 500
BE SURE
YOUR GEARS
ARE PERFECT
Grinding quality and heat treatment control by Barkhausen Noise
Residual stress measurement by X-ray diffraction
stresstech group
www.stresstechgroup.com

R & P Metrology GmbH
www.rp-metrology.de

RAM Optical Instrumentation, Inc.
www.ramoptical.com

Ravjeet Engineering Specialty Ltd.
www.ravjeet.com

Renishaw Inc.
www.renishaw.com

Reska Spline Products Co.
www.reskasplinegauge.com

Russell Holbrook & Henderson
www.tru-volute.com

S.S.Tools
www.sstools.net

SMS Elotherm North America
www.techinduction.com

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

Samputensili S.p.A.
www.samputensili.com

Schnyder SA
JAKOBSTRASSE 52
CH-2504 BIEL
SWITZERLAND
Phone: +(41)(32) 344-0406
Fax: +(41)(32) 344-0404
george.boon@schnyder.com
www.schnyder.com
SEE OUR AD P4

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Sensor Developments Inc.
sendev.com

Sensor Products Inc.
www.sensorprod.com

SerWeMa GmbH & Co. KG
www.serwema.de

Slone Gear International, Inc.
www.slonegear.com

Spline Gage Solutions
splinegagesolutions.com

Star Cutter Co.
www.starcutter.com

Star SU LLC
5200 PRAIRIE STONE PARKWAY, SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-1,58

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

Stotz Gaging Co.
www.stotz-usa.com

Stresstech Oy
TIKKUTEHTAANTIE 1
40800 VAAJAKOSKI
FINLAND
Phone: +(358) 14-333-000
Fax: +(358) 14-333-0099
info@stresstech.com
www.stresstech.com
SEE OUR AD P39

Sunnen Products Company
www.sunnen.com

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

Surplex GmbH
www.surplex.com

TECO Werkzeugmaschinen GmbH & Co.
www.teco-germany.com

TSA America, LLC
www.tsageartools.com

Techcellence
www.broachindia.com

TechnoMax Inc.
www.technomax-j.com

Test Equipment Distributors
www.tedndt.com

Tianjin No.1 Machine Tool Works
www.tmtw.com

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

United Broach Company
www.unitedbroach.net

United Calibration Corp.
www.tensiletest.com

United Tool Supply
www.united-tool.com

View Micro-Metrology
www.viewmm.com

Wenzel America
www.wenzelamerica.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Westport Gage
www.westportcorp.com

Willrich Precision Instrument Company
willrich.com

Zoller Inc.
www.zoller-usa.com

LUBRICANTS

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

Aarna Lube Private Ltd.
www.aarnalube.com

Aerospace Lubricants, Inc.
www.aerospacelubricants.com

American Chemical Technologies, Inc.
www.americanchemtech.com

American Refining Group, Inc.
www.amref.com

Avalon International Corporation
www.avalongateway.com

BASF
www.basf.com/lubes

BFK Solutions LLC
www.bfksolutions.com

Blaser Swisslube Inc.
www.blaser.com

Bodycote Thermal Processing - Melrose Park
www.bodycote.com

Brighton Laboratories
www.brightonlabs.com

Byington Steel Treating
www.byingtonsteel.com

Carborundum Universal Ltd.
www.cumiabrasives.com

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

Chemtool Inc.
www.chemtool.com

Cimcool Fluid Technology
www.cimcool.com

Cortec Corporation
www.cortecvci.com

Daubert Cromwell
www.daubertcromwell.com

Des-Case Corporation
descase.com

Dillon Chuck Jaws
2115 PROGRESS DRIVE
SPRINGFIELD OH 45505
Phone: (800) 428-1133
Fax: (800) 634-6480
sales4@dillonmfg.com
www.dillonmfg.com
SEE OUR AD P53

Engis Corporation
www.engis.com

Etna Products, Inc.
www.etna.com

ExxonMobil Oil Corp.
www.mobilindustrial.com

Fuchs Lubricants Company
www.fuchs.com

General Magnaplate
www.magnaplate.com

Hangsterfer's Laboratories
www.hangsterfers.com

Hanro Tools Incorporation
www.hanrotools.com

Heatbath/Park Metallurgical
www.heatbath.com

Hoffmann Filter Corporation
www.hoffmannfilter.com

Houghton International
www.houghtonintl.com

Hydrotex
www.hydrotexlube.com

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

Isel Inc.
www.iselinc.com

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

Lafert North America
www.lafertna.com

Lubegard/International Lubricants Inc.
www.lubegard.com

Lubrication Engineers
www.lelubricants.com

Lubriplate Lubricants Co.
129 LOCKWOOD STREET
NEWARK NJ 07105
Phone: (973) 589-4432
Fax: (800) 347-5329
www.lubriplate.com
SEE OUR AD P13

ML Lubrication Inc.
www.ml-lubrication.com

Nye Lubricants
www.nyelubricants.com

Oelheld U.S., Inc.
1760 BRITANNIA DRIVE, SUITE 1
ELGIN IL 60124
Phone: (847) 531-8501
Fax: (847) 531-8511
hutec-us@oelheld.com
www.oelheld-us.com
SEE OUR AD P60

Particular Technology, Inc.
www.particulartechnology.com

PetroChoice
www.PetroChoice.com

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

RedLine Tools
www.redlinetools.com

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

SWD Inc.
www.swdinc.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Shell Lubricants
www.shellus.com

Summit Industrial Products
www.klsummit.com

Sunnen Products Company
www.sunnen.com

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

Swiss Precision Gear Grinding

Cars, aircraft and industrial machinery all require high-accuracy gears for their transmissions. Worldwide, Reishauer gear grinding machines play a major role in the manufacturing process of grinding gears used in such transmissions. Demands placed on these transmissions include the reliable transfer of high torque and power density, low weight and minimal noise emissions. Reishauer precision ground gears ensure that the demands placed on transmission gears are fully met.

Reishauer AG, Switzerland
www.reishauer.com

Reishauer Corp. / 1525 Holmes Road / 60123 Elgin
Tel. +1 847 888 38 28 / email: usa@reishauer.com

REISHAUER

Gear Grinding Technology

Tecsia Lubricants USA
www.tecsialube.com

Texas Refinery Corp.
www.texasrefinery.com

United Tool Supply Ltd.
www.unitedtoolsupply.com

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

Whitmore
whitmores.com

MACHINE TOOLS

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

2L Inc.
www.2Linc.com

ACE Metal Tech. Co., Ltd
www.ace-tra.com

ACO Mold Co.LTD
www.acomold.com

ADF Systems Ltd.
www.adfsys.com

AGA Parts
www.aga-parts.com

ANCA, Inc.
www.anca.com

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

Accura Technics/EDAC Machinery
www.edacmachinery.com

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

Acme Manufacturing Co.
www.acmemfg.com

Advico
www.advico.co.uk

Aksan Steel Forging
www.aksanforging.com

Alliance Broach & Tool
www.alliancebroach.com

Almco Finishing & Cleaning Systems
www.almco.com

American Broach & Machine Co.
www.americanbroach.com

Ampere Metal Finishing
www.amperemetal.com

Andec Mfg. Ltd.
www.andec.ca

Arbortech Corporation
www.arbortech.com

BFK Solutions LLC
www.bfksolutions.com

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

Bates Technologies, LLC
www.batestech.com

Becker GearMeisters, Inc.
www.maagmachines.com

Best Technology Inc.
www.besttechnologyinc.com

Bohle Machine Tools, Inc.
www.bmtbohle.com

Bourn & Koch Inc.
www.bourn-koch.com

Breton USA
www.bretonusa.com

Brighton Laboratories
www.brightonlabs.com

Broaching Machine Specialties
www.broachingmachine.com

Bryant Grinder
www.bryantgrinder.com

C & B Machinery
www.cbmachinery.com

CNC Center
www.cnccenter.com

CNC Design Pty Ltd
www.cncdesign.com

CNC Machining by American Swiss Products
www.americanswiss.com

Capital Equipment LLC
www.capitalequipment.com

Capital Tool Industries
www.capital-tool.com

Carborundum Universal Ltd.
www.cumiabrasives.com

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

Cleaning Technologies Group/Ransohoff
www.ctgclean.com

Clemco Industries Corp.
www.clemcoindustries.com

Cleveland Deburring Machine Co.
cdmcmachine.com

Colonial Tool Group
www.colonialtool.com

Comco Inc.
www.comcoinc.com

Cortec Corporation
www.cortecvci.com

Cosen Saws USA
www.cosensaws.com

Creative Automation, Inc.
www.cautomation.com

Crest Ultrasonics Corp.
www.crest-ultrasonics.com

D.C. Morrison Company
www.dcmorrison.com

DMG MORI USA
www.dmgmori-usa.com

DVS Technology America Inc.
44099 PLYMOUTH OAKS BLVD. SUITE 102
PLYMOUTH, MI 48170
Phone: (734) 656 2080
sales.america@dvs-technology.com
www.dvs-technology.com
SEE OUR AD P21

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

DataLink Technologies
www.datalinkgateways.com

Daubert Cromwell
www.daubertcromwell.com

Des-Case Corporation
descase.com

Desch Canada Ltd.
www.desch.de

Drake Manufacturing Services Co., LLC
www.drakemfg.com

Duffy Company, The
www.duffycompany.com

EMAG L.L.C.
www.emag.com

Eagle PLC
www.eagleplc.com

ElectroHeat Induction
www.electroheatinduction.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Abrasives
www.engineeredabrasives.com

Engis Corporation
www.engis.com

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

Euro-Tech Corporation
www.eurotechcorp.com

Extremeion Hard Carbon
www.CarbonRaptor.com

FPM Heat Treating
www.fpmht.com

Felsomat USA Inc.
www.felsomat.com

Firbimatic Metal Cleaning Division
www.metalcleaning-firbimatic.com

Flame Treating & Engineering
www.flametreating.com

Flexbar Machine Corporation
www.flexbar.com

Foerster Instruments Incorporated
140 INDUSTRY DRIVE
PITTSBURGH PA 15275
Phone: (412) 788-8976
Fax: (412) 788-8984
sales@foerstergroup.com
foerstergroup.com
SEE OUR AD P62

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

Fuji Machine America Corp.
www.fujimachine.com

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

GH Induction Atmospheres
www.gh-ia.com

GMN USA LLC
www.gmnusa.com

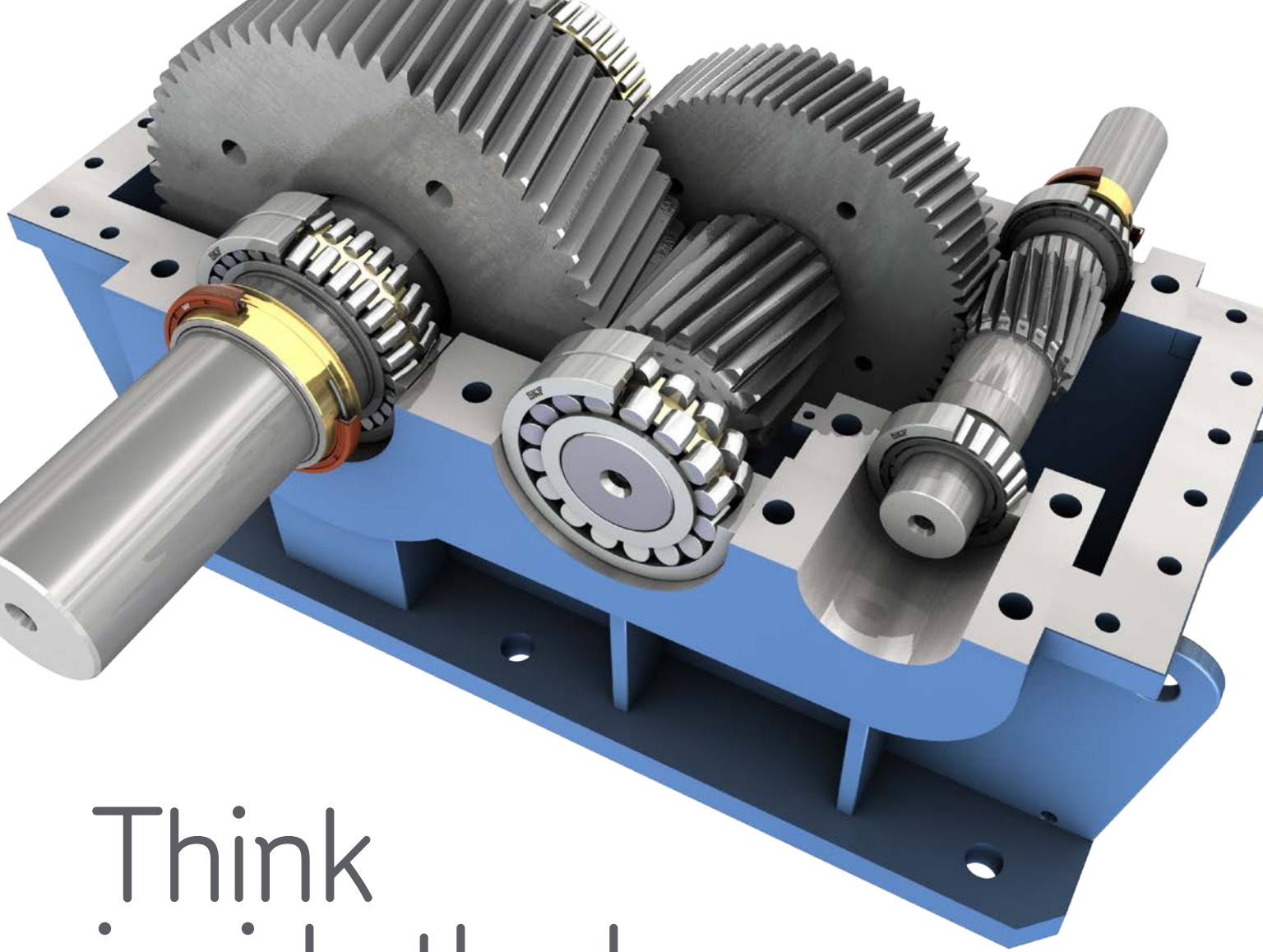
Galomb Inc.
www.injectionmolder.net

Gehring L.P.
www.gehring.de

General Broach Company
www.generalbroach.com

General Magnaplate
www.magnaplate.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57



Think inside the box.

Optimize driveline performance with a range of proven SKF gearbox solutions.

With expertise in bearings, seals, lubrication and condition monitoring, SKF can add value to the complete gear unit by enhancing reliability and performance, while improving the cost-effectiveness of the complete solution.

For example, upgraded SKF Explorer spherical roller bearings have enhanced wear and contamination resistance, and are better able to sustain external loads – up to 20% more load for a given life of a gear unit.

And when needed, complete gearbox remanufacturing services from SKF can return gearboxes to like-new or even better-than-new condition.

For more information, visit **skf.com**

SKF®

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P56–57

GoHz Inc.
www.gohz.com

Goldstein Gear Machinery LLC
1840 JARVIS AVE.
ELK GROVE VILLAGE IL 60007
Phone: (847) 437-6605
Fax: (847) 437-6618
michael@goldsteingearmachinery.com
www.goldsteingearmachinery.com
SEE OUR AD P62,110

Gozuk Co.LTD
www.vfds.org

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

Greenerd Press & Machine Co. Inc.
www.greenerd.com

Guardair Corporation
www.guardair.com

Haas Multigrind LLC
www.multigrind.com

Hans-Juergen Geiger Maschinen-Vertrieb GmbH
JAMES-WATT-STRASSE 12
D-72555 METZINGEN
GERMANY
Phone: +(49) 7123-18040
Fax: +(49) 7123-18384
geiger@geiger-germany.com
www.geiger-germany.com
SEE OUR AD P36

Hardinge Inc.
ONE HARDINGE DRIVE
ELMIRA NY 14902
Phone: (800) 843-8801
Fax: (607) 734-3886
marketinginfo@hardinge.com
www.hardinge.com
SEE OUR AD P44,53

Havlik International Machinery Inc.
www.havlikinternational.com

Heatbath/Park Metallurgical
www.heatbath.com

Heiko Machine Tools
www.heikomachine.com

Heller Machine Tools
www.heller-machinetools.com

Hines Industries
www.hinesindustries.com

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

Hoffmann Filter Corporation
www.hoffmannfilter.com

Huff Carbide Tool
www.huffcarbide.com

Hy-Pro Filtration
www.hyprofiltration.com

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

IHI Ionbond Inc.
ionbond.com

IMEXSU Group
www.imexsu.com

Index Corporation
www.indextraub.com

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

International Tool Machines (ITM)
www.itmfl.com

Interstate Tool Corp.
itctoolcorp.com

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

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

Jenfab
www.jenfab.com

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

KGK International Corp.
www.kgki.com

Kennametal Inc.
www.kennametal.com

Kinefac Corporation
www.kinefac.com

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE, SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

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

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

Kwikmark Inc.
www.kwikmark.com

Lafert North America
www.lafertna.com

Lambda Technologies
www.lambdatechs.com

Laser Tools Co.
www.lasertoolsco.com

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

Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
SEE OUR AD P5

Longevity Coatings
www.longevitycoatings.com

Luren Precision Chicago
707 REMINGTON RD., SUITE 1
SCHAUMBURG IL 60173
Phone: (847) 882-1388
Fax: (847) 882-1933
sales@lurenusa.com
lurenusa.com
SEE OUR AD P31

MPT Manufacturing Process Technologies
www.mptinc.com

Machine Tool Builders
www.machinetoolbuilders.com

Machine Tool Solutions, Inc.
machtoolinc.com

Material Handling Exchange
www.m-h-e.com/pallet-rack-uprights/

Mazak Corporation
www.mazakusa.com

Meccanica Nova Corporation
www.novagrinders.com

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

Melfast - Fasteners
www.melfast.com

Metal Improvement Company
www.metalimprovement.com

Metallurgical High Vacuum Corp.
www.methivac.com

Metallurgical Processing, Inc.
www.mpimetaltreating.com

Methods Machine Tools Inc.
www.methodsmachine.com

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
SEE OUR AD P8

Modern Gearing
www.moderngearing.com

Modicon PLC
www.modiconplc.com

Mutschler Edge Technologies
mutschleredgetech.com

NTC America Corporation
www.ntcmc.com

Nachi America Inc.
www.nachiamerica.com

Nagel Precision
www.nagelusa.com

National Heat Treat
nationalheattreat.com

Normac, Inc.
www.normac.com

Oelheld U.S., Inc.
1760 BRITANNIA DRIVE, SUITE 1
ELGIN IL 60124
Phone: (847) 531-8501
Fax: (847) 531-8511
hutec-us@oelheld.com
www.oelheld-us.com
SEE OUR AD P60

Oerlikon Balzers USA
www.oerlikon.com/balzers

Ohio Broach & Machine Co.
www.ohiobroach.com

Okuma America Corporation
www.okuma.com

PTG Holroyd
www.holroyd.com

Pegard Productics Division HARO
harotechnologies.com

Penna Flame Industries
www.pennaflame.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
SEE OUR AD P25

Philadelphia Carbide Co.
www.philacarbide.com

Phoenix Inc.
www.phoenix-inc.com

Pinpoint Laser Systems
pinpointlaser.com

Pioneer Broach Co.
www.pioneerbroach.com

PlasmaRoute CNC
www.cncplasmacutterinc.com

Power Inverter Inc.
www.powerinverter.org

Precision Finishing Inc.
www.precisionfinishinginc.com

Precision Spindle & Accessories Inc.
www.precisionspindleinc.com

Preco Inc.
www.precolaser.com

Pro-Beam USA
www.pro-beam.com

Promess Inc.
www.promessinc.com

QC American
www.qcamerican.com

Röders GmbH
www.roeders.de

R.A. Heller
www.raheller.com

RAM Optical Instrumentation, Inc.
www.ramoptical.com

Reade Advanced Materials
www.reade.com

Redin Production Machine
www.redinmachine.com

Renishaw Inc.
www.renishaw.com

Rewitec GmbH
www.rewitec.com

Riten Industries, Inc.
www.riten.com

Roberts Sinto Corp.
www.robertssinto.com

Roto-Flo/U.S. Gear Tools
www.roto-flo.com

Russell Holbrook & Henderson
www.tru-volute.com

SETCO Precision Spindles
www.setcousa.com

SMS Elotherm North America
www.techinduction.com

SWD Inc.
www.swdinc.com

Samputensili S.p.A.
www.samputensili.com

Schunk
www.schunk.com

Schutte LLC
www.schutteusa.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

SerWeMa GmbH & Co. KG
www.serwema.de

Slater Tools Inc.
www.slatertools.com

Slone Gear International, Inc.
www.slonegear.com

Star Cutter Co.
www.starcutter.com

Star SU LLC
5200 PRAIRIE STONE PARKWAY, SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-1,58

Stenhoj Broaching Machines
www.stenhoj.dk

Stotz Gaging Co.
www.stotz-usa.com

Studwell Engineering
studwellengineering.com

Sunnen Products Company
www.sunnen.com

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

Surplex GmbH
www.surplex.com

TECO Werkzeugmaschinen GmbH & Co.
www.teco-germany.com

Thermal Spray Coatings - A&A Coatings
www.thermalspray.com

Toolink Engineering
www.toolink-eng.com

Toolmex Corporation - Lathe group
www.toolmexlathes.com

Toshiba Machine Co.
www.toshiba-machine.com

Tribo Surface Engineering LLC
www.tribosurfaceengineering.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

Ultramatic Equipment Co.
ultramatic-equipment.com

Ultrasonic LLC
www.ultrasonicllc.com

United Grinding
www.grinding.com

Usach Technologies Inc.
www.usach.com

VaporKote, Inc.
www.vaporkote.com

Venture Mfg. Co.
www.venturemfgco.com

Vermont Machine Tool
www.vermontmachinetool.com

View Micro-Metrology
www.viewmm.com

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

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

WardJet
www.wardjet.com

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

Weldon Solutions
www.weldonsolutions.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Westminster Machine Tools Ltd.
www.wmtg.co.uk

Wheelabrator
www.wheelabratorgroup.com

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

Yaskawa Motoman
www.motoman.com

RESOURCES

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

AGMA - American Gear Manufacturers Association
www.agma.org

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

ASM International
www.asminternational.org

American Bearing Manufacturers Association
www.americanbearings.org

American Wind Energy Association
www.awea.org

Banyan Global Technologies LLC
www.banyangt.com

CTI – Car Training Institute
www.car-training-institute.com

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

EES KISSsoft GmbH
www.ees-kisssoft.ch

FVA GmbH
www.fva-service.de

FZG
www.fzg.mw.tum.de

Forging Industry Association
www.forging.org

Gear Consulting Group
www.gearconsultinggroup.com

Gehring L.P.
www.gehring.de

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Cutting Tools Corporation
1351 WINDSOR RD.
LOVES PARK IL 61111
Phone: (815) 877-8900
Fax: (815) 877-0264
gctc@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works Rochester
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 256-6776
rewanow@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P56–57

Goldstein Gear Machinery LLC
1840 JARVIS AVE.
ELK GROVE VILLAGE IL 60007
Phone: (847) 437-6605
Fax: (847) 437-6618
michael@goldsteingearmachinery.com
www.goldsteingearmachinery.com
SEE OUR AD P62,110

Guardair Corporation
www.guardair.com

Hannover Fairs USA
www.hfusa.com

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

Kapp Technologies
2870 WILDERNESS PLACE
BOULDER CO 80301
Phone: (303) 447-1130
Fax: (303) 447-1131
sales-USA@kapp-niles.com
www.kapp-usa.com
SEE OUR AD P3,59

Koepfer America
635 SCHNEIDER DRIVE
SOUTH ELGIN IL 60177
Phone: (847) 931-4121
Fax: (847) 931-4192
sales@koepferamerica.com
koepferamerica.com
SEE OUR AD P59

Lafert North America
www.lafertna.com

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

Lubrication Engineers
www.lelubricants.com

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

Noria Corporation
www.noria.com

Randall Publications LLC
www.geartechnology.com

Robert E. Smith, Consultant
gearman@rochester.rr.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Suresh Mehta Associates
www.sureshmehta.com

Thors, LLC
www.thors.com

VDI
www.vdi.de

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

West Michigan Spline, Inc.
www.westmichiganspline.com

SERVICES

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

ACE Metal Tech. Co., Ltd
www.ace-tra.com

ACO Mold Co.LTD
www.acomold.com

ATS - Advanced Technology Services
www.advancedtech.com

Acedes Gear Tools
www.acedes.co.uk

Advanced Heat Treat Corp.
www.ahtweb.com

Aksan Steel Forging
www.aksanforging.com

American Broach & Machine Co.
www.americanbroach.com

Ampere Metal Finishing
www.amperemetal.com

Andec Mfg. Ltd.
www.andec.ca

Anthony Best Dynamics Ltd
www.abd.uk.com

Apex Broaching Systems
www.apexbroach.com

BG&S Peening and Consulting LLC
www.peeningconsultants.com

Banyan Global Technologies LLC
www.banyangt.com

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

Bates Technologies, LLC
www.batestech.com

Becker GearMeisters, Inc.
www.maagmachines.com

Best Technology Inc.
www.besttechnologyinc.com

Beyta Gear Service
www.beytagear.com

Bill's Machine Repair
www.billsmachinerepair.com

Borescopes-R-US
www.borescopesrus.com

Bourn & Koch Inc.
www.bourn-koch.com

Broach Masters/Universal Gear Co.
1605 INDUSTRIAL DRIVE
AUBURN CA 95603
Phone: (800) 563-3442
Fax: (530) 885-8157
sales@broachmasters.com
www.broachmasters.com
SEE OUR AD P51

Broaching Technologies, LLC
keyway-spline-broaching.com

Bruce Cox Engineering Corporation
www.bcoxengineering.com

Bryant Grinder
www.bryantgrinder.com

C & B Machinery
www.cbmachinery.com

CNC Center
www.cnccenter.com

CNC Design Pty Ltd
www.cncdesign.com

CNC Machining by American Swiss Products
www.americanswiss.com

Canada Broach
www.canadabroach.com

Capital Tool Industries
www.capital-tool.com

Carbide Tool Services, Inc.
www.carbidetool.com

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

Cincinnati Gearing Systems Inc.
5757 MARIEMONT AVE
CINCINNATI OH 45227
Phone: (513) 527-8600
Fax: (513) 527-8635
gearsales@cst-c.com
www.cincinnatigearingsystems.com
SEE OUR AD P47

DK Surface Hardening
7427 W. 90TH ST.
BRIDGEVIEW IL 60455
Phone: (708) 233-9095
Fax: (708) 233-9366
contactus@dksurfacehardening.com
www.dksurfacehardening.com
SEE OUR AD P48, 59

Daubert Cromwell
www.daubertcromwell.com

Delta Inspection
www.deltainspect.com

Diametal AG
www.diametal.ch

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

Dixitech CNC
www.dixitechcnc.com

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

EES KISSsoft GmbH
www.ees-kisssoft.ch

EMAG L.L.C.
www.emag.com

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

Eicher Engineering Solutions
www.eicherengineering.com

ElectroHeat Induction
www.electroheatinduction.com

Electronics Inc.
www.electronics-inc.com

Ellwood City Forge
www.ellwoodcityforge.com

Eltro Services, Inc.
www.eltroservices.com

Engineered Abrasives
www.engineeredabrasives.com

Estudio Piña
www.estudiopina.com.ar

Excel Gear
11865 MAIN STREET
ROSCOE IL 61073
Phone: (815) 623-3414
Fax: (815) 623-3314
Chinn@excelgear.com
www.excelgear.com
SEE OUR AD P12

Extremeion Hard Carbon
www.CarbonRaptor.com

FPM Heat Treating
www.fpmht.com

FVA GmbH
www.fva-service.de

Fine Wisdom(suzhou) Driving System Co.,Ltd
www.fw-gearbox.com

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

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

Frenco GmbH
www.frenco.de

Friedrich Gloor Ltd.
www.gloorag.ch

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

GMN USA LLC
www.gmnusa.com

GWJ Technology GmbH
www.gwj.de

Gear Consulting Group
www.gearconsultinggroup.com

Gear Consulting Services of Cincinnati LLC
octave@fuse.net

Gear Technology
www.geartechnology.in

Gehring L.P.
www.gehring.de

General Magnaplate
www.magnaplate.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Cutting Tools Corporation
1351 WINDSOR RD.
LOVES PARK IL 61111
Phone: (815) 877-8900
Fax: (815) 877-0264
gctc@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Metrology Systems
300 PROGRESS ROAD
DAYTON OH 45449
Phone: (937) 859-8273
Fax: (937) 859-4452
gleason-metrology@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P56–57

Gleason Works Rochester
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 256-6776
rewanow@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P56–57

GoHz Inc.
www.gohz.com

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

Greg Allen Company
www.gallenco.com

Grindal Company
www.grindal.com

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

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

Hydrotex
www.hydrotexlube.com

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

IHI Ionbond Inc.
ionbond.com

Impact Finishers
www.wheelabratorgroup.com

Index Technologies Inc.
www.gallenco.com

Industrial Metal Finishing, Inc.
www.indmetfin.com

Innovative Analytical Solutions
www.steelanalyzer.com

Involute Gear & Machine Company
www.involutegearmachine.com

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

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

KISSsoft AG
www.kisssoft.ch

Kapp Technologies
2870 WILDERNESS PLACE
BOULDER CO 80301
Phone: (303) 447-1130
Fax: (303) 447-1131
sales-USA@kapp-niles.com
www.kapp-usa.com
SEE OUR AD P3,59

Kinematics Manufacturing, Inc.
www.kinematicsmfg.com

Kingsford Broach & Tool Inc.
www.kingsfordbroach.com

Kleiss Gears, Inc.
www.kleissgears.com

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE, SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Koepfer America
635 SCHNEIDER DRIVE
SOUTH ELGIN IL 60177
Phone: (847) 931-4121
Fax: (847) 931-4192
sales@koepferamerica.com
koepferamerica.com
SEE OUR AD P59

Koro Sharpening Service
9530 85TH AVENUE NORTH
MAPLE GROVE MN 55369
Phone: (763) 425-5247
Fax: (763) 425-5261
info@koroind.com
www.koroind.com
SEE OUR AD P59

Lafert North America
www.lafertna.com

Lalson Tools Corporation
www.lalsoncuttingtools.com

Laser Tools Co.
www.lasertoolsco.com

Liebherr-Verzahntechnik GmbH
KAUFBEURER STRASSE 141
D-87437 KEMPTEN
GERMANY
Phone: +(49) 831-786-0
Fax: +(49) 831-7861279
info.lvt@liebherr.com
www.liebherr.com
SEE OUR AD P5

Longevity Coatings
www.longevitycoatings.com

Luren Precision Chicago
707 REMINGTON RD., SUITE 1
SCHAUMBURG IL 60173
Phone: (847) 882-1388
Fax: (847) 882-1933
sales@lurenusa.com
lurenusa.com
SEE OUR AD P31

MDM-Mecatronics
www.mdm-mecatronics.com

MESYS AG
www.mesys.ag

MTI Systems, Inc.
www.mtisystems.com

Machine Tool Builders
www.machinetoolbuilders.com

Machine Tool Solutions, Inc.
machtoolinc.com

Magnetic Inspection Laboratory
www.milinc.com

Maguire Technologies
www.maguiretech.com

Mahr Federal Inc.
1144 EDDY STREET
PROVIDENCE RI 02905
Phone: (800) 343-2050
Fax: (401) 784-3246
orders@mahr.com
www.mahr.com
SEE OUR AD P15

Masternet Ltd.
www.masternetltd.com

Metal Improvement Company
www.metalimprovement.com

Metallized Carbon Corporation
www.metcar.com

Metallurgical Processing, Inc.
www.mpimetaltreating.com

Micro Precision Calibration Inc.
microprecision.com/repair-service

Micro Surface Corp.
465 BRISCOE DR.
MORRIS IL 60450
Phone: (800) 248-4221
Fax: (815) 942-4265
www.microsurfacecorp.com
SEE OUR AD P62

MicroTek Finishing, LLC
www.microtekfinishing.com

Milburn Engineering, Inc.
www.milburnengineering.com

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
SEE OUR AD P8

Mitsubishi Materials USA
www.mmus.com

Mitutoyo America Corporation
www.mitutoyo.com

The Modal Shop
www.modalshop.com

New England Gear
www.newenglandgear.com

Noria Corporation
www.noria.com

Oerlikon Balzers - PPD Division
www.oerlikon.com

Oerlikon Balzers USA
www.oerlikon.com/balzers

Peening Technologies
www.hydro-honing.com

Perry Technology Corporation
P.O. BOX 21
120 INDUSTRIAL PARK ROAD
NEW HARTFORD CT 06019
Phone: (860) 738-2525
Fax: (860) 738-2455
dseger@perrytechnology.com
www.perrygear.com
SEE OUR AD P61

Phoenix Tool & Thread Grinding
phoenixthreadgrinding.com

Pinpoint Laser Systems
pinpointlaser.com

Precision Pump and Gear Works
www.ppg-works.com

Precision Spindle & Accessories Inc.
www.precisionspindleinc.com

Proto Manufacturing
12350 UNIVERSAL DRIVE
TAYLOR MICHIGAN 48180
Phone: (313) 965-2900
Fax: (734) 946-0974
info@protoxrd.com
www.protoxrd.com
SEE OUR AD P19

Quality Reducer Service, Inc
www.qualityreducer.com

R & P Metrology GmbH
www.rp-metrology.de

REM Surface Engineering
www.remchem.com

Red Rover
www.red-rover-china.com

Rewitec GmbH
www.rewitec.com

GEAR GRINDING – 2 DAY TURNAROUND
RIVERSIDE SPLINE & GEAR INC.
810-765-8302
www.splineandgear.com

Riverside Spline & Gear
1390 SOUTH PARKER
PO BOX 340
MARINE CITY MI 48039
Phone: (810) 765-8302
curtd@splineandgear.com
www.splineandgear.com
SEE OUR AD P49,63

Robert E. Smith, Consultant
gearman@rochester.rr.com

Romax Technology
www.romaxtech.com

SWD Inc.
www.swdinc.com

Samputensili S.p.A.
www.samputensili.com

Sandvik Coromant
www.sandvik.coromant.com

Seco/Warwick Europe S.A.
www.secowarwickeurope.com.pl

Sedlock Companies
www.sedlockcompanies.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Sinterite, A Gasbarre Furnace Group Company
www.sinterite.com

Slone Gear International, Inc.
www.slonegear.com

Smart Manufacturing Technology
CHARTWELL HOUSE
67-69 HOUNDS GATE
NOTTINGHAM NOTTINGHAMSHIRE NG1 6BB
UNITED KINGDOM
Phone: +44 (0) 115 941 9839
Fax: +44 (0) 115 958 1583
info@smartmt.com
www.smartmt.com
SEE OUR AD P50

Southern Gear & Machine
3685 NW 106 ST.
MIAMI, FL 33147
Phone: (305) 691-6300
allanarch@southerngear.net
www.southerngear.net
SEE OUR AD P50

Star Cutter Co.
www.starcutter.com

Star SU LLC
5200 PRAIRIE STONE PARKWAY, SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-1,58

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

Stresstech Oy
TIKKUTEHTAANTIE 1
40800 VAAJAKOSKI
FINLAND
Phone: +(358) 14-333-000
Fax: +(358) 14-333-0099
info@stresstech.com
www.stresstech.com
SEE OUR AD P39

Suresh Mehta Associates
www.sureshmehta.com

Surface Finishing Equipment Co.
www.sfecindia.net

Thermal Spray Coatings - A&A Coatings
www.thermalspray.com

TopGun Consulting LLc
www.topgunconsulting.com

Ty Miles, Inc.
www.tymiles.com

U.S. Equipment
www.usequipment.com

Ultramatic Equipment Co.
ultramatic-equipment.com

United Tool Supply
www.united-tool.com

United Tool Supply Ltd.
www.unitedtoolsupply.com

VFA Engineering Group
failure-analysis-durability.com

VaporKote, Inc.
www.vaporkote.com

Vermont Machine Tool
www.vermontmachinetool.com

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

Welter Group
www.welter-lahr.com

West Michigan Spline, Inc.
www.westmichiganspline.com

Willrich Precision Instrument Company
willrich.com

SOFTWARE

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

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

AKGears, LLC
www.akgears.com

ATS - Advanced Technology Services
www.advancedtech.com

Acme Manufacturing Co.
www.acmemfg.com

Andec Mfg. Ltd.
www.andec.ca

Anthony Best Dynamics Ltd
www.abd.uk.com

Artis Division of Marposs
www.artis.de

Ash Gear & Supply
www.ashgear.com

Bourn & Koch Inc.
www.bourn-koch.com

Broach Masters/Universal Gear Co.
1605 INDUSTRIAL DRIVE
AUBURN CA 95603
Phone: (800) 563-3442
Fax: (530) 885-8157
sales@broachmasters.com
www.broachmasters.com
SEE OUR AD P51

CD-adapco
www.cd-adapco.com

Camnetics, Inc.
camnetics.com

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

Community PC
www.meshingwithgears.com

DMG MORI USA
www.dmgmori-usa.com

Diametal AG
www.diametal.ch

Donner+Pfister AG
KIRCHWEG 5
CH-8855 WANGEN-NUOLEN
SWITZERLAND
Phone: +(41) 55 440 20 32
Fax: +(41) 55 440 29 80
info@dpag.ch
www.dpag.ch
SEE OUR AD P4

Dontyne Systems
www.dontynesystems.com

Drake Manufacturing Services Co., LLC
www.drakemfg.com

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

Dynamic Systems
www.dynamic-systemsinc.com

EES KISSsoft GmbH
www.ees-kisssoft.ch

Eicher Engineering Solutions
www.eicherengineering.com

Eltro Services, Inc.
www.eltroservices.com

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

Estudio Piña
www.estudiopina.com.ar

Euro-Tech Corporation
www.eurotechcorp.com

Excel Gear
11865 MAIN STREET
ROSCOE IL 61073
Phone: (815) 623-3414
Fax: (815) 623-3314
Chinn@excelgear.com
www.excelgear.com
SEE OUR AD P12

FARO Technologies, Inc.
www.faro.com

FPM Heat Treating
www.fpmht.com

FVA GmbH
www.fva-service.de

FastCAM Inc.
www.fastcam.com

Frenco GmbH
www.frenco.de

GWJ Technology GmbH
www.gwj.de

Gear Technology
www.geartechnology.in

GearOffice
www.gearoffice.com

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Metrology Systems
300 PROGRESS ROAD
DAYTON OH 45449
Phone: (937) 859-8273
Fax: (937) 859-4452
gleason-metrology@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works Rochester
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 256-6776
rewanow@gleason.com
www.gleason.com
SEE OUR AD P56–57

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

Hanro Tools Incorporation
www.hanrotools.com

Heller Machine Tools
www.heller-machinetools.com

Hexagon Industriesoftware GmbH
www.hexagon.de

Hexagon Metrology
www.hexagonmetrology.

HiTech e Soft
www.hitechesoft.com

ITI GmbH
www.itisim.com

Involute Simulation Softwares Inc.
www.hygears.com

KISSsoft AG
www.kisssoft.ch

KISSsoft USA LLC
3719 N. SPRING GROVE ROAD
JOHNSBURG IL 60051
Phone: (815) 363-8823
Fax: (815) 363-8832
dan.kondritz@kisssoft.com
www.kisssoft.com
SEE OUR AD P107

Khemka Broach & Spline Gauge
www.khemkabroach.com

CATEGORY LISTINGS

Klingelnberg AG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

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

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

MDM-Mecatronics
www.mdm-mecatronics.com

MESYS AG
www.mesys.ag

MSC Software Corp.
www.mscsoftware.com

MTI Systems, Inc.
www.mtisystems.com

Machine Tool Builders
www.machinetoolbuilders.com

Marposs Corporation
www.marposs.com

Mitutoyo America Corporation
www.mitutoyo.com

Normac, Inc.
www.normac.com

PTG Holroyd
www.holroyd.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
SEE OUR AD P25

Pinpoint Laser Systems
pinpointlaser.com

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

Prime Technologies
www.gear-testers.com

Promess Inc.
www.promessinc.com

Romax Technology
www.romaxtech.com

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

SWG Solutions
www.swgsolutions.com

Saazor
www.saazor.de

Sandvik Coromant
www.sandvik.coromant.com

Scientific Forming Technologies Corp.
www.deform.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

SerWeMa GmbH & Co. KG
www.serwema.de

Slone Gear International, Inc.
www.slonegear.com

Smart Manufacturing Technology
CHARTWELL HOUSE
67-69 HOUNDS GATE
NOTTINGHAM NOTTINGHAMSHIRE NG1 6BB
UNITED KINGDOM
Phone: +44 (0) 115 941 9839
Fax: +44 (0) 115 958 1583
info@smartmt.com
www.smartmt.com
SEE OUR AD P50

Spring Technologies Inc.
www.springplm.com

Stotz Gaging Co.
www.stotz-usa.com

Stresstech Oy
TIKKUTEHTAANTIE 1
40800 VAAJAKOSKI
FINLAND
Phone: +(358) 14-333-000
Fax: +(358) 14-333-0099
info@stresstech.com
www.stresstech.com
SEE OUR AD P39

Super Systems Inc.
www.supersystems.com

Techcellence
www.broachindia.com

Thermo-Calc Software Inc.
www.thermocalc.com

Universal Technical Systems, Inc.
www.uts.com

Vermont Machine Tool
www.vermontmachinetool.com

WardJet
www.wardjet.com

Waterloo Manufacturing Software
www.waterloo-software.com

Web Gear Services Ltd.
www.webgearservices.com

Wenzel America
www.wenzelamerica.com

Yash International
www.yashtools.com

USED MACHINERY

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

Advico
www.advico.co.uk

Ajax Tocco Magnethermic
1745 OVERLAND AVE NE
WARREN OH 44483
Phone: 330-372-8511
Fax: 330-372-8608
sales@ajaxtocco.com
www.ajaxtocco.com
SEE OUR AD P58

Apex Auctions Inc.
www.apexauctions.com

CBI Industrial Asset Management bv
www.cbiworld.com

CNC Machining by American Swiss Products
www.americanswiss.com

Cincinnati Industrial Auctioneers
www.cia-auction.com

Corporate Assets Inc.
www.corpassets.com

Dixitech CNC
www.dixitechcnc.com

Fairfield Auctions
www.lotsurf.com

Gear Machinery Exchange
www.gearmachineryexchange.com

Gear Technology
www.geartechnology.in

Gibbs Machinery Company
www.gibbsmachinery.com

GoIndustry DoveBid
www.go-dove.com

Goldstein Gear Machinery LLC
1840 JARVIS AVE.
ELK GROVE VILLAGE IL 60007
Phone: (847) 437-6605
Fax: (847) 437-6618
michael@goldsteingearmachinery.com
www.goldsteingearmachinery.com
SEE OUR AD P62,110

Gray Machinery Company
www.graymachinery.com

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

Hans-Juergen Geiger Maschinen-Vertrieb GmbH
JAMES-WATT-STRASSE 12
D-72555 METZINGEN
GERMANY
Phone: +(49) 7123-18040
Fax: +(49) 7123-18384
geiger@geiger-germany.com
www.geiger-germany.com
SEE OUR AD P36

Hilco Industrial
www.hilcoind.com

Koster Industries
www.kosterindustries.com

Mohawk Machinery Inc.
www.mohawkmachinery.com

PPL Group
www.pplauction.com

Prestige Equipment
www.prestigeequipment.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

U.S. Equipment
www.usequipment.com

Used Machinery Sales LLC
www.cnctool.com

West Michigan Spline, Inc.
www.westmichiganspline.com

WORKHOLDING & TOOLHOLDING

All of the suppliers listed here are broken down by category (arbors, chucks, collets, mandrels, etc.) at *www.geartechnology.com*.

2L Inc.
www.2Linc.com

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

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

Acme Manufacturing Co.
www.acmemfg.com

Acme Wire Products
www.acmewire.com

American Broach & Machine Co.
www.americanbroach.com

Andec Mfg. Ltd.
www.andec.ca

Apex Broaching Systems
www.apexbroach.com

Ash Gear & Supply
www.ashgear.com

Banyan Global Technologies LLC
www.banyangt.com

Bourn & Koch Inc.
www.bourn-koch.com

Broach Masters/Universal Gear Co.
1605 INDUSTRIAL DRIVE
AUBURN CA 95603
Phone: (800) 563-3442
Fax: (530) 885-8157
sales@broachmasters.com
www.broachmasters.com
SEE OUR AD P51

Chevin Tools Inc.
www.chevintools.com

Cleveland Deburring Machine Co.
cdmcmachine.com

DT Technologies
www.dttechnologies.com

DVS Technology America Inc.
44099 PLYMOUTH OAKS BLVD. SUITE 102
PLYMOUTH, MI 48170
Phone: (734) 656 2080
sales.america@dvs-technology.com
www.dvs-technology.com
SEE OUR AD P21

Dillon Chuck Jaws
2115 Progress Dr. Springfield, OH 45505
PHONE: **800-428-1133**
FAX: **800-634-6480**
EMAIL: **sales4@dillonmfg.com**
www.dillonmfg.com

Dillon Chuck Jaws
2115 PROGRESS DRIVE
SPRINGFIELD OH 45505
Phone: (800) 428-1133
Fax: (800) 634-6480
sales4@dillonmfg.com
www.dillonmfg.com
SEE OUR AD P53

Dinanath
www.dinanathengineering.com

Dr. Kaiser Diamantwerkzeuge
www.drkaiser.de

Drewco Workholding
www.drewco.com

Emuge Corp.
www.emuge.com

Engineered Tools Corp.
www.engineeredtools.com

Euro-Tech Corporation
www.eurotechcorp.com

Forkardt
2155 TRAVERSEFIELD DR
TRAVERSE CITY MI 49686
Phone: (231) 995-8300
Fax: (231) 995-8361
sales@forkardt.www.forkardt.Franco GmbH
www.franco.de
SEE OUR AD P53

Fuji Machine America Corp.
www.fujimachine.com

GMI Group
www.gmigroup.com

Galaxy Sourcing Inc.
www.galaxysourcing.com

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

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

Gleason Corporation
1000 UNIVERSITY AVENUE
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 473-1000
Fax: (585) 461-4348
sales@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Metrology Systems
300 PROGRESS ROAD
DAYTON OH 45449
Phone: (937) 859-8273
Fax: (937) 859-4452
gleason-metrology@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason Works (India) Private Ltd.
PLOT NO. 37
DODDENAKUNDI INDUSTRIAL AREA
WHITEFIELD RD., MAHADEVAPURA
BANGALORE 560 048
INDIA
Phone: 011-91-80-2850-4376/15/16/91
www.gleason.com
SEE OUR AD P56–57

Gleason Works Rochester
P.O. BOX 22970
ROCHESTER NY 14692-2970
Phone: (585) 256-6776
rewanow@gleason.com
www.gleason.com
SEE OUR AD P56–57

Gleason-Hurth Tooling GmbH
MOOSACHER STR. 42-46
D-80809 MUENCHEN
GERMANY
Phone: 011-49-89-35401-0
www.gleason.com
SEE OUR AD P56–57

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

Greg Allen Company
www.gallenco.com

Guardair Corporation
www.guardair.com

Hainbuch America
www.hainbuchamerica.com

Hanro Tools Incorporation
www.hanrotools.com

Hardinge Inc.
ONE HARDINGE DRIVE
ELMIRA NY 14902
Phone: (800) 843-8801
Fax: (607) 734-3886
marketinginfo@hardinge.com
www.hardinge.com
SEE OUR AD P44, 53

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

Hydra-Lock Corporation
www.hydralock.com

IMEXSU Group
www.imexsu.com

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

Industrial Tools Corporation
www.industrialtoolscorp.com

Interstate Tool Corp.
itctoolcorp.com

Involute Gear & Machine Company
www.involutegearmachine.com

JRM International, Inc
www.jrminternational.com

Kennametal Inc.
www.kennametal.com

Kitagawa - NorthTech Workholding
www.kitagawa.com

KlingelnbergAG
BINZMÜHLESTRASSE 171
CH-8050 ZURICH
SWITZERLAND
Phone: +(41) 44-2787979
Fax: +(41) 44-2781594
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg America Inc.
118 E. MICHIGAN AVENUE, SUITE 200
SALINE MI 48176
Phone: (734) 470-6278
Fax: (734) 316-2158
kla.info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

Klingelnberg GmbH
PETERSTRASSE 45
HUECKESWAGEN 42499
GERMANY
Phone: +(49) 2192-810
Fax: +(49) 2192-81200
info@klingelnberg.com
www.klingelnberg.com
SEE OUR AD BACK COVER P11

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

LMC Workholding
www.lmcworkholding.com

Lyndex-Nikken
www.lyndexnikken.com

Machine Tool Builders
www.machinetoolbuilders.com

Machine Tool Solutions, Inc.
machtoolinc.com

Maprox
www.rotectools.com

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

Miller Broach
www.millerbroach.com

Mitsubishi Heavy Industries America
MACHINE TOOL DIVISION
46992 LIBERTY DRIVE
WIXOM MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
brenda_motzell@mhiahq.com
www.mitsubishigearcenter.com
SEE OUR AD P8

Nachi America Inc.
www.nachiamerica.com

Northfield Precision Instrument Corp.
www.northfield.com

Ohio Broach & Machine Co.
www.ohiobroach.com

P.G. Engineers
www.pgcollets.info

Parker Industries Inc.
www.parkerind.com

Penta Gear Metrology LLC
6161 WEBSTER STREET
DAYTON OH 45414
Phone: (937) 660-8182
mnicholson@pentagear.com
www.gearinspection.com
SEE OUR AD P25

Phase II
www.phase2plus.com

Pinpoint Laser Systems
pinpointlaser.com

Pioneer Broach Co.
www.pioneerbroach.com

Polygon Solutions
www.polygonsolutions.com

Positrol
www.positrol.com

Precision Devices, Inc.
www.predev.com

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

Precision Spindle & Accessories Inc.
www.precisionspindleinc.com

Pro-Beam USA
www.pro-beam.com

QC American
www.qcamerican.com

RedLine Tools
www.redlinetools.com

Renishaw Inc.
www.renishaw.com

Reska Spline Products Co.
www.reskasplinegauge.com

Riten Industries, Inc.
www.riten.com

Royal Products
www.royalprod.com

Samchully Machinery Co., Ltd.
www.samchully.com

Schunk
www.schunk.com

Seenpin Precision Products (Zhejiang) Co., Ltd.
www.seenpin.com

Slater Tools Inc.
www.slatertools.com

Slone Gear International, Inc.
www.slonegear.com

Speedgrip Chuck
www.speedgrip.com

Stace-Allen Chucks, Inc.
www.stace-allen.com

Star SU LLC
5200 PRAIRIE STONE PARKWAY, SUITE 100
HOFFMAN ESTATES IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
sales@star-su.com
www.star-su.com
SEE OUR AD IFC-1,58

Steelmans Broaches Pvt. Ltd.
www.steelmans.com

Stotz Gaging Co.
www.stotz-usa.com

Toolink Engineering
www.toolink-eng.com

Toolmex Corporation - Lathe group
www.toolmexlathes.com

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

If your company is NOT listed in the buyers guide, but you think it should be, please visit *www.geartechnology.com/getlisted.php*.

Please send any errors or corrections to *publisher@geartechnology.com*.

GEARS, GEAR DRIVES AND POWER TRANSMISSION COMPONENTS

The following advertisers in this issue of ***Gear Technology*** will appear with hundreds of other suppliers in the Buyers Guide in the December 2016 issue of ***Power Transmission Engineering***. They can also be found online at *www.powertransmission.com*.

Arrow Gear Co.
2301 CURTISS STREET
DOWNERS GROVE IL 60515
Phone: (630) 969-7640
Fax: (630) 969-0253
quote@arrowgear.com
www.arrowgear.com
SEE OUR AD P27

B & R Machine and Gear Corp.
4809 U.S. HWY. 45
SHARON TN 38255
Phone: (731) 456-2636 or (800) 238-0651
Fax: (731) 456-3073
inquiry@brgear.com
www.brgear.com
SEE OUR AD P45

Beyta Gear Service
0N230 COUNTY FARM ROAD
WINFIELD IL 60190
Phone: (630) 209-1652
chuck@beytagear.com
www.beytagear.com
SEE OUR AD P106

Cincinnati Gearing Systems Inc.
5757 MARIEMONT AVE
CINCINNATI OH 45227
Phone: (513) 527-8600
Fax: (513) 527-8635
gearsales@cst-c.com
www.cincinnatigearingsystems.com
SEE OUR AD P47

Circle Gear & Machine Co.
1501 S. 55TH COURT
CICERO IL 60804
Phone: (708) 652-1000
Fax: (708) 652-1100
sales@circlegear.com
www.circlegear.com
SEE OUR AD P59

Excel Gear, Inc.
11865 MAIN STREET
ROSCOE IL 61073
Phone: (815) 623-3414
Fax: (815) 623-3314
chinn@excelgear.com
www.excelgear.com
SEE OUR AD P12

Forest City Gear Co.
11715 MAIN STREET
ROSCOE IL 61073
Phone: (815) 623-2168
Fax: (815) 623-6620
www.fcgear.com
SEE OUR AD P7

Gleason Plastic Gears
8210 BUFFALO ROAD
BERGEN NY 14416
Phone: (585) 494-2470
Fax: (585) 494-2474
gdiaz@gleason.com
www.gleasonplasticgears.com
SEE OUR AD P56–57

Jiangyin Ke'an Transmission Machinery Co., Ltd.
NO.8 HUANGTAI ROAD, YUNTING INDUSTRIAL PARK,
JIANGYIN JIANGSU PROVINCE
CHINA
Phone: +86 510-8615 1187, 8601 3998
Fax: +86 510-8601 2666
ka@keancn.com
www.keanchina.com
SEE OUR AD P105

KISSsoft AG
ROSENGARTENSTRASSE 4
BUBIKON ZURICH 8608
SWITZERLAND
Phone: +(41) 552542050
Fax: +(41) 552542051
info@KISSsoft.AG
www.kisssoft.ch
SEE OUR AD P107

Koro Industries, Inc.
9530 85TH AVE N
MAPLE GROVE MN 55369
Phone: (763) 425-5247
Fax: (763) 425-5261
info@koroind.com
www.koroind.com
SEE OUR AD P59

Lubriplate Lubricants Co.
129 LOCKWOOD STREET
NEWARK NJ 07105
Phone: (800) 733-4755
Fax: (973) 589-4432
www.lubriplate.com
SEE OUR AD P13

McInnes Rolled Rings
1533 EAST 12TH STREET
ERIE PA 16511
Phone: (814) 459-4495
Fax: (814) 459-8443
sales@mcrings.com
www.mcinnesrolledrings.com
SEE OUR AD P18,26

Midwest Gear & Tool, Inc.
15700 COMMON RD.
ROSEVILLE MI 48066
Phone: (586) 779-1300
Fax: (586) 779-6790
midwestgear@sbcglobal.net
www.powertransmission.com/copage/956_Midwest-Gear/
SEE OUR AD P105

Nordex, Inc.
426 FEDERAL ROAD
BROOKFIELD CT 06804
Phone: (203) 775-4877
Fax: (203) 775-6552
sales@nordex.com
www.nordex.com
SEE OUR AD P44,60

Oelheld U.S., Inc.
1760 BRITANNIA DR. #1
ELGIN IL 60124
Phone: (847) 531-8501
Fax: (847) 531-8511
hutec-us@oelheld.com
www.oelheld.com
SEE OUR AD P60

Perry Technology Corporation
P.O. BOX 21
120 INDUSTRIAL PARK ROAD
NEW HARTFORD CT 06057
Phone: (860) 738-2525
Fax: (860) 738-2455
sales@perrytechnology.com
www.perrygear.com
SEE OUR AD P61

Rave Gears LLC
425 STREMPLE STREET
SEGUIN TX 78115
Phone: (855) 728-4327
Fax: (830) 421-3532
sales@ravegears.com
www.ravegears.com
SEE OUR AD P33

Riverside Spline & Gear
1390 SOUTH PARKER
PO BOX 340
MARINE CITY MI 48039
Phone: (810) 765-8302
curtd@splineandgear.com
www.splineandgear.com
SEE OUR AD P49,63

SKF USA Inc.
890 FORTY FOOT ROAD
LANSDALE PA 19446
Phone: (267) 436-6000
Fax: (267) 436-6001
www.skf.com
SEE OUR AD P43

SMT - Smart Manufacturing Technology
CHARTWELL HOUSE
67-69 HOUNDS GATE
NOTTINGHAM NG1 6BB
UK
Phone: +44 (0)115 941 9839
Fax: +44 (0)115 958 1583
info@smartmt.com
www.smartmt.com
SEE OUR AD P50

Southern Gear & Machine
3685 NW 106 ST.
MIAMI, FL 33147
Phone: (305) 691-6300
allanarch@southerngear.net
www.southerngear.net
SEE OUR AD P50

Suhner Manufacturing Inc.
43 ANDERSON ROAD
ROME GA 30161
Phone: (706) 235-8046
Fax: (706) 235-8045
info.usa@suhner.com
www.suhner.com
SEE OUR AD P107

Total Gear Solutions to Improve All Your ‘Apps’

Your single source for all the latest gear production, automation, tooling and inspection technologies to improve your applications. With reliable service to support you anywhere, all the time.

www.gleason.com

Total Gear Solutions Gleason

Gear Shop of Tomorrow

Machine Innovations Hint at Future for Gear Manufacturing

Matthew Jaster, Senior Editor

It's Monday morning, December 15, 2036. An autonomous vehicle drops off two engineers in front of a gear manufacturing facility in Metro Detroit. They punch in for work on their wristwatches and pay Uber for the ride on a smartphone. One of the engineers begins walking the shop floor, monitoring a series of collaborative robots using a tablet the size of a paperback novel. These robots interact right on the floor with the minimal staff scheduled to oversee manufacturing operations. Another engineer wears an interactive headset and begins training a group of new engineers (in real time) from China using some form of augmented reality.

Digital message boards across the factory prioritize jobs and prep machining cells for the upcoming production schedule. Automated Guided Vehicles (AGVs) move carts across the floor carrying cutting tools to various machine tool stations. As tools and systems breakdown, automation and additive manufacturing capabilities help maintain deadlines. Everything is orderly, automated and optimized.

Could your average gear manufacturing facility look something like this in 20 years? What can we expect from machine tool technology over that period of time? What advancements and innovations are going to change the way gear manufacturers work and collaborate in the future? Many of the concepts above were readily available if you roamed the halls at AMB 2016 (Stuttgart) or IMTS 2016 (Chicago).

Technologies such as collaborative robots, automation cells and intelligent machining will no doubt link components, processes and analytical tools together now and in the future. With IMTS fresh in our minds, we felt it was the perfect opportunity to ask machine tool builders and gear manufacturers "What's next?"

Scott Yoders, vice president of sales, Liebherr Gear Technology, Inc. has been in the gear industry for about 20 years. "From my persepective, it can be said that the rate of change in the past five years has been exponential, when compared to the prior 15. The advancements in cutting tool and abrasive technologies have vastly improved, resulting in significantly more efficient processes. Moreover, the intelligence of machine tools and the technology infrastructure in machine controls have also drastically improved."

For Fred Young, chairman, Forest City Gear, the easiest way to look at the future is to review the past. "Historically Forest City Gear has invested in new technology to the tune of 25-40 percent of our gross sales each year. Naturally we benefitted from the obvious increases in

EMAG's automation technology hints at what the future gear shop may look like. (Photo courtesy of EMAG)

productivity and quality and versatility. What we've also discovered is that these investments inspired more creativity and they've led to more experimentation with all sorts of productivity increases not only with our gear equipment but also our peripheral manufacturing, inspection and process improvement efforts," he said.

IMTS has always been the gateway into future machine tool technology here in North America. This is why Young finds it so important to take 30 or more Forest City Gear employees to the show every two years. Young challenges his staff to identify new equipment and systems that could help grow and expand FCG's operations.

This year's show had everything from interactive exhibits, multifunctional machine tools and virtual and augmented reality headsets to 3D-printed vehicles, houses and medical implants. It also included robots serving coffee and ice cream with minimal human intervention. The potential for Industry 4.0 (or the Industrial Internet of Things) was evident across all pavilions.

Bill Miller, vice president at Kapp Technologies, however believes that potential has yet to be realized in the gear industry. "Industry 4.0 already describes the interconnectedness of all devices including gear machines. Yet the power for immense diagnostic features are scarcely utilized and barely understood. This technology will be fully evolved and enable rapid capture, sharing, analysis and corrective action prescriptions on a global basis."

And Miller believes these "smart" machine features will one day be essential for a gear company's success and growth. "Currently, case studies abound where new ownership or management either emphasizes quarterly results over long term continuous improvements and/or rapid deployment of too many new technologies that are not digested wholly. Neither is smart," he added.

The Machine Tool Perspective

Industry 4.0 or IIoT alone can't take the gear industry into the future. Machine tool technologies, cutting tools/materials and inspection capabilities will continue to evolve at a rapid pace. The future accomplishments of the gear grinding machine tool, for example, will greatly depend on the types of gears to be ground.

With the automated bin picking solution, Liebherr sets new standards in the handling of un-machined parts that are fed into a modern production system. (Photo courtesy of Liebherr)

"Assuming that in 20 years time some 30 percent of cars will be electric; this will put higher demands on the quality of ground gears, regarding both the gear flank geometry and the surface structure," said Walter Graf, marketing manager at Reishauer AG. "Gears of electric drives systems turn at much higher revolutions than those of the internal combustion engine. Presently, for electric drives, we are looking at 15,000 rpm and this may be as high as 30,000 rpm in 20 years."

Therefore, the question of noise suppression will be much more pertinent as noise generation is exponential to the rotational frequency. "The future hard-finishing machine tool will have to be able to deal effectively with gear noise. This will not be limited to the machine tool itself but will extend to the tooling such as the grinding wheels and the diamond dressing tool, and as a consequence, to the perfect symbiosis of all three. Grinding wheels, for example, will have to be absolutely constant in their homogeneity from lot size to lot size," Graf added.

According to Graf, new abrasive materials will also be invented in the next 20 years that will positively impact surface quality and grinding cycle times. "However, it is also reasonable to assume that the gear materials will evolve to be more lightweight and more wear-resistant. Hence, these gears will be harder to machine and the future machine tools will have to be capable of coping with this," Graf said.

In the past a new coating might come out every five or 10 years, according to David Goodfellow, president and CEO at Star SU. "Today, it seems we get one every two to three years and who knows what the future will hold. We might get a new coating material every year, possibly every month, but the fact remains that you have to validate every process change that comes along."

D. Kirk Stewart. Jr., director of sales at EMAG LLC., envisions more intelligent utilization of robots for tool and fixture exchanges in the future. "Further automation will be necessary to stay competitive in our markets going forward. Our equipment will be connected to the users, manufacturers, tooling and accessory suppliers like never before."

The smart gear factory will feature a highly automatized production floor with flow optimization between all manufacturing and inspection equipment involved, said Christian Albrecht, director of global marketing at Gleason.

"Here manufacturing systems will benefit from self-learning mechanisms, based on data analytics that can run in the cloud or in a local system."

With new capabilities for advanced data analytics, self-learning systems, virtual testing and real-time correction loops optimizing design changes, Albrecht thinks it will be easier to perfect the evolution of contact patterns and flank forms prior to making a single chip. Non-contact inspection systems like laser scanning open up new possibilities for rapid in-process inspection and closed loop systems.

"Also auxiliary assets like perishable tools and workholding become smarter and will transfer valuable data to the machine to produce higher quality products with maximum productivity and tool life," Albrecht added.

There are a plethora of monitoring systems on machine tools nowadays, and this will be further enhanced in the future. "Many are mistake-proofing operator assistance features, like our Liebherr Collision Control feature, to avoid any major machine breakdwons. Further, tool life monitoring systems in Liebherr gear hobbing machines have been in use now for five years — like Artis tool monitoring — so these will undoubtedly operate in an adaptive mode for operator assitance," Yoders said. These features will continue to progress in gear manufacturing in the future.

For many in the industry, gear machines will be faster, more efficient and consume less energy. But in 20 years, it won't be as futuristic and automated as some might expect. A typical gear manufacturing operation will look remarkably similar to today's gear shop, said Adam Gimpert, business manager at Koepfer.

"Look a bit closer and it will be cleaner, faster, with less humans on the shop floor. Intelligent (relative to today's) robots will replace some operators and will be able to move and adapt to existing machines that may still be decades old. Teaching those robots, however, will still be a human occupation. Digital standardization of gear manufacturing information will allow more seamless operations — even between organizations. This will increase the velocity of all processing and tracking from the conception of a gear through the entire life of the gear," Gimpert said.

Machines in the future will produce higher quality products with maximum productivity and tool life. (Courtesy of Gleason).

The Gear Manufacturers' Perspective

Mike McKernin, president of Circle Gear and Machine, envisions a future gear shop where blueprints no longer exist and automated part movement is the norm. "Employees will have tablets (or similar devices) to access all the information they need for the project at hand. Display screens will replace message or white boards throughout the factory."

He also believes mechanical machines built in the 1950's through the 1980's will still be producing a decent industrial grade gear. "Unfortunately the market will not need as many industrial grade gears. Early generation CNC machines will have been discarded due to a lack of electronic components. Creative operators will still be required to determine workholding on challenging parts. Determining machine rates will be much easier. I also think *The Machinist's Handbook* will be a flash drive that contains 100 times the information currently printed."

Software advances will help gear manufacturers achieve difficult setups with less experienced workers in the future, said Young at Forest City Gear. "Visual instructions will be more common place as well. I would anticipate the equipment to have more diagnostic equipment to avoid maintenance issues (perhaps even some self-repairing machines). New machinery will be able to be upgraded without the necessity of complete replacement thereby lowering cost for new advances and reducing time for the ordinary job shop. These machines will feature integrated inspection capabilities for self-correcting. We should expect to load the prints into the machine and have them research any specification with which they are not familiar off the Internet or its successor."

In the future there will be more focus on core competencies with heavier cost reduction and On-Time Delivery (OTD) pressures. "This may lead to more specialization shops instead of trying to be everything to everyone since companies won't be willing to pay for any machine downtime in pricing structures," said Patrick Kay, controller at Forest City Gear. "I also think the focus will be so heavy on cost that one-stop-shopping may not be possible. This is contrary to the current FCG model."

Man Versus Machine Tool

Though we can't forecast the percentage of robotics and automation that will play a daily role in the gear shop of the future, Albrecht at Gleason is sure future

manufacturing systems will rely less on traditional human experience, but will demand a highly trained engineering staff supporting advanced systems reacting to real-time data exchange. "The role of the machine operator will change to a highly skilled systems specialist," he said.

And this could lead to some interesting problems in manufacturing. "What happens when you increase the complexity of the machine tool? Automation improvements will be great opportunities in gear manufacturing, but when you complicate the machine, you make it more difficult to get the right kind of people to run it effectively," Goodfellow said. "Instead of hiring a machine operator or two, you'll need to find an engineer with an additional set of skills. Where are we going to find these people in the future?"

Miller at Kapp expects the diversity gap to widen over the next two decades. "The investment required to stay ahead will outpace potential profit for most gear manufacturing businesses that don't serve a niche market. The decision-making requires empowered, nimble, educated and risk-oriented human resources. These resources have to be grown and not outsourced. Management must prioritize staff development over task management."

No matter what technologies push the industry forward, academics and industry will have to come together to prepare the next workforce for the gear shop of the future. And while electric cars make headlines and direct drive motors replace gears, this industry will be fine 20 years down the road.

A Kawasaki robot serves ice cream during IMTS 2016 (photo by David Ropinski).

"Gears will still be in the differential box, they'll be in the all-wheel-steering and you'll find them in all the gizmos and gadgets utilized for the automation of the vehicle," Goodfellow said. "Gears are still going to be a huge part of our life; they just might have different characteristics."

He also warns of accepting new technology and innovation in haste. "I have a car that will brake if I don't stop to avoid the car in front of me. I haven't tried it yet, simply because I don't trust it. The feature is there, but I'm not comfortable testing it out. We're going to have to look at things differently and trust that these technologies will work in the future."

Koepfer's Gimpert thinks we're still a long way from the automated factory that techies and futurists envision in manufacturing today. And there will be plenty of time to work the kinks out.

"I think of the comments made by Michael Rogers (*The New York Times* author and futurist-in-residence) at the 2015 AGMA Annual Meeting where he referred to the building industry as leading the way in futurizing digital 3D models and shared information," Gimpert said. "Having spent the start of my own career in the building industry, I know firsthand the challenges and difficulties involved in moving an entire industry into the promise of the future. As much as we want to imagine artificial intelligence running factories without people, this is probably more than 20 years away."

Contributors: *www.circlegear.com, www.emag.com, www.forestcitygear.com, www.gleason.com, www.kapp-usa.com, koepferamerica.com, www.liebherr.com, www.reishauer.com, www.star-su.com, www.wzl.rwth-aachen.de, www.imts.com.*

Nachi Robotic Systems featured an array of robot technologies during IMTS 2016 (photo by David Ropinski).

For Related Articles Search
future
at www.geartechnology.com

DIGITIZE or DIE?

New Brain Bank Dedicated to Coaching U.S. Manufacturing into Digital Age

Jack McGuinn, Senior Editor

In a capitalist society, the way things usually work is that government and academia focus on research and development, while industry focuses on commercialization. The result is an increasingly wide disconnect in the applied research sector, which deals primarily with technology development and demonstration. Meanwhile, there exists — especially in the manufacturing and technological sectors — a decided lack of both able and want-to candidates to replace their rapidly retiring elders. To give it a number — there are approximately 600,000 unfilled manufacturing positions around the country — a sure sign that Baby Boomers are seemingly retiring as soon as their IRAs and Social Security will allow. Accordingly, their former employers cannot find sufficiently skilled workers to replace them.

None of this is news. Yet the fact remains today that while 81% of U.S. manufacturers agree digital manufacturing is key to their future competitiveness, only *14%* said they were adequately equipped with today's available digital technologies and related expertise. While many majors — Siemens, John Deere and General Electric, etc. — are true believers in digital manufacturing and all that that entails, others — especially small to mid-size companies — are understandably of a "show me more" mindset.

Nevertheless there is clear, general consensus on how difficult it is to compete with foreign manufacturers able to pay poverty-level wages and get away with it.

What *is* new is UI LABs' Digital Manufacturing and Design Innovation Institute (DMDII) — a "public/private partnership of American companies, academia, and government agencies that are benefiting from early advances in digital manufacturing and design." UI LABS is, citing its Website, "a first-of-its-kind innovation accelerator" that tackles problems too large-scale or complex for any one organization to handle. The challenges being addressed in manufacturing "are at the intersection of digital convergence."

Located in Chicago's West Loop corridor, UI LABS in spring of 2015 was granted $70 million from the U.S. Department of Defense (DoD) to fund the DMDII. The DoD funds were complemented by commitments of approximately $250 million from a consortium of industry, academic, government and community partners. With this blend of industry, academia, the nonprofit sector and government, DMDII sponsors research "projects" in digital manufacturing and design; disseminates lessons learned; and helps educate the workforce of tomorrow.

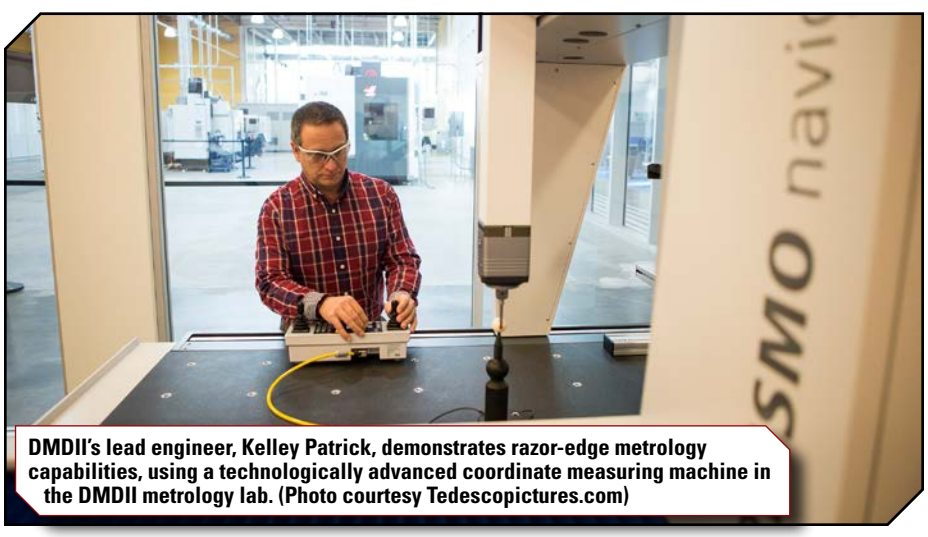
Among its (over 500) member supporters are such heavyweights as Lockheed Martin, General Electric, Siemens, Rolls-Royce, Boeing, John Deere, Caterpillar and Illinois Tool Works. Also on board from Academia are the University of Illinois; Northwestern University; the University of Chicago (*University of Chicago??*); Purdue University; the University of Texas-Austin; the University of Louisville; the University of Iowa; and the Rochester Institute of Technology. Remaining essential DMDII members are among the country's small and mid-size manufacturers — otherwise known as the bedrock and benchmark of U.S. manufacturing and its economic stability.

And so it is that DMDII is charged with aiding "U.S. manufacturers (in the capturing of data) to make their products better, faster, and more cost-competitive," while also zeroing in on "helping U.S. manufacturers to increase their return on investment (ROI) by making their production processes more efficient and agile."

Perhaps it was to underscore the significant and urgent need for U.S. entities such as DMDII that the $70 MM came from the coffers of the DoD — although Homeland Security might be even more appropriate. Of most importance perhaps is the backing of the previously mentioned consortium and its $250MM in monetary commitments.

In return, other important assets readily available to members include downloadable manufacturing software collaboration tools; opportunities to exchange product information; advertise manufacturing capability, and transmit detailed design information in a secure, neutral and intellectual property-secure digital environment.

And there's more; highest



DMDII's lead engineer, Kelley Patrick, demonstrates razor-edge metrology capabilities, using a technologically advanced coordinate measuring machine in the DMDII metrology lab. (Photo courtesy Tedescopictures.com)

(investment)-level members receive rights to intellectual property produced via DMDII collaborative research projects, and gain access to a group of digital manufacturing and design experts that can help form strategic partnerships between corporations and universities. And all members, at any level, can take advantage of:

- Coordinated support to prepare and align your workforce to digital manufacturing and design outcomes and trends
- Access to live demonstrations of the latest digital manufacturing and design technologies
- Collecting and analyzing data drawn from various types of manufacturing equipment, including:
  - Standard machining
  - Multi-access machining
  - Metrology
  - Welding & fabrication
  - Micro manufacturing
  - Additive manufacturing
  - Circuit assembly

U.S. manufacturing employment has decreased from 18 million jobs in 1970 to less than 12 million jobs today. In 2016 it remains difficult to compete with foreign manufacturers ready and able to pay poverty-level wages — and get away with it. But with game-changing digital manufacturing and design technologies/processes to help speed product design and production processes, the playing field levels dramatically.

And in the near future, according to the DMDII site, will be the ability to:

- Reduce or eliminate prototyping with advanced simulations
- Enable true transparency in the supply chain
- Benefit from further advances in intelligent machining
- Predict and apply manufacturability and operability feedback at the initial design stage

For more details on DMDII — we've only scratched the surface here — following is an interview conducted with three individuals key to DMDII's success: Andrew Watkins (**AW**), managing director – strategy; Haley Stevens (**HS**), director, workforce development and manufacturing engagement; and Kelley Patrick (**KP**), lead manufacturing engineer.

GT: Why Chicago? How fierce was the bidding from competing cities?

Andrew Watkins (AW): Chicago, Illinois, and the Midwest have long been at the epicenter of American manufacturing. Illinois was a logical location for the Digital Manufacturing Design & Innovation Institute (DMDII) given the region's strong ties to the manufacturing sector, an abundance of skilled engineering and computer science talent, and technological assets. DMDII is able to draw from large industrial manufacturing companies, world-class universities in engineering and computer science, local super computers, a large base of small and medium-sized manufacturers, and a growing startup scene for industrial technology. All that said, we are a national institute with partners in more than 30 states that contribute to the network and projects.

The bid process was certainly competitive with bids from all over the country, but our mix of team, assets, and vision for the future of manufacturing made Chicago the ultimate choice.

GT: Who/what was the spark — the big bang — that led DMDII from the what-if stage to today's reality?

AW: The spark was a convergence of forces. Local and state leaders from industry, university, and government were working on a plan for tighter collaboration and use of our assets to lead in areas of historic strength, such as manufacturing. At the same time, President Obama announced the Manufacturing USA program (formerly known as the National Network for Manufacturing Innovation) to launch a series of manufacturing-focused institutes. Our team was well positioned to respond and lead when the topic of digital manufacturing was announced, based on the alignment that was established with our partners over the prior 2-3 years. Our partners had already determined that digital and advanced manufacturing was a good topic to work together on through applied R&D, so it became a natural area to collaborate within.

GT: How, if at all, difficult was it to make it happen?

AW: The biggest challenges we encountered were in establishing the institute. We started with approximately 70 partners and have more than 300 today. Establishing a structure, legal framework, and process that work for each partner is a tall order, which is why these unique partnerships and collaborations do not happen frequently.

GT: How were your key players (core team) recruited? Was it easy or did DMDII have to do some serious selling?

AW: Bringing the initial core partners to buy in was easy in some ways, while difficult in others. It was amazing to see the shared vision of both the challenges and the potential future for manufacturing. Getting all of the partnerships to line up certainly took a lot of effort and time to ensure there was alignment on the structure and details. Our early partners included the University of Illinois, Northwestern, GE, Rolls-Royce, and Procter and Gamble, as well as officials from the city and the state. As additional partners have signed up, they have become our biggest champions.

GT: Please explain the connection with UI Labs — e.g. are they equal shareholders or something else?

AW: UI LABS is Chicago-based in innovation accelerator that addresses problems too big for any one group to solve on its own. The organization has built a portfolio of labs that accelerate the deployment of digital technology within industries. The first lab is the Digital Manufacturing & Design Innovation Institute, established in 2014, and we launched City Digital, focused

on smart city infrastructure, in 2015. UI LABS is a nonprofit entity—the 'UI' stands for University + Industry—that runs and executes the programs of its two labs, with the potential to add other labs to the portfolio in the future.

GT: Is there an existing organization in Europe—Germany comes to mind—that may have served as a model for DMDII?

AW: The Fraunhofer institutes in Germany (*www.fraunhofer.de/en.html*) certainly were a model for the Manufacturing USA network established by the federal government, and a group we have learned from. (*The Fraunhofer Society for the advancement of applied research is a German research organization with 67 institutes spread throughout Germany—each focusing on different fields of applied science.*) There are other examples of government catalysts for industry innovation in the UK (Catapults) and Singapore. We have tried to learn from all of these groups as well as models of innovation that work in the U.S., such as SRI or MIT Media Lab, but have different structures or focus.

GT: Given all this new cost-efficient, energy-saving, data-rich technology, there still must exist a market actually needing/wanting manufactured products. Therefore is there any question among entities like DMDII or, for example, OEM members, that perhaps tomorrow's technology is outstripping today's somewhat iffy economy?

Kelley Patrick (KP). There's always going to be a need to make things. At DMDII we're trying to make things more energy-efficient, and data-rich, with the ultimate goal of producing more here in the United States at a lower cost to help grow the economy—and reduce the amount of work that's outsourced abroad. Raising the capability level of all manufacturing across the United States is a key part of the DMDII mission.

GT: Are you anticipating new funds any time soon from Congress beyond the initial $70 million?

AW: We are constantly working with our partners to understand priorities and ways that our model can help address their problems as they relate to digital manufacturing or transition and commercialization of technology. We have added additional funding to our agreement for specific programs and we continue to see strong support for the institute from Congress and our partners.

GT: Are entities like DMDII frustrated by Washington's continuing refusal to pass a meaningful and comprehensive infrastructure bill—one significantly larger in scope than what was recently passed?

KP: We're excited that the federal government is acknowledging the need to improve the manufacturing capability in the United States, which they've done by supporting the Manufacturing USA network.

GT: DMDII's site states one of its goals as "educate the digital workforce." What does that mean, exactly?

Haley Stevens (HS). Manufacturing has evolved into a highly innovative, interactive, and compelling career. We must begin with challenging the misperceptions that plague manufacturing careers as 'dirty, dark, dangerous, and moving offshore.' According to a recent Deloitte study, only 33% of parents say they want their children to pursue manufacturing as a career, seeing it as potentially unstable and lacking growth opportunities. So, what do we do to create and educate the "digital workforce" we need?

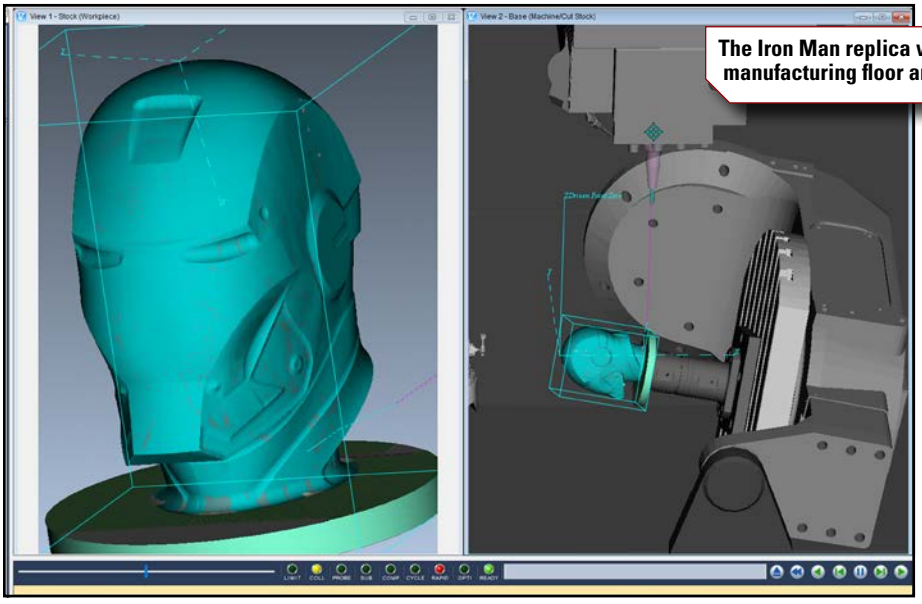
The following a short list of the basic things we need to do:

- Manufacturing has changed and we need to understand what skills are needed today and what skills will be needed tomorrow as manufacturing continues evolving to in the future. We need a 'taxonomy' of all the digital manufacturing jobs as a starting point.
- We need to develop formal training programs that are similar to the old 'apprentice' programs of the past that include technical and hands-on training that result in recognized credentials. We can use the German apprentice program as a model.
- The digital manufacturing workforce needs engineering skills coupled with basic IT skills that allow a digital manufacturing worker to interface with CAD, CAM, Virtual Reality simulation, physics-based software and information system like PLM, ERP, and MES. STEM skills are critical to these new digital manufacturing jobs.
- We need to adopt new methods of training that include online distance learning models like DMDII DM&D (Digital Manufacturing & Design) 101.
- Training programs must be quick to adapt to develop new training programs as new manufacturing technologies like 3-D Additive Manufacturing are perfected.

The U.S. is behind much of the industrial world in creating a skilled digital manufacturing workforce and must play catch up to retain manufacturing in the U.S. The good news is that organizations like DMDII are creating and testing the tools necessary to train the future manufacturing workforce. Those who chose this path will find a bright future with challenging high skilled and high paying jobs.

GT: What would you say are today's most pressing manufacturing challenges?

KP: The most pressing challenge is weaving and integrating the digital thread throughout the entire manufacturing process, and throughout the supply chain. Large players in the industry have the scale and capabilities to do a lot of this in-house, but for the smaller players in the supply chain, digital integration is challenging, leaving us short of the



The Iron Man replica was produced at DMDII using equipment on the manufacturing floor and software to refine the design prior to production.

ultimate goal of a fully digitized supply chain.

GT: While I realize that gear industry manufacturing-specific projects are yet a way off, can you speak to how Intelligent Machining (IM)—which "integrates smart sensors and controls to enable equipment to automatically sense and understand the current production environment in order to conduct self-aware manufacturing"—will benefit for example (wind) gearboxes, gears and gear components—their design and manufacture?

KP: Any and all manufacturing, regardless of the industry, will benefit from the application of smart sensors, data collection, digital twin, etc., which help define what we mean by digital manufacturing. For example, we've partnered with Omative Systems to demonstrate added intelligent machine technology on CNC machines on our manufacturing floor, focusing on adaptive control monitoring and vibration. The technology has real-time reactivity to material uncertainties as well as tool-life optimization and failure prediction.

GT: Might there be any gear-design, etc. -related software in or soon to be in development?

KP: Using manufacturing experts from our partners, we determine which projects and technology to develop based on impact to the industry and technology readiness. The tools, techniques, and methodologies resulting from our products can be applied to a wide variety of products and industries, including gear design. When partners have a specific problem within their industry, we'll work with them to form the right team and solution to address the challenge. Projects such as gear cutting can certainly be developed at DMDII where there is a partner mandate to undertake it.

GT: Will in the future any portion of your attention to metrology be applied to gear quality, etc.?

KP: The digital integration of metrology can be applied to multiple product types and industries, including gears. We're open to future partner-driven projects related to metrology applied to gear quality.

In the metrology lab at DMDII, we've introduced scanning technologies from our partner ChromoLogic that enable fingerprinting products to eliminate the part-marking operations and prevent counterfeiting. We also have an Alicona Infinite Focus unit in the lab that enables surface finish and geometric evaluation with a resolution of 10 nanometers.

GT: These must be heady days for system integrators; or has their traditional role evolved into something else?

KP: These are indeed good days for system integrators. System integration is a challenge, working across different controls, operating systems, etc. Meanwhile, the role is evolving to include digital as well as mechanical systems integration. Integration across the supply chain will be critical to the successful adoption of digital technologies.

GT: The advantages of one-stop suppliers have been documented for years. In this new, increasingly integrated world, how is a one-stop supplier defined? What must a supplier do in order to "get vertical?"

KP: A one-stop supplier is defined by being able to work with and communicate with all data formats within your market and supply chain. In the new integrated world, the supply chain is more flexible and competitive across the entire chain. This empowers OEMs and suppliers to broaden their supply chain. From the supplier perspective, a company can open up its market by being able to deal with more data formats and integrating the digital thread.

For more information:
UI LABS Innovation Center – DMDII
1415 N. Cherry Ave.
Chicago, IL 60642
www.DMDII.org
uilabs.org.

Locating Multiple Bore Diameters Via Hobbing

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

Attached photos (Figs. 1–2) show a bushing to locate one single bore. This will be used to locate one single bore diameter of a gear wheel. What is (the latest) technology for common clamping a bushing to locate multiple bore diameters in hobbing?

Figure 1

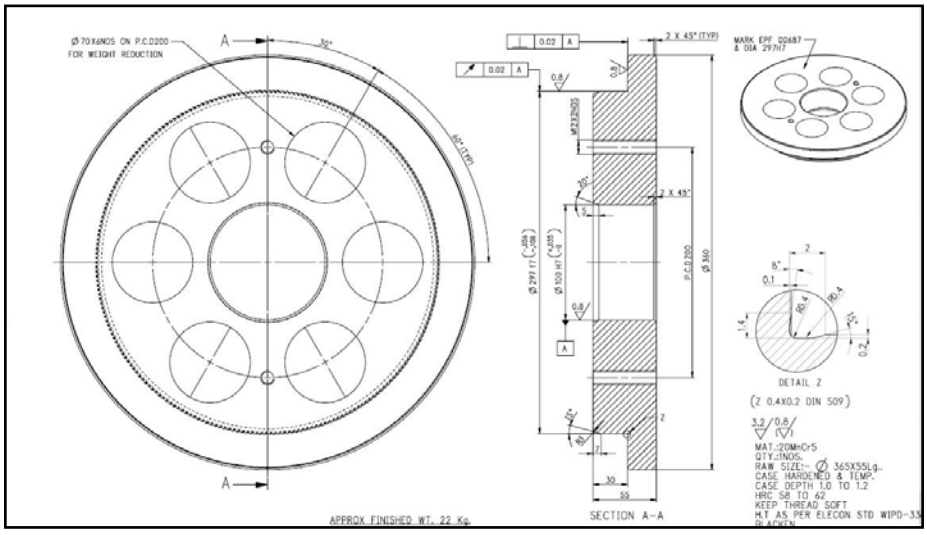


Figure 2

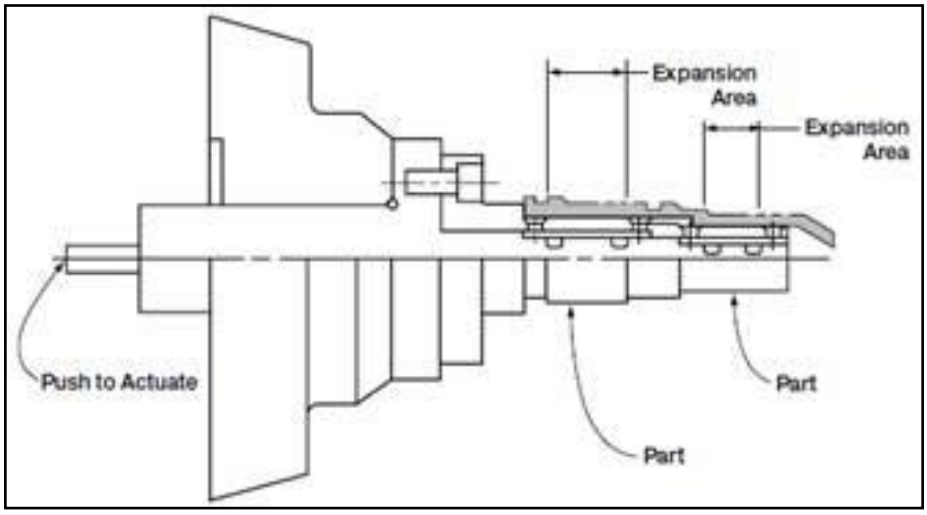


Figure 3

Expert response provided by Tim Zenoski, Gleason Corp. Director, Global Product Management/Workholding: Utilizing a bushing for an application like this is typically something that Gleason wouldn't do. The bore of the gear has a .0014" tolerance. This means that the bushing would have a certain level of clearance in the bore. We refer to this as solid centering. It's done, but usually for low-quality hobbing applications. I would recommend using a mechanical collet or spring (as shown in Figure 3) to center and clamp the gear. You would then utilize the downward pressure of the tailstock to face clamp the gear blank.

Another possible low-cost option would be to center the gear blank with a ball sleeve (cage). A ball sleeve would be designed with an interference fit to the gear bore. This would center the gear — even with the .0014" tolerance. Tailstock clamping would be needed to drive the blank.

Regarding your question about clamping or centering in multiple bores; we normally wouldn't do this, (but) if we were to, I would most likely recommend a hydraulic expansion arbor.

For Related Articles Search
workholding
at www.geartechnology.com

Hungry for More?

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

gear TECHNOLOGY®

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

FREE SUBSCRIPTIONS

www.geartechnology.com

The Role of Natural Frequencies in Grinding Systems Vibration

John Hagan, corporate applications engineer,
Norton|Saint-Gobain Abrasives

Excessive machine tool vibration during a precision grinding operation can result in poor workpiece quality in the form of chatter, rough finishes, burn, etc. One possible reason for excessive vibration is directly associated with the relationship between natural frequencies of a machine tool system and the operating speed of the grinding wheel spindle.

A machine tool system can comprise the entire machine or some sub-component of the machine, such as the grinding spindle, the fixture, workhead, etc. and multiple natural frequencies exist in all structures, including grinding machines. A natural frequency is the rate at which an object vibrates when a shock force excites the system, such as a tuning fork when it is struck. A system's natural frequency can also be excited by vibrational forces such as the centrifugal force generated by a rotating grinding wheel. Vibration severity can increase dramatically if this vibrational force frequency (e.g. wheel rpm) coincides with, or is close to, the natural frequency. This is also known as resonance frequency.

Machine tools are typically, but not always, designed to avoid this situation by keeping the natural frequency away from wheel operating speeds. For this reason natural frequencies are generally not an issue.

However, adding fixtures, grinding quills or grinding wheels can change the systems dynamics and as such either introduce new natural frequencies and/or modify existing natural frequencies.

An example of this type of vibration took place during a grinding test that was evaluating the effect of the wheel speed on a workpiece surface finish. Figure 1 shows the workpiece. During the test it was found that chatter amplitude on the workpiece had unexpectedly increased greatly when the wheel speed was reduced from 7,000 rpm to 6,250 rpm. Figure 2 shows the roundness when the workpiece was ground at 7,000 rpm and Figure 3 when ground at 6,250 rpm. This was inconsistent to what would be expected since reducing the wheels speed should decrease the centrifugal force and reduce vibration. Therefore it was decided to evaluate the vibration levels of the machine

Figure 1 The workpiece.

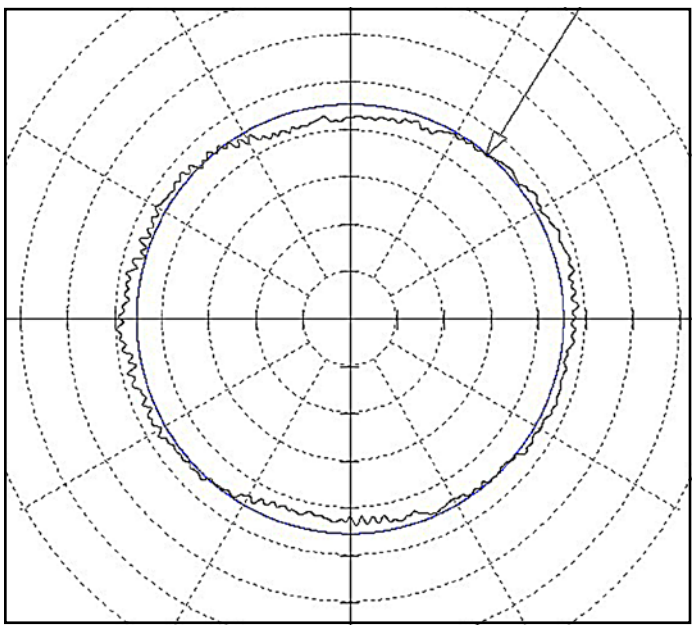


Figure 2 The workpiece with no chatter.

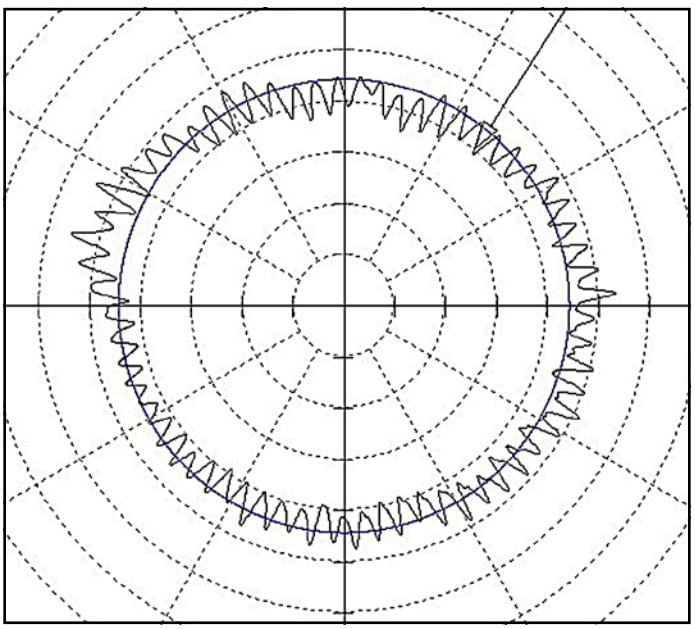


Figure 3 The workpiece with chatter.

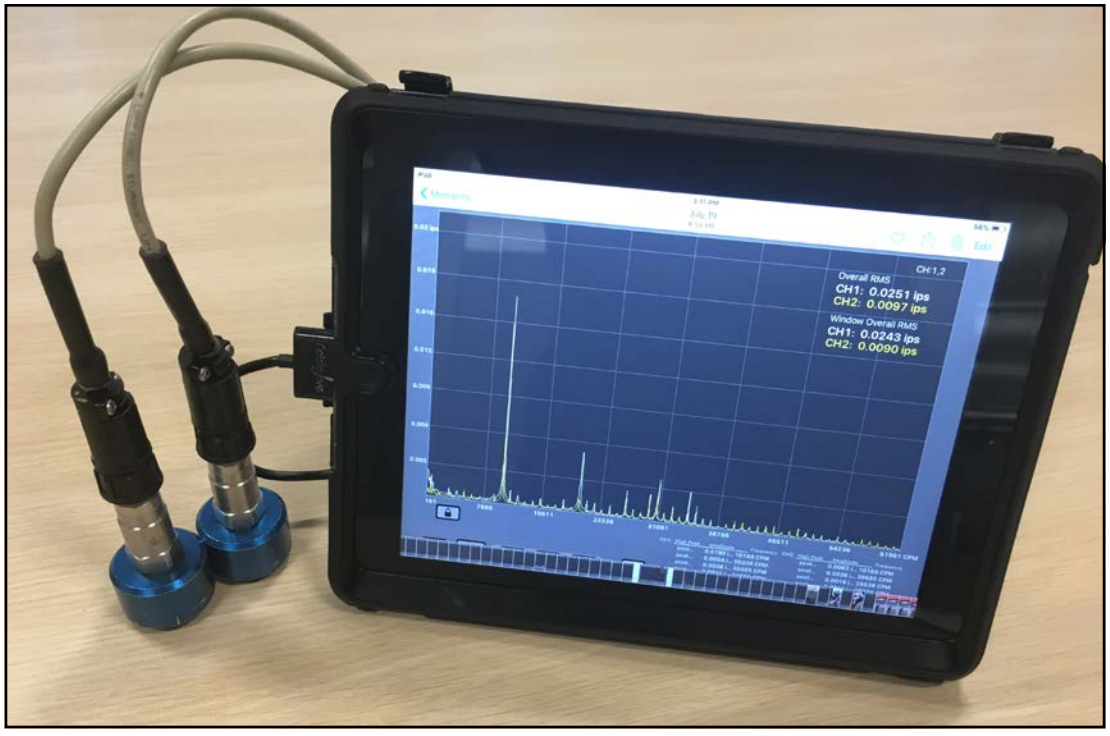


Figure 4 iPad based vibration analysis (VA) equipment.

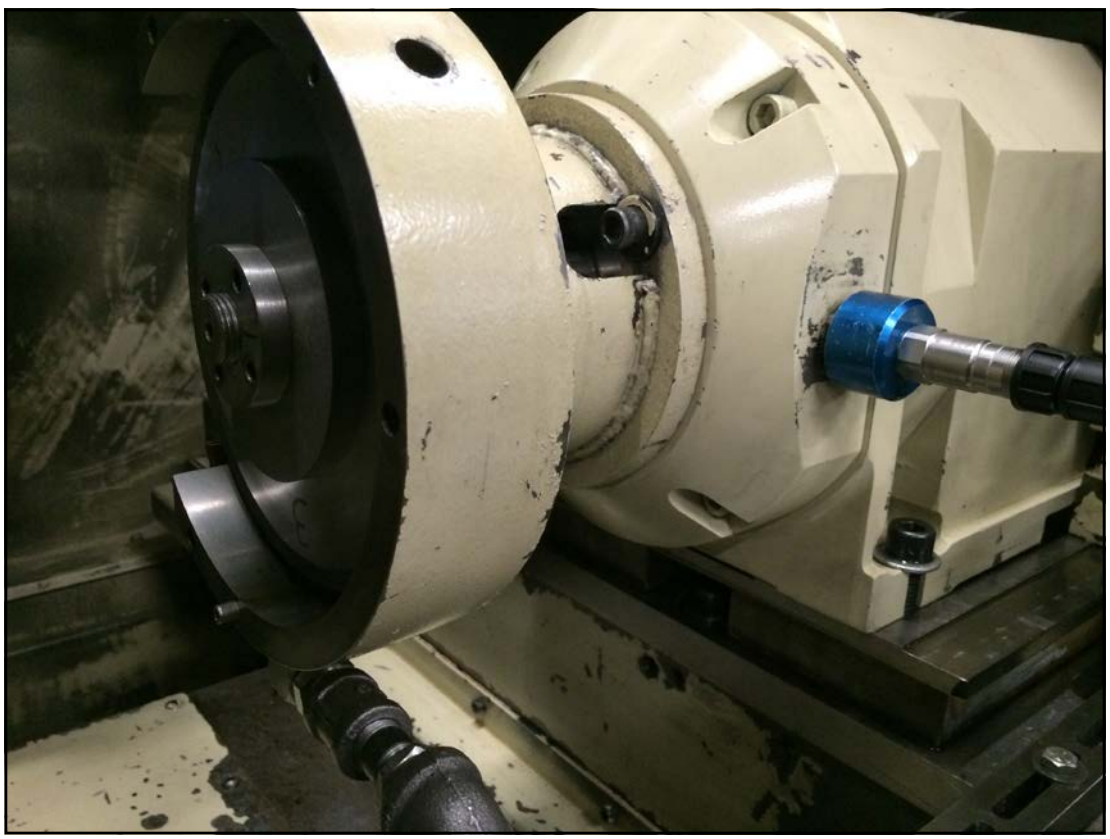


Figure 5 Machine spindle.

at the different operating speeds. The vibration analysis (VA) equipment shown in Figure 4 was used to measure the vibration amplitude at nine different operating speeds between 5,400 rpm and 7,453 rpm. The accelerometer was placed horizontally on the spindle as shown in Figure 5. The results showed that the vibration amplitude (Displacement Mils PK-PK) increased substantially as the speed approached 6,250 rpm and decreased away from this speed, as shown in Figure 7. Based on this data it appeared that there was a natural frequency at approximately 6,250 cpm (104 Hz).

In order to confirm this conclusion, an impact test was performed on the grinding spindle. The impact test was carried out

Figure 6 Chatter on gear tooth.

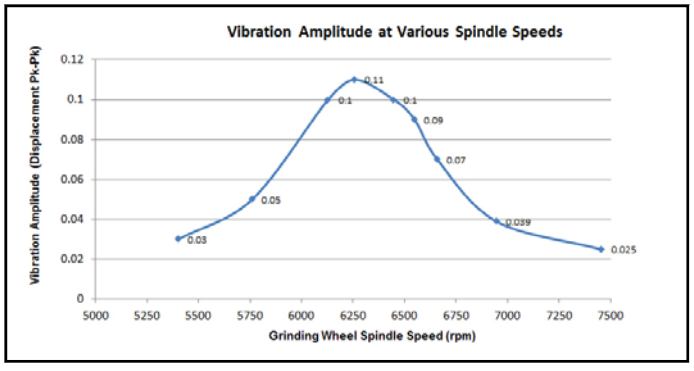


Figure 7 Vibration at different speeds.

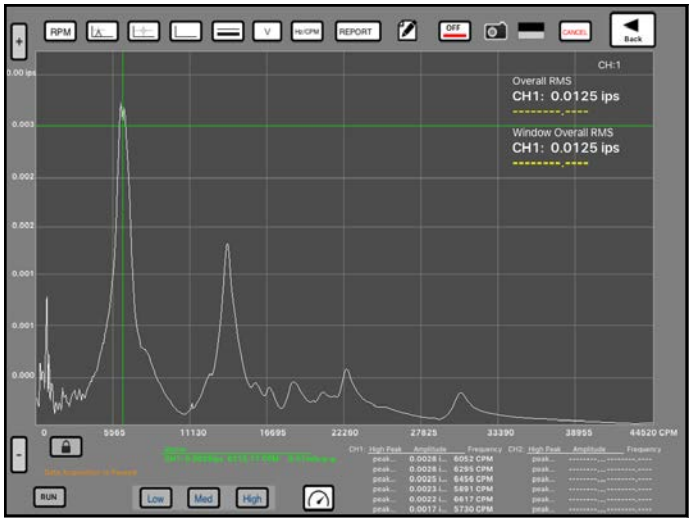


Figure 8 Impact test results.

using the same vibration analysis equipment. The accelerometer was mounted as shown in Figure 5. The spindle was then lightly tapped with a plastic hammer creating the shock force required to excite the natural frequency. The results of this test are shown in Figure 8. The large peak at 6,250 cpm (104 Hz) verifies that there is a natural frequency was causing the chatter issue.

The example in the case study describes the issues encountered when grinding the outside diameter (OD) of a workpiece on a cylindrical grinder. However this type of vibration issue is not unique to any one type of grinding machine or operation. Natural frequencies and the resulting detrimental vibration can be potentially found in many grinding processes, including creepfeed grinding, surface grinding, internal grinding, gear grinding, etc. In a gear manufacturing process, grinding the teeth is typically the final step when the required surface finishes and tooth profile are being generated. It is therefore critical that vibration is kept to a minimum. At this late stage of the process a tooth face with poor surface finish or chatter (Figure 6) could result in rejections, reworks and possibly additional honing time, if there is a subsequent honing operation. Poor quality surface finish can also result in an increase in gear noise and a reduction in gear life for the end users.

Dealing with Natural Frequencies

In the example described above the solution was to run at spindle speeds of 5,500 rpm and 7,300 rpm to avoid the natural frequency. In most cases the best and only solution is to adjust the wheel speed away from the natural frequency by about 15 to 20 percent. There are other available options such as trying to move the natural frequency by changing the system stiffness or mass, but these actions can be complicated and difficult to apply. However, improving the system stiffness by adding support brackets or improving the setup design should be considered if some component of the machine is clearly weak, as in a workpiece fixture or grinding quill. Utilizing a tuned mass damper is another option to consider. A tuned mass damper (TMD) is a device that is tuned closely to the same frequency as the natural frequency. The stiffness and mass of the damper is adjusted to obtain the target frequency. When the machine starts to vibrate the TMD will vibrate out-of-phase at the same frequency with the machine and as a result, reduce the vibration amplitude. Various versions of TMDs are used in many applications to combat natural frequencies, including, buildings, spacecraft, planes, bridges, etc. If considering this approach it would be advisable to consult a company that specializes in this type of device to determine if a TMD a good solution for your application.

Conclusion

A machine tool with a spindle speed range that overlaps a natural frequency can result in high vibration levels, leading to poor part quality and disruptions in production. Recognizing this type of issue can be difficult because in many cases the natural frequencies are not known. The best way to prevent vibration issues is to be proactive in measuring and tracking machine vibration by using vibration analysis equipment like the system shown in Figure 4, or similar types of equipment. This type of equipment can also be used for problem solving techniques like the impact test described above.

For more information:
Norton | Saint Gobain Abrasives
Phone: (508) 351-7296
www.nortonabrasives.com

Our Librarian Will Never Shush You

at the GT LIBRARY

That's because the GT LIBRARY is all online, and you can visit it anytime. Just go to *www.geartechnology.com* and use the search box for access to 32 years of technical content focused on gears.

- **Every issue since 1984**
- **More than 2,000 technical articles**
- **More than 6,000 archived news items**
- **Addendum, Publisher's Page, Back to Basics and more**

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

www.geartechnology.com

Calculation of the Tooth Root Strength of Worm Wheel Teeth Based on Local Stresses

Prof. Dr.-Ing. E. Leidich and Dr.-Ing. J. Reissmann

Calculating the root strength of worm wheel teeth is necessary to more accurately predict the formation of cracks. The starting point of this investigation was the difference between the analytical calculation of the tooth root strength based on the shear stress and fatigue tests. The strength calculated by the numerical analysis differed from that of the actual strength. An analytical method based upon the equivalent stress (von Mises stress) rather than the formerly used shear stress was investigated first. The results showed some improvement, but through a detailed investigation, additional deficiencies were identified. The best method for meeting the requirements was found in the use of local stresses. These stresses can be determined using a finite element analysis (FEA). According to the FKM guideline "Analytical strength assessment of components in mechanical engineering" the local stresses obtained from the FEA can be used to determine the fatigue strength of the worm wheel teeth. This paper explains the use of this algorithm and shows the improved results.

Introduction

Worm gear sets have a simple layout that creates a large transmission ratio in single stage. Because of the sliding rate, these types of gear drives are quiet in operation. The current technology uses a case-hardened worm and a bronze worm wheel to optimize friction and strength (Fig. 1, left). Because the worm gear is made of bronze, the teeth are the critical points of failure. The standard DIN 3996 (Ref. 1) provides design guidelines that include wear, pitting and fracture. In cases of high torque and low speed, the root strength of the teeth is the dominant design criterion (Fig. 1, right).

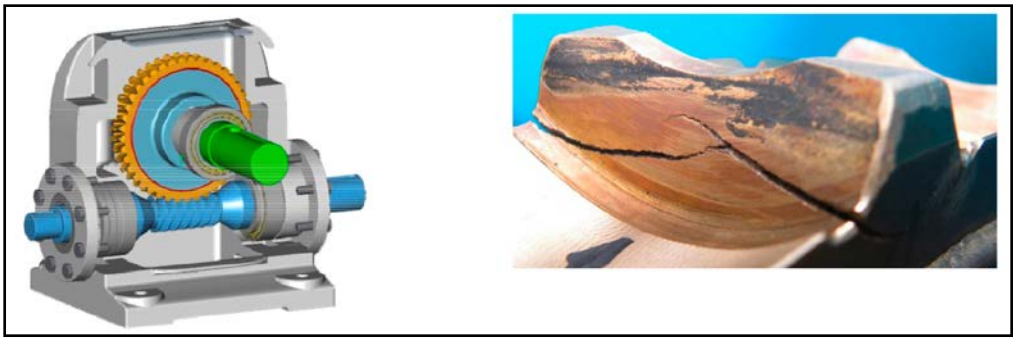


Figure 1 (Left): CAD model of the worm gear set; right: tooth with cracks at the tooth root notch.

Reason for Investigation

To find the gear best suited for a particular application, it is important to know the maximum load that the gear can bear. The failure limits for wear and pitting are well known from many studies, so the calculations in these cases are sufficiently precise. The limits of the strength of the tooth root are less well known because there have been only a few investigations of this subject. The current practice is to calculate the tooth root strength based upon

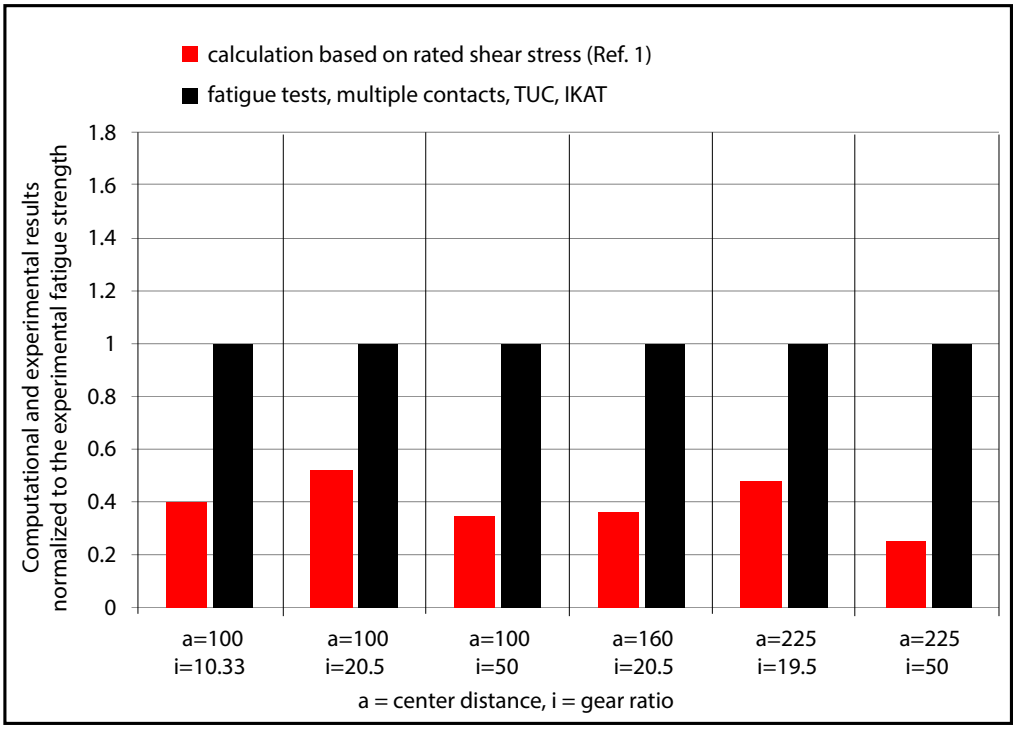


Figure 2 Comparison of calculated forces based on shear stress (red) and measured forces (black) normalized to the fatigue strength (Ref. 2).

This paper was initially presented at the 2013 VDI International Conference on Gears, Technical University of Munich (TUM), Garching (near Munich), Germany.

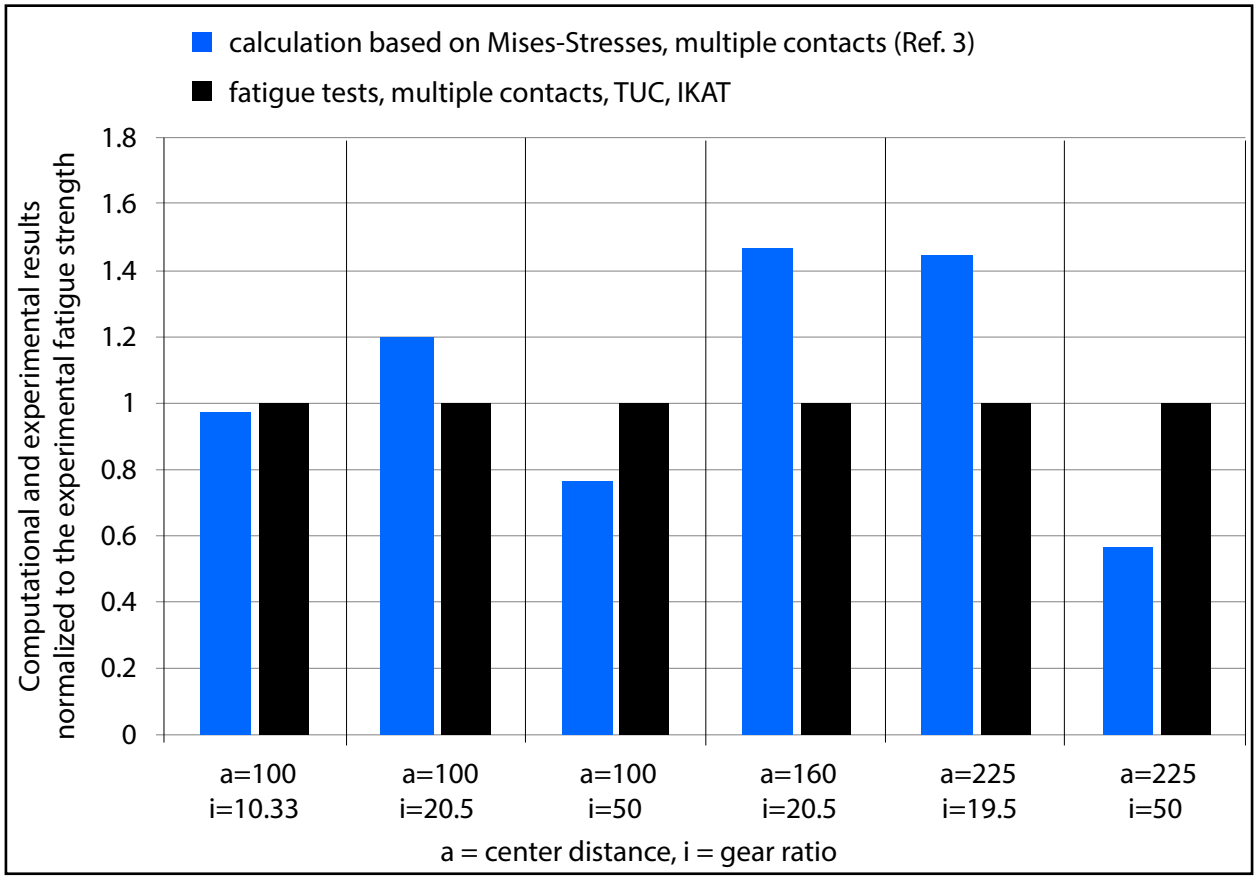


Figure 3 Comparison of calculated forces based on von Mises stress (blue) (Ref. 2) and measured forces (black) normalized to the fatigue strength.

the nominal shear stress. This method is easy to use and is well suited for small gears up to a center distance of $a = 100$ mm because it was adjusted with tests on small gears. However, for all gears the prediction of lifetime given by this method underestimates the actual lifetime (Fig. 2).

Because the load on the tooth root consists of a shear stress, a bending stress and a compressive stress, focusing only on the shear stress underestimates the actual load. One attempt to improve the prediction of the tooth strength was to use the von Mises stress as a replacement for the shear stress (Ref. 6). The results of this calculation method showed an improvement for a wider variety of worm gears, but this method has the same weaknesses overall (Fig. 3).

Because the geometry is not considered, an optimization of the geometry is not possible. One reason for the shortfall is the improper consideration of the geometric details of the tooth. The analytical method is based on the geometry in the middle of the tooth, but the cracks start at the edges of the tooth. Therefore, the locations of the calculated and actual failures are not the same (Fig. 4).

When the von Mises stress is used, the tip circle diameter da2 is used as the lever to calculate the bending stress. The outside diameter de_2 is not taken into account like the embedding of the tooth because of the globoid, too. In contrast to the standard method, in the method based on the von Mises stress, the notch effect of the rounding of the tooth root is taken into account.

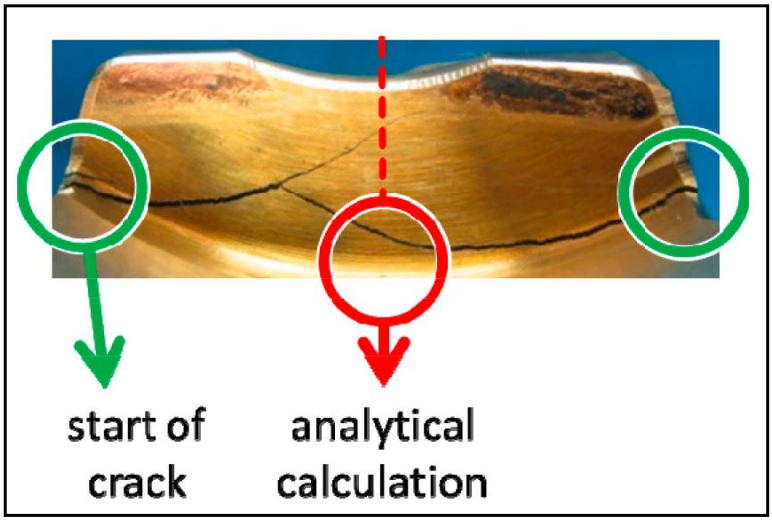


Figure 4 Difference between the calculated and the actual point-of-failure (Ref. 3).

Another reason is the older data in the standard for the material properties for bronze.

To solve these problems the complete geometry, the influence of the tooth contact, and the relative mounting locations of the worm and the wheel must be included. It would not be possible to include these effects using an analytical model based on rated stresses. The use of local stresses is more suitable than rated stresses, especially in the case of components with complex shapes. To determine the local stresses, a numerical method was chosen.

Figure 5 Framework of the method based on local stresses.

Research Program and Test Procedures

The task was to develop and to test a method based on the numerical evaluation of local stresses. This method includes an input for the geometry, a finite element program with a mesh generator, an input for boundary conditions, a solver and an algorithm to evaluate the fatigue life from the computed stresses (Fig. 5).

To evaluate the strength of the tooth root, the FKM guideline is an appropriate tool. Currently, however, the FKM guideline is valid only for steel and aluminum alloys. To include other metals, experiments on specimens including complete worm gears and finite element analyses were performed. For the method to be accurate, the strength limits must be known. Therefore, fatigue tests were performed on actual components using a hydraulic fatigue tester (Fig. 6). These results formed the basis for the comparison of the various methods.

Computation of stresses at tooth root. A simulation was required to compute the local stresses and to determine the parameters mentioned in the previous section. To evaluate the local stresses, the point at which the maximum occurs must be identified. This point is located on the tension side at the end face of the tooth (Fig. 7). The stresses obtained at this point were used to estimate the strength according to the FKM guideline (Ref. 4).

Using the parameters from actual worm gear sets, virtual models were created with CAD software. Next, with FEA software, meshes were generated and boundary conditions were defined for the model (Fig. 8). The stresses at the tooth root caused by applied forces were analyzed with the FEA software.

Calculation process. The calculation process was obtained from the FKM guideline (Ref. 4). To evaluate the worm wheel according to the FKM Guideline, both the static strength and the fatigue strength must be calculated; the procedures are shown in Figure 9.

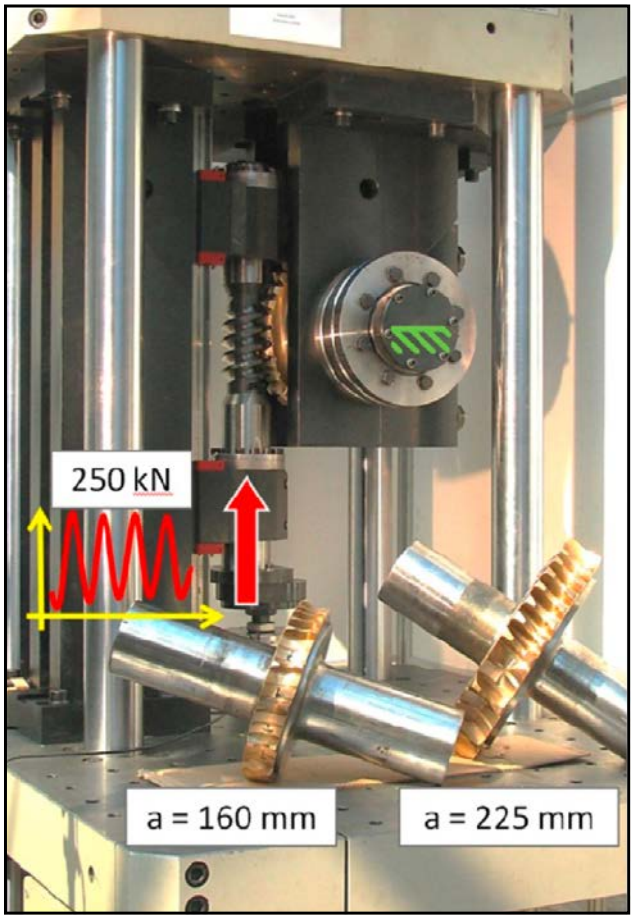


Figure 6 Hydraulic tester used for the fatigue tests.

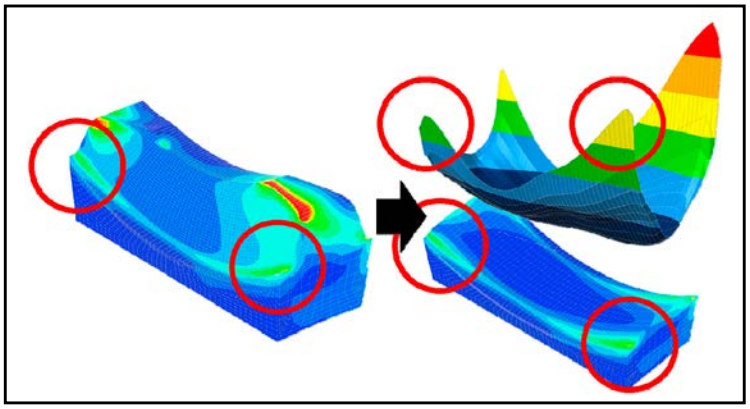


Figure 7 Points of maximum local stresses in the tooth root.

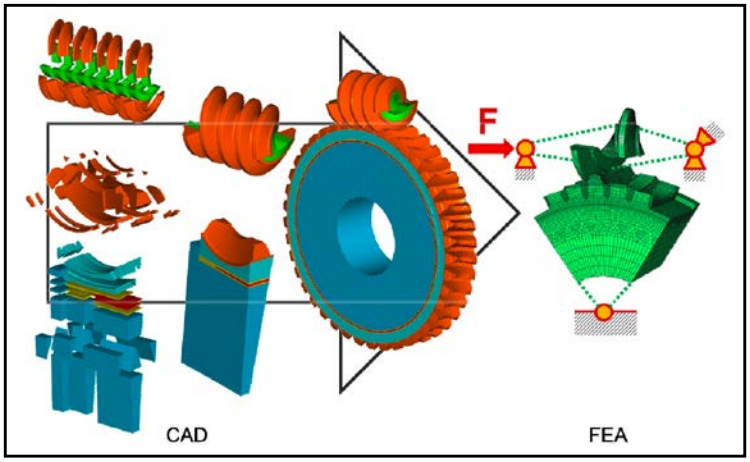


Figure 8 Procedure to construct the FEA model.

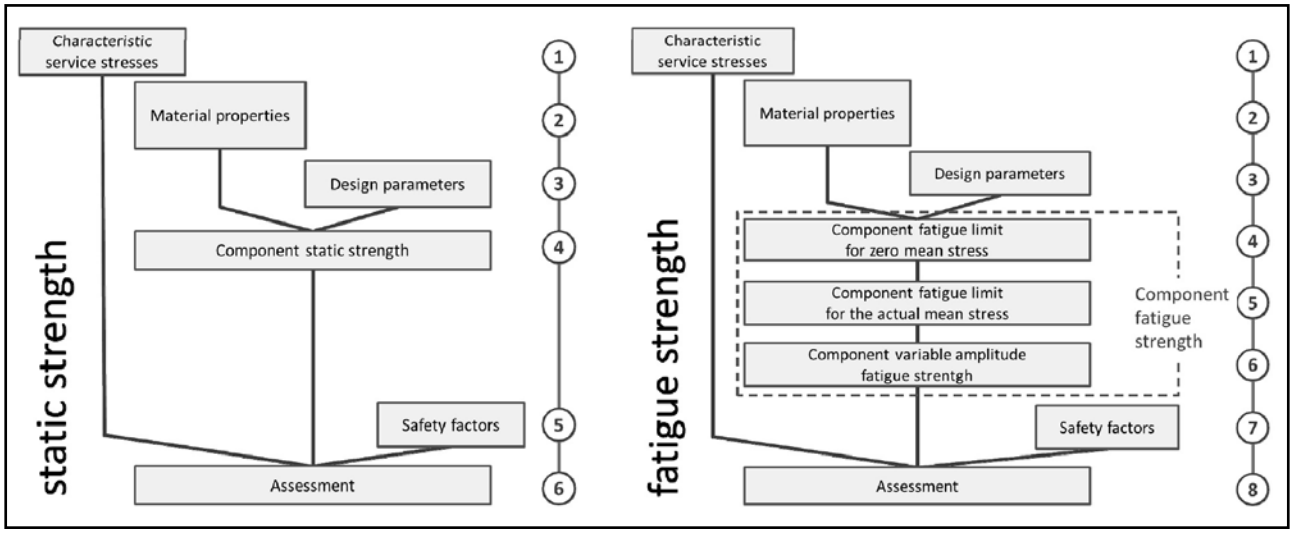


Figure 9 Calculation process for static strength and fatigue strengths (Ref. 4).

Both values are based on the determination of a degree of utilization. The utilization is determined by comparing the stress limit σ_{AK} with the working stress. The bearable stress σ_{AK} is evaluated on the basis of the tensile strength, the geometrical parameters and the material properties. The local stresses were determined from the finite element analysis, and the material properties were investigated through laboratory tests.

Determining parameters for bronze. The challenge was to determine the constants a_G and b_G to calculate the notch sensitivity n_σ and defining the constants a_M and b_M to identify the factor for the mean stress M_σ, which depends on the material. In addition, contributory factors that were required for the calculation were obtained. The tests shown in Figure 10 were performed to obtain these factors.

To determine the notch sensitivity n_σ in Equation 1 for $0.1 < G_\sigma < 1$, the stress gradient G_σ and the two factors a_G and b_G for bronze were required.

$$n_\sigma = 1 + \sqrt[4]{G_\sigma \cdot \text{mm}} \cdot 10^{-\left(a_G + \frac{R_m}{b_G \cdot \text{MPa}}\right)} \quad (1)$$

The FKM guideline provides an equation to calculate the gradient G_σ, which is shown in Equation 2. The two required local stresses, the one at the surface of the tooth root $\sigma_{1,2}$ and the other at the next node under the surface in the vertical direction $\sigma_{1,2\_\Delta s}$, can be computed in the FEA. The distance Δs between the two points was measured (Fig. 11).

$$G_\sigma = \frac{1}{\Delta s} \cdot \left(1 - \frac{\sigma_{1,2\_\Delta s}}{\sigma_{1,2}}\right) \quad (2)$$

To calculate a_G and b_G, the notch factor K_f was identified for a notch that was similar to the rounding of the tooth root used in four-point bending tests (Ref. 3) with a notched specimen. The form factor K_t was determined using the FKM guideline according to Reference 4. With these two factors the notch sensitivity n_σ can be calculated from the test results using Equation 3.

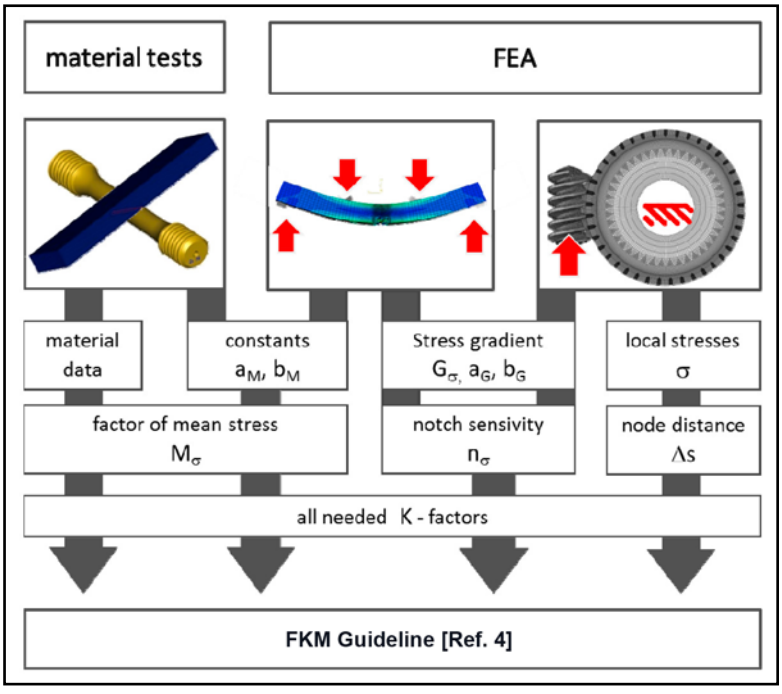


Figure 10 Adaption and validation of the FKM guideline.

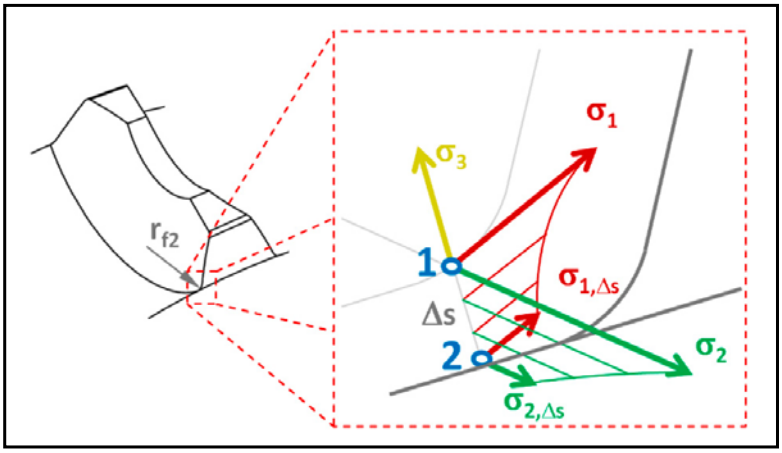


Figure 11 Locations of the principal stresses in the tooth root.

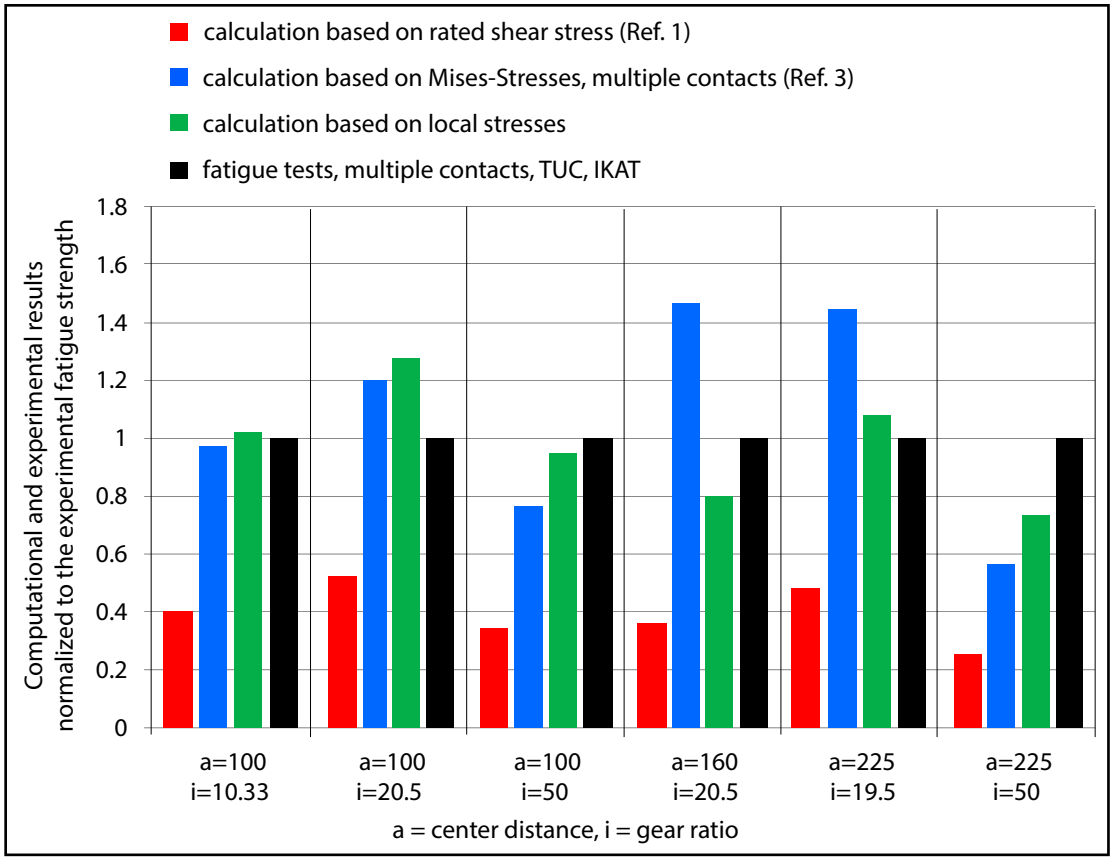


Figure 12 Comparison of calculated force based on local stresses (green) and measured force (black) normalized to fatigue strength.

The notch factor K_f can be calculated from the form factor K_t and the notch sensitivity n_σ:

$$K_f = \frac{K_t}{n_\sigma} \tag{3}$$

Given n_σ, the values of a_G and b_G can be determined. These two parameters, which are given in Table 1, are valid for the alloy CuSn12Ni.

Table 1 Parameters a_G and b_G

a_G	see [Ref. 3]
b_G	see [Ref. 3]

The next factor to consider is the mean stress, M_σ, which describes the dependency between the mean stress and the stress amplitude and depends on the material. To determine M_σ as in Equation 4, the material constants a_M and b_M were required.

$$M_\sigma = a_M \cdot 0.001 \cdot \frac{R_m}{\text{MPa}} + b_M \tag{4}$$

Both constants were reversely specified using the mean stress factor $K_{AK\sigma}$ (Eq. 5). It is possible to calculate this factor from the fatigue bending strength σ_{AK} obtained from the bending tests and the alternating bending strength σ_{WK} (Ref. 5). The values for the bronze alloy CuSn12Ni were determined to be $\sigma_{AK} = 280$ MPa and $\sigma_{WK} = 140$ MPa. The factor for residual stresses $K_{E\sigma}$ was set to 1 in accordance with the FKM guideline.

$$K_{AK\sigma} = \frac{\sigma_{AK}}{\sigma_{WK} \cdot K_{E\sigma}} \tag{5}$$

With the value of $K_{AK\sigma}$ and Equation 6, M_σ could be specified iteratively. The mean stress σ_m and the stress amplitude σ_a were obtained from the four-point bending tests, whereas σ_a was determined from the stresses obtained from the FEA and Equation 7. In knowing M_σ, the parameters a_M and b_M for the bronze alloy tested could be identified (Table 2).

Table 2 Mean stress coefficients a_M and b_M for bronze

a_M	see [Ref. 3]
b_M	see [Ref. 3]

$$K_{AK\sigma} = \frac{\frac{1 + M_\sigma/3}{1 + M_\sigma}}{1 + \frac{M_\sigma}{3} \cdot \frac{\sigma_m}{\sigma_a}} \tag{6}$$

$$\sigma_a = \frac{1}{2} \cdot \sigma_{1,2FEA} \tag{7}$$

Because the tension-compression fatigue stress σ_{Wzd} was unknown, Equation 8 was invoked using the tensile strength R_m and the tension-compression fatigue stress factor $f_{W\sigma}$, for which guidelines recommend a value of 0.3.

$$\sigma_{Wzd} = f_{W\sigma} \cdot R_m \tag{8}$$

All other required factors, including the K factors, were determined according to the guideline. The factor $K_{NL,E}$, which describes the non-linear, elastic range of the stress-strain behavior and depends on the material, was determined (Ref. 3) for the bronze alloy used. The roughness factor R_z was measured to determine the coefficient $K_{R\sigma}$.

The factor for the edge layer K_V and the factor K_S, which include the influence of a protective layer, were set to 1.0. With all these factors, the parameter $K_{WK\sigma}$ is calculated as:

$$K_{WK\sigma}=\frac{1}{n_\sigma}\cdot\left(\left(1+\frac{1}{K_f}\cdot\left(\frac{1}{K_{R\sigma}}-1\right)\right)\cdot\frac{1}{K_V\cdot K_S\cdot K_{NL,E}}\right) \quad (9)$$

Validation of results. Figure 12 shows the comparison between the fatigue strength determined from the fatigue tests and the calculated strength based on the various prediction methods. The investigated force limits were normalized to the experimental values. The solid black columns show the fatigue force, which was determined from fatigue tests on actual components. This was the reference by which the results of the various methods were evaluated.

The columns with the checkerboard pattern show the fatigue force calculated on the basis of the rated shear stress. These forces are much lower than the forces from the tests, so this method underestimates the actual strength. The striped columns show the fatigue force calculated based on the von Mises stress. The results from this method are closer to those from the fatigue tests, but the strength is overestimated in certain cases. This problem can be solved by introducing a factor based on the geometry of the worm wheel teeth. At this point, no factor was included to adjust the calculated results to match the fatigue tests.

The dotted columns show the forces from the method based on local stresses. In comparison with the fatigue forces from the tests, this method shows the best results of the three computational methods. These results show the importance of computing the root strength of the worm wheel teeth. In addition, the usefulness of the FKM guideline for bronze materials was shown.

Summary and Outlook

To choose the appropriate worm gearing for a specific application, the strength of the root of the worm wheel tooth is important, especially in cases with low speed and high torque. This paper compared the results of the calculation of worm wheel stresses based on local stresses as well as on nominal stresses. It was demonstrated that the analytical method is not very precise due to the specific geometry of the worm wheel. It was then shown that a method based on local stresses fits well with the test results. This method was developed by adapting the FKM guideline for the material properties of bronze.

A further improvement is possible as an improvement of the FEA model; to include the operational stability, the amount of damage D should be taken into account (Ref. 6).

This will be the subject of future research.

(*The authors gratefully acknowledge the financial support of the AiF [German Federation of Industrial Research Associations] and the FVA [Research Association for Drive Technology]*).

References

1. DIN 3996 08-05. Tragfähigkeitsberechnung von Zylinderschneckengetrieben mit sich rechtwinklig kreuzenden Achsen, 2005.
2. Reißmann, J. and E. Leidich. Tooth Strength of Worm Wheels Based on Fatigue Damage Hypothesis, VDI International Conference on Gears, Munich, 2010.
3. Reißmann, J. and E. Leidich. Optimierung der Zahnfuß-Tragfähigkeit von Schneckenrädern, AiF-Forschungsvorhaben BR15433, FVA Abschlussbericht Heft 1008, 2012.
4. FKM Guideline. Analytical Strength Assessment of Components in Mechanical Engineering, VDMA-Verlag, 5th Edition, 2003.
5. Guss aus Kupfer und Kupferlegierungen. Technische Richtlinien, GDM, VDG, DKI, Düsseldorf, 1997.
6. Thiele, R. and E. Leidich. Zahnfuß-Tragfähigkeitsberechnung für Schneckenräder auf Basis des Zahnfußschädigungskonzeptes. FVA-Forschungsvorhaben 375/I+II, Heft 784, 2006.

Prof. Dr.-Ing. Erhard Leidich has since 1993 served as full professor and chair of IKAT (Institute of Design and Drive Technology) at the Technical University of Chemnitz. His main field of research is shaft-hub connections; his additional fields of research include friction, fretting fatigue, bearings and strength of machine elements in general. For more than 15 years Leidich has led the investigation of the strength of tooth roots of worm gears.

Dr.-Ing. Jan Reissmann is a staff member of IKAT (Institute of Design and Drive Technology) at the Technical University of Chemnitz. He recently completed his doctoral studies and was awarded a Ph.D. for his thesis "Contribution to the Development of Improved Calculation Method for the Tooth Root Strength of Worm Gears." Reissmann's primary field of research is the strength of worm gears.

Influence of Topography Deviations on the Psychoacoustic Evaluation of Ground Bevel Gears

Dipl.-Ing. Peter Knecht, Dr.-Ing. Dipl.-Wirt.-Ing. Christoph Löpenhaus, Prof. Dr.-Ing. Christian Brecher

In the design process of transmissions, one major criterion is the resulting noise emission of the powertrain due to gear excitation. Within the past years, much investigation has shown that the noise emission can be attributed to quasi-static transmission error. Therefore, the transmission error can be used for a tooth contact analysis in the design process, as well as a characteristic value for quality assurance by experimental inspections.

The noise behavior of bevel gears can be subdivided in accordance to the two main manufacturing chains — face hobbing and lapping — in comparison to face milling and grinding. Apart from the different lead function of both bevel gear types, their acoustic behavior also differs. While the frequency spectrum of the ground gear set shows, in general, low background noise levels with pronounced gear mesh amplitude and their higher harmonics, the noise spectrum of a lapped gear set looks the opposite. The background noise level is higher and the tooth mesh amplitude is less dominant, as well as the higher harmonics.

The difference can be explained by the resulting microgeometry deviation after the hard-fine machining. The grinding process has high reproducibility and high pitch accuracy. Furthermore, the closed-loop manufacturing allows narrow deviation fields. In contrast, the lapping process is subject to higher geometry fluctuations due to a lower material removal rate and, therefore, the strong dependency of the geometry after heat treatment.

The difference in the transmission error frequency distribution has a huge impact on dynamic noise behavior. Apart from the evaluation of the differential acceleration as a counterpart to the quasi-static transmission error, the consideration of weightings regarding human noise perception is common in other acoustic disciplines. Therefore, it is the aim to evaluate in the impact of an individual topography deviation on the dynamic noise behavior. In the first step, the tooth contact analysis *ZaKo3D* is evaluated comparing the measured and simulated loaded transmission error. Afterwards, a microgeometry scatter is applied on a ground gear set and the impact on the transmission error is shown. As observed for lapped bevel gear set, the background noise increases and the gear mesh amplitudes decrease. Finally, in a simulation study two variants are compared regarding the difference in psychoacoustic parameters as loudness, sharpness, roughness and tonality.

Introduction

A major criterion in the quality assessment of bevel gears is the noise behavior in the application. In the gear design, the noise behavior is addressed via the Ease-Off design that represents a compromise between a low transmission error level and a sufficient load-carrying capacity. Numerous past investigations proved that quasi-static transmission error is the appropriate evaluation parameter when it comes to noise behavior. The transmission error is the excitation source of the dynamic system (Fig. 1). Therefore, in the design process of noise-critical applications, optimization requires a low transmission error fluctuation or low amplitudes for the transmission error frequency and higher harmonics. The final Ease-Off geometry for an optimal performance over the load range poses a challenge in the bevel gear design. Dynamic influences and hearing-related noise evaluations are not considered, to date. Furthermore, micro deviations, e.g. — for a lapped gear set, or long-wave deviations as pitch or run-out deviations — lead to significant differences compared to nominal transmission error (Refs. 7, 9 and 15).

Noise behavior of bevel gears. Unique to bevel gears when compared with spur or helical gears is that the noise behavior is already influenced by the soft-machining process and the following process. The process chain for the discontinuous face milling processes results in a circular arc as lead function for the teeth. In this way heat treatment distortions can be eliminated in the grinding process. The ground gear set shows in general a high reproducibility of the nominal topography, with low pitch errors. Bevel gears manufactured in the continuous hobbing process provide an epicycloidal lead function and are lapped for the reduction of heat treatment distortions. The material removal rate in the lapping process is lower compared to grinding and, therefore, lapped gear sets are strongly influenced by the quality of the soft-cut gear geometry. In general, the topography deviation and the pitch deviations are higher for lapped gears (Refs. 15 and 19).

In Figure 2 the structure-borne spectra for a lapped and ground gear set is shown (Ref. 18). The process-related differences in the topography and the pitch error characteristic after the hard finishing lead to a tendency of higher tonality for ground gears, with pronounced noise shares by the tooth mesh frequency and their higher harmonics, and a low background noise level. The noise spectrum of a lapped gear set, in contrast, shows a lower tonality and higher background noise level. The differences in the noise spectra of the lapped and ground gear

This paper was initially presented at the 6th WZL Gear Conference in the USA, Ann Arbor, MI, June 2016. Reprinted with permission.

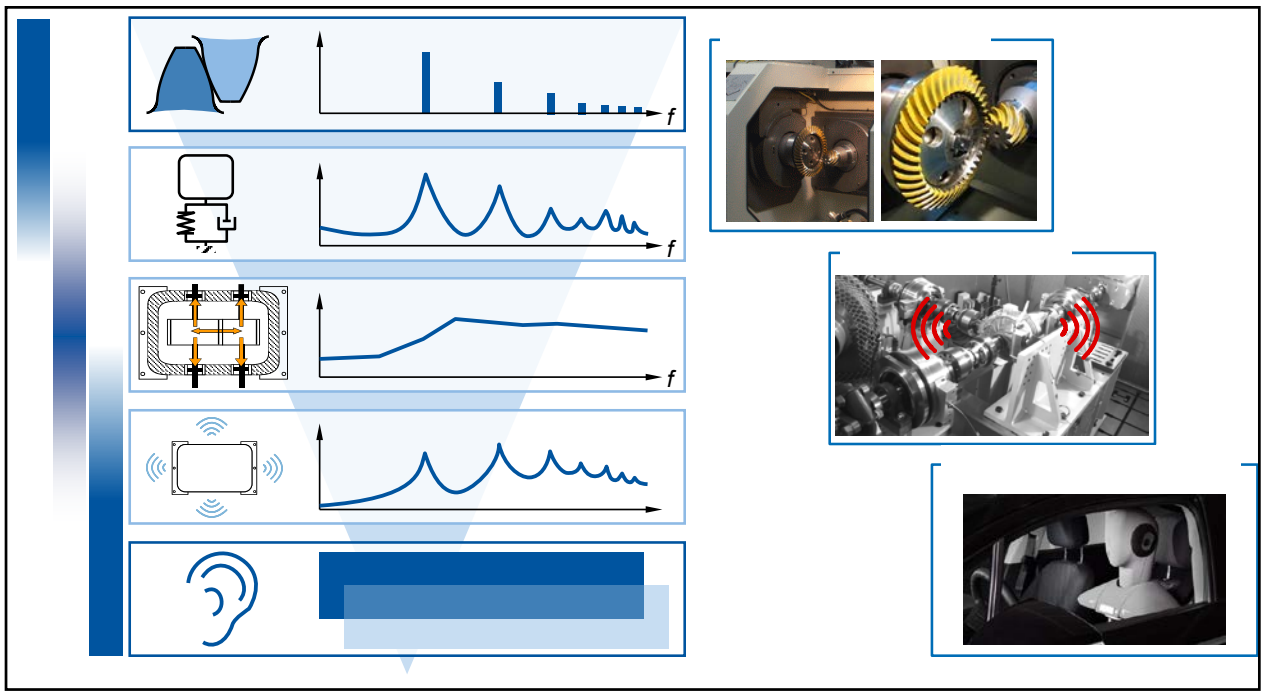


Figure 1 Source-path-receiver concept of bevel gear transmissions.

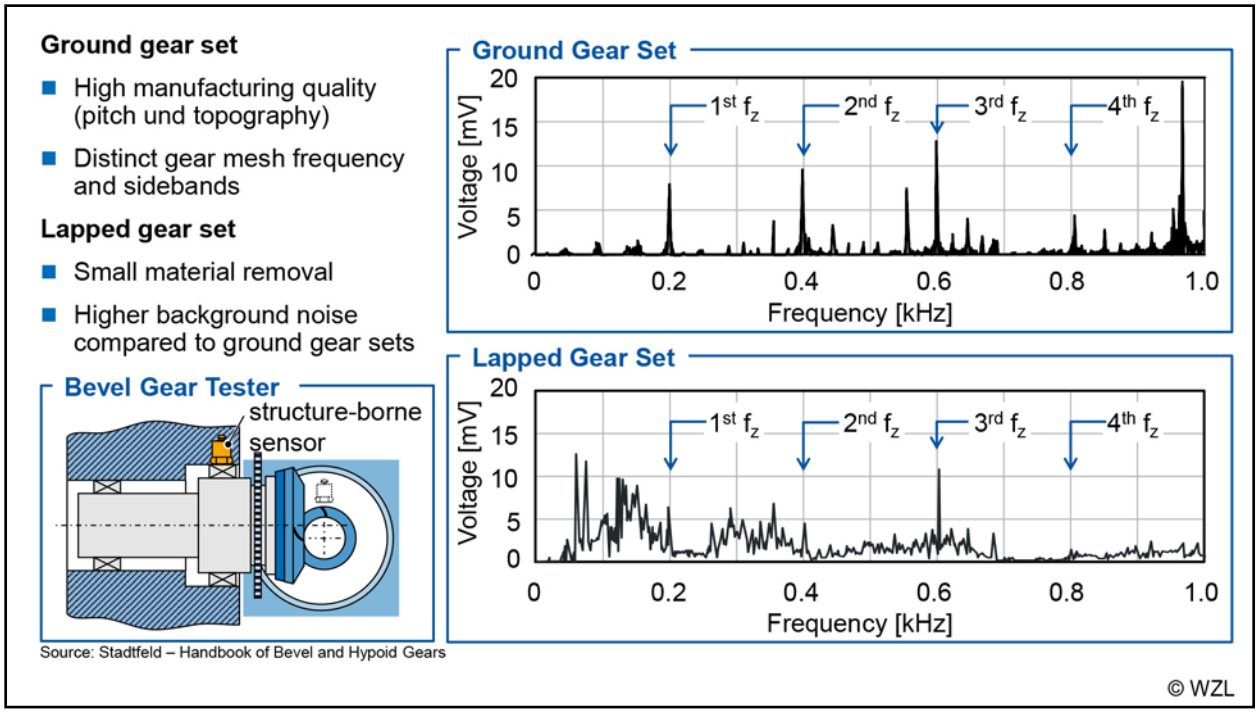


Figure 2 Structure-borne noise spectra of ground and lapped bevel gears.

set leads to the fact that lapped gear set are perceived to be quieter or more pleasant (Refs. 3, 16, and 18).

Aim. The aim of the report is the investigation of the influence of the topography deviations of ground bevel gears on noise behavior; therefore, three gear set variants are analyzed here. Quasi-static transmission error analysis and dynamic simulation in accordance to Gacka are performed (Refs. 4 and12). The simulated, differential rotary acceleration is evaluated by means of psychoacoustic parameters.

The gear set macro geometry originates from an automobile application. The reference gear set is ground with high pitch quality and low topography deviations. The other two ground variants are developed in similarity to lapped gear set characteristics. They provide a low, individual deviation from tooth to tooth and high pitch quality as well. By reproduction of the topography deviation from tooth to tooth it is targeted to imitate the low tonality of the lapped gear set.

The gear set variants are simulated with the FE-based tooth contact analysis (TCA) *ZaKo3D*. Therefore, it is the first subordinate target in the validation of the FE-based TCA under load for bevel gears. Loaded transmission error measurements are performed with a new bevel gear fixture and compared to sim-

ulations in *ZaKo3D*. In the following a procedure is shown to imitate the topography deviations of a lapped gear set by means of overlaying a small microgeometry deviation from tooth to tooth. In connection with the manufacturing of the gear set variants, single flank tests are performed. The load-free results are validated via simulations considering the topographies of all teeth. Finally, the dynamic behavior of the gear set is simulated and the results are evaluated considering human hearing with psychoacoustic metrics.

Measurement and Simulation of the Loaded Transmission Error

The transmission error is a central design parameter for the optimization of the acoustic excitation behavior. For the development of software programs for gear design, a validation of test rig results in comparison to simulations is essential. In (Ref. 5) a bevel gear fixture for the investigation of the acoustic behavior is presented. In the following, results of loaded transmission error (LTE) measurements and loaded contact pattern are shown. Finally, the test rig results are simulated with *ZaKo3D*.

Commissioning of bevel gear fixture. In past years a significant number of gear set fixtures were developed. Plewnia developed a bevel gear fixture for the investigation of the excitation behavior of bevel and hypoid gears (Ref. 17). The test fixture consists of two bearing blocks for the pinion and ring gear shaft that can be positioned via rail guidance on the base plate. In order to acquire the gear mesh excitation close to the tooth contact, the measurement systems for the measurement of the transmission error and the rotary acceleration are integrated in these bearing blocks. The hypoid offset is realized by ground adapter plates below the bearing block of the pinion. Reproducibility of the positioning of the gear set via bearing blocks was a disadvantage for the narrow tolerances of automotive applications. Hohle used the same test concept for a test fixture for spur and helical gears. Due to the smaller sensitivity of the involute for spur and helical gears, the disadvantage regarding the positioning is not given for this application.

Carl analyzes the noise behavior of spur and helical gears. The test set-up is developed as a frame base structure with bolted front plates with integrated bearing seats. The frame structure provides good accessibility for contact patterns and a close connection of the measurement systems. In order to measure the dynamic excitation, rotary accelerometers with a telemetric system were developed that provide a compact design (Ref. 7).

Figure 3 shows the constructional design of the bevel gear fixture for the investigation of the noise characteristic of bevel and hypoid gears derived from the results of (Refs. 6, 7 and 17). As well, a frame structure instead of separated bearing blocks is realized. In this way the gear set can be positioned by housing elements. The pinion and ring gear installation position are adjusted by paired ground shim plates (Fig. 3-1, 2). The hypoid offset and the crossing angle are given by the pinion front plate (Fig. 3-3). In order to avoid influences from the differential gear set, the differential and differential basket are substituted by the ring gear shaft. The measurement of the transmission error is realized by angle encoders. The dynamic rotary excitation is measured by the measurement systems from (Refs. 5 and 7).

The commissioning of the gear fixture is performed with a hypoid axle with a ratio of $z_1/z_2 = 11/46$ and a hypoid offset of 35 mm. The test fixture is tested on the universal gear test rig II at WZL and flanged on the machines via CV shafts. One criterion of the commissioning tests is the reproducibility of the transmission error measurements. A measurement cycle consists of constant torque levels at 60 rpm from 25 to 1,200 Nm in drive mode, and from 25 to 600 Nm in coast mode. The measurement cycles are repeated three times, measuring always a complete tooth hunt. The ground gear set shows relevant amplitudes of excitation for the first four gear mesh orders. In Figure 4 the minimum, average and maximum graphs over load for the amplitudes of the first four gear mesh orders are depicted.

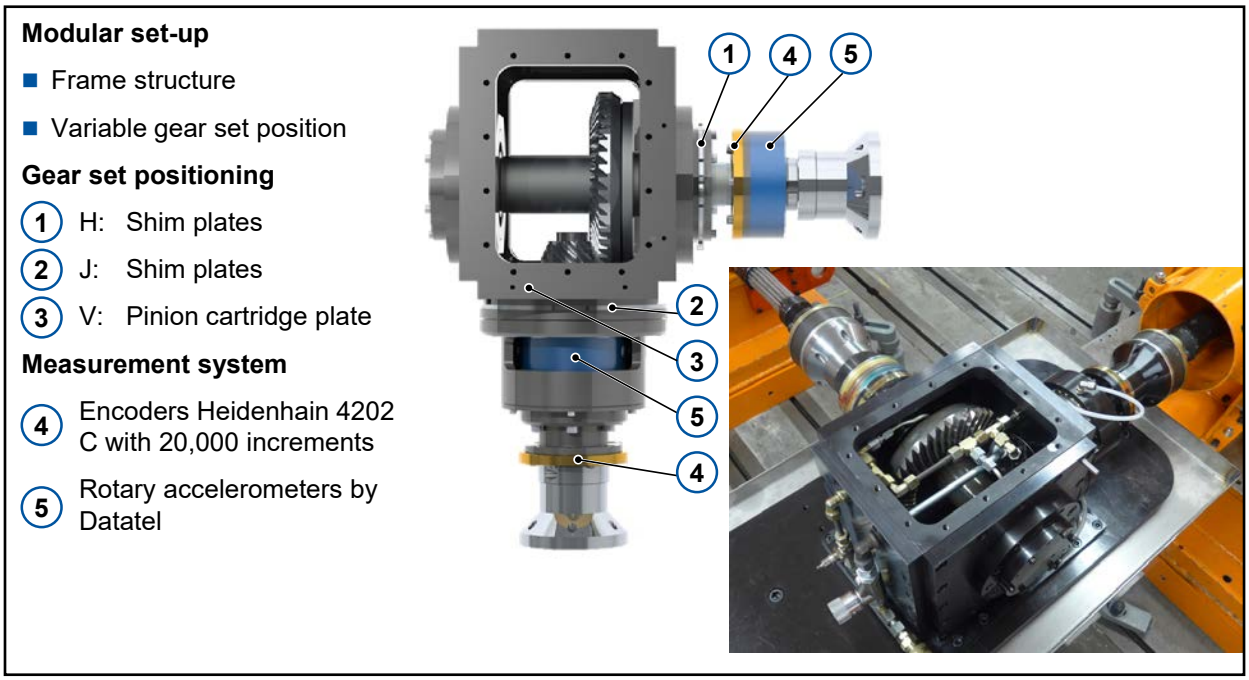


Figure 3 Bevel gear fixture for investigation of excitation behavior of hypoid gears.

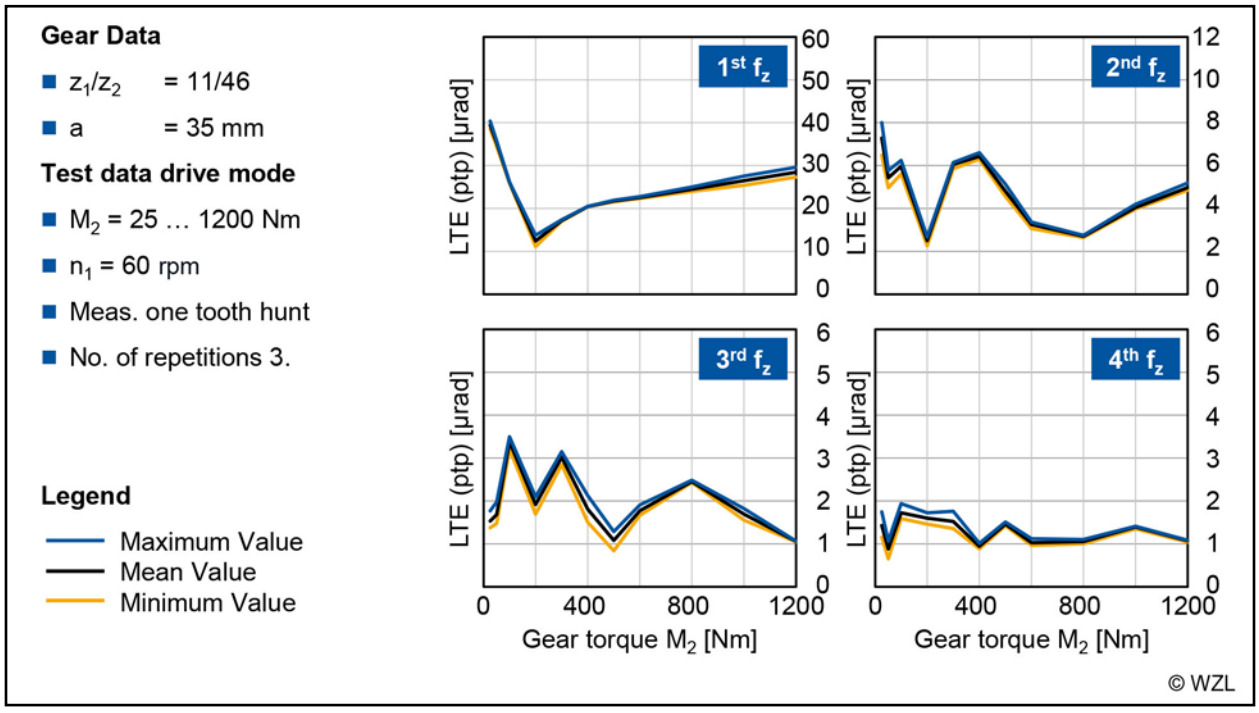


Figure 4 Repeatability of measured loaded transmission error (LTE) graphs.

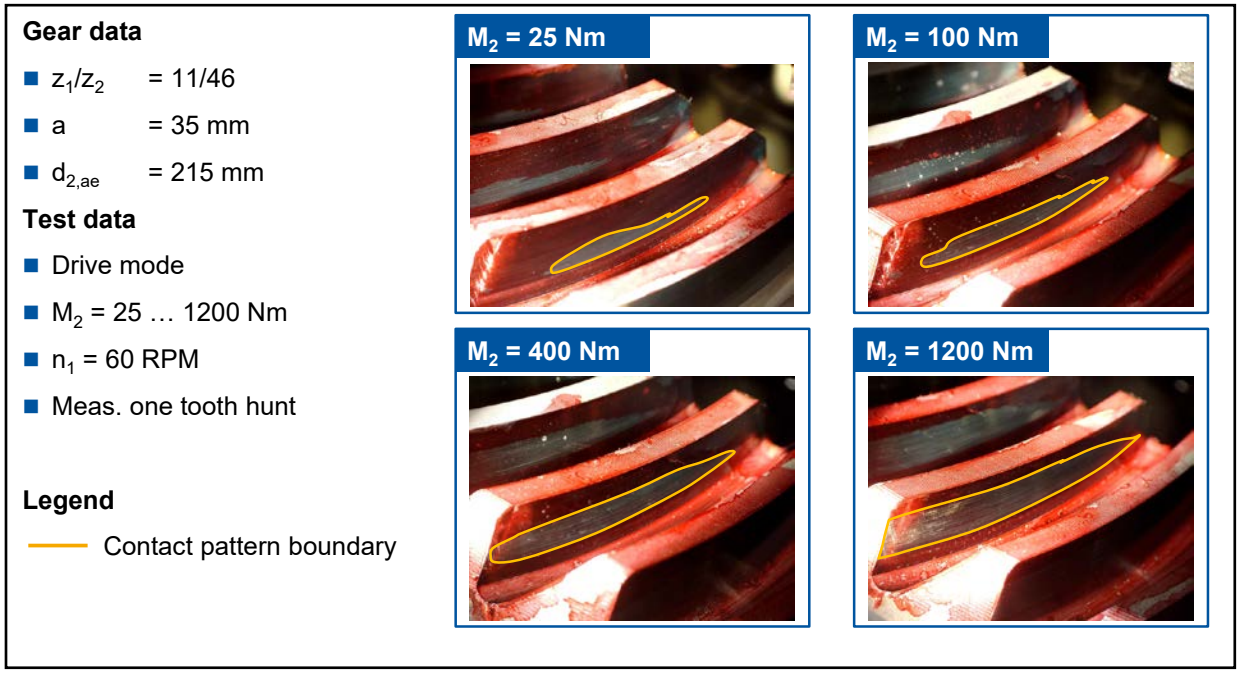


Figure 5 Measured contact pattern for various load levels.

Qualitatively, the graphs of the orders show a high reproducibility. The local extrema are repeatedly measured for the considered gear mesh orders. The maximum deviations of the first and second gear mesh amplitude are smaller than 2.7 µrad; the maximum differences for the third and fourth gear mesh amplitude are below 0.7 µrad. The measured differences in the test rig investigations are attributed to the temperature behavior of the test fixture, which influences the bearing stiffness and therewith the displacement behavior of the gear set.

Comparison of measured and simulated loaded transmission error. The measured transmission error graphs are simulated in the FE-based tooth contact analysis *ZaKo3D*. For characterization of the installation position of the gear set, the contact pattern for different load levels is considered. Furthermore, the contact pattern enlargement — as well as the contact pattern displacement — is considered for the load-caused displacement. The contact pattern from the test rig is depicted in Figure 5. The quasi-load-free contact pattern at 25 Nm shows a centered contact area in lead direction with a tendency to the tooth root area. With increasing load the contact area increases and reaches the heel of the flank at a gear torque of 400 Nm. At maximum torque of 1,200 Nm the contact pattern is enlarged over the edge at the heel. The position is especially unfavorable for high torques; nevertheless, the commissioning tests enable conclu-

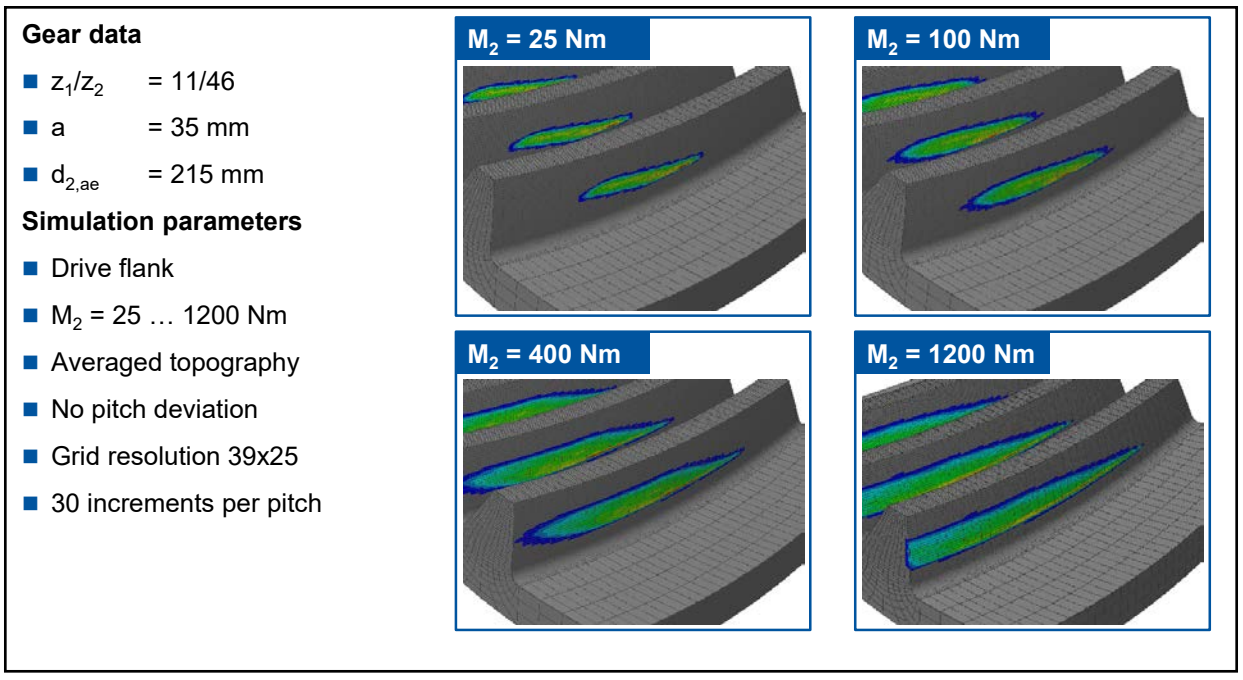


Figure 6 Simulated contact pattern for various load levels.

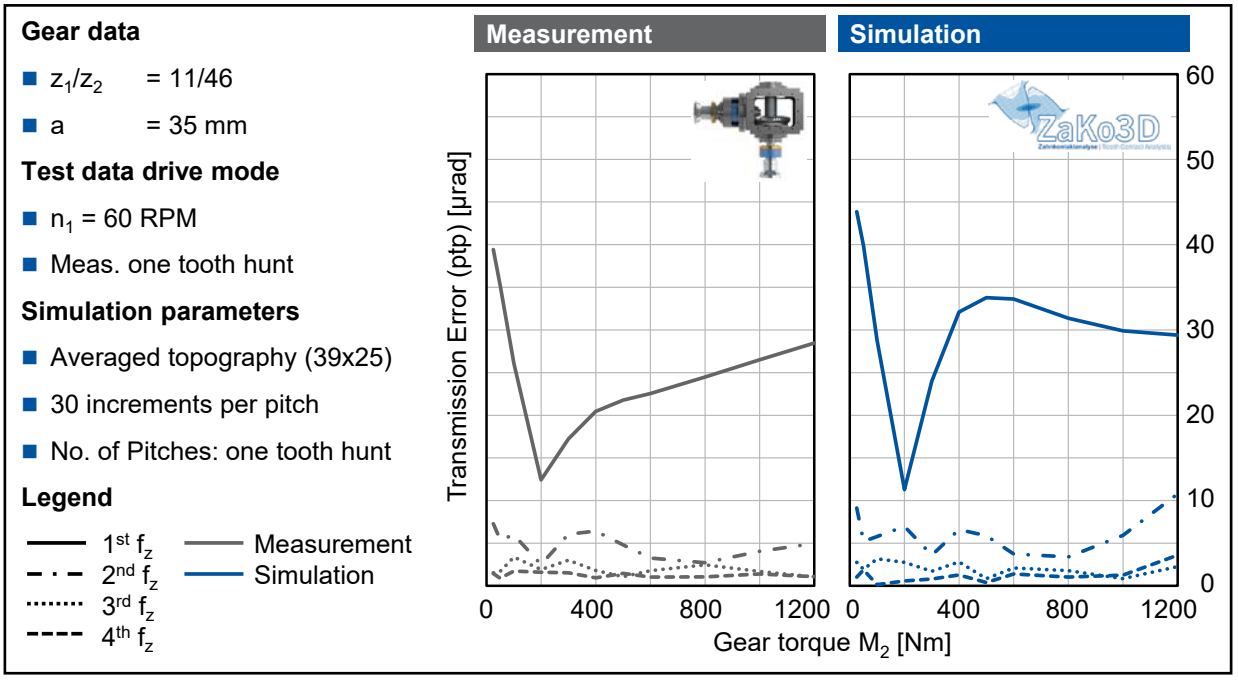


Figure 7 Comparison of measured and simulated transmission error in drive mode.

sions about the simulation capability of *ZaKo3D*.

Following is the contact pattern from the tests imitated in the simulations in *ZaKo3D*. Input data of the tooth contact analysis are the averaged topographies from four teeth of pinion and gear. In Figure 6 the simulated contact pattern is depicted. In general, the simulated contact pattern position in lead and profile direction on the flank show good agreement with the tests. The color scale of the pressure distribution allows identification of the center of the contact pattern — located in the root area. At 400 Nm the contact pattern also reaches the edge of the flank at the heel. At 1,200 Nm it is prolonged clearly over the edge. In toe direction the contact pattern is tapered to the root but, in comparison to the test rig, the distance is too great.

Furthermore, the contact pattern in profile direction at higher loads shows a smaller width in the simulation compared to the tests, meaning that the distance of the contact pattern edge to the tip of the flank at maximum torque is bigger. The difference between measurement and simulation can be explained by the fact that only the averaged topography of the simulation is considered. Furthermore, as the documented contact pattern from the measurement is an accumulation of various pitches, the simulated contact pattern in this case should always be of a smaller extent. But the deviation in profile direction could also be caused by a lower crowning compared to the flank used for the simulation.

After comparison of the gear set position the graphs of the

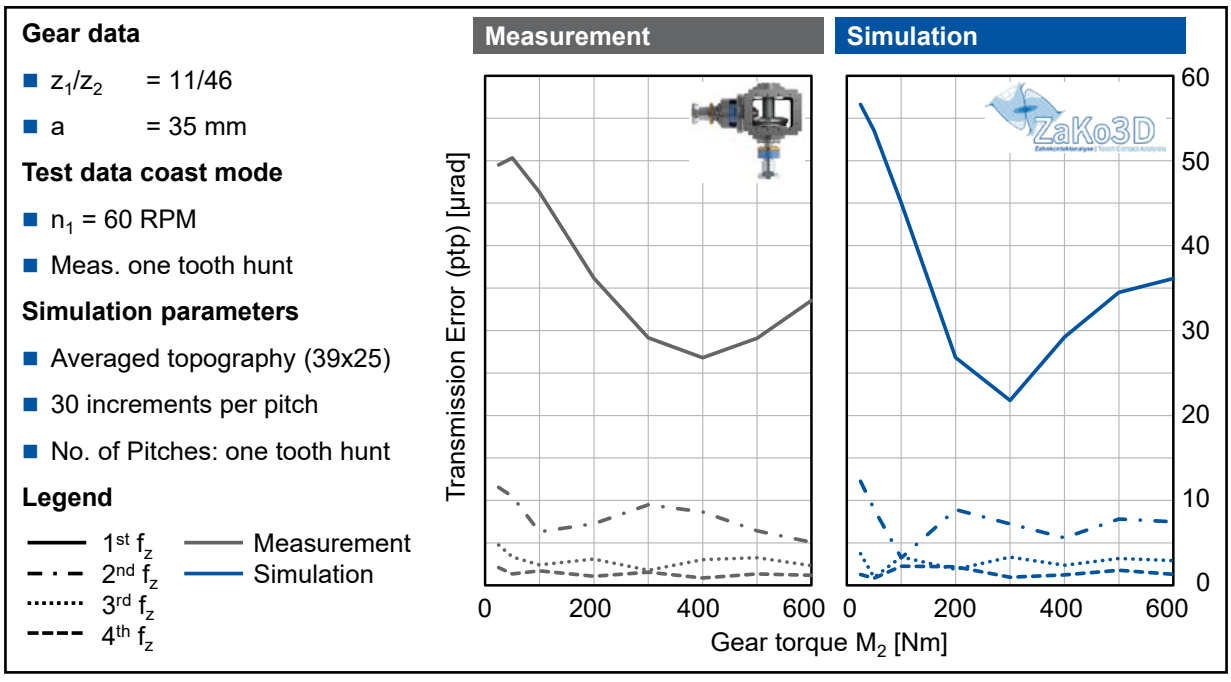


Figure 8 Comparison of measured and simulated transmission error in coast mode.

first four gear mesh orders for drive mode (Fig. 7) and coast mode (Fig. 8) are presented. For the drive flank the amplitude drops from 40-45 µrad at 25 Nm to a minimum of approx. 13 µrad. This characteristic is shown in the simulation and in the measurement. For higher torques the amplitudes rise higher in the simulation. While the simulation shows a local maximum at 500 Nm of 34 µrad with a following digressive drop to 30 µrad at 1,200 Nm, the amplitude in the measurement increases nonstop up to 28.5 µrad. The difference in the transmission error amplitudes is in agreement with the difference in the simulated contact pattern size. The higher contact pattern size of the measurement leads to a higher contact ratio and, therefore, lower transmission error.

The change of the simulated transmission error amplitude for the second to the fourth gear mesh order shows qualitatively and quantitatively a good agreement to the measurement. Especially for the measured and simulated second gear mesh order local minima at the torque levels of 50, 200 and 800 Nm are shown.

The comparison of the first four gear mesh amplitudes for torque levels up to 600 Nm in coast mode is depicted (Fig. 8). The change of amplitude over torque shows a minimum at a medium torque in the simulation and measurement. In the measurement the transmission error drops digressively from 50 to 27 µrad at 400 Nm, and rises afterwards up to approx. 33 µrad. In the tooth contact analysis, the transmission error starts at 56 µrad and falls down to 22 µrad at 300 Nm, and rises to 36 µrad at 600 Nm. The gradation matches qualitatively for the higher harmonics.

The differences in the validation results for the gear set are explained with effects of the topography of all teeth and pitch deviations. In spite of a grinding finishing process, slight deviations in the topography and pitch quality are given that might impact transmission error. Also, the gear set position was not determined via CMM measurements and, therefore, no correction to the nominal position with a better contact pattern was done. In future investigations, the installation position needs to be measured and the load-caused deflections for various bearing preloads for the torque range must be determined.

Summarizing the validation of the FE-based tooth contact analysis *ZaKo3D*, it can be stated that the simulation provides high agreement with the measurement with the new bevel gear fixture; the load-caused contact ratio increase is displayed accordingly. The gradation and change of the amplitudes of the higher harmonics of the gear mesh order over torque match qualitatively.

Reduction of Tooth Mesh Amplitudes by Individual Topography

The results of the measured and the simulated transmission error show an excitation of the gear set up to the fourth gear mesh order. This is in accordance to the formulated characteristic of ground bevel gear sets. Landvogt investigates the impact of the hard finishing process of bevel gears on the transmission error. Landvogt concludes that the higher individual deviations of the topography of a lapped gear set may lead to a higher background noise level in the transmission error frequency spectrum. Derived from that fact he stated that a small topography changes from tooth to tooth may lead as well to a transmission error reduction (Ref. 16).

The load-free results of the tooth contact analysis *ZaKo3D* were already validated in (Refs. 2–3). Herein it can be seen that the amplitudes in the frequency spectrum for a lapped and structural lapped gear set are clearly higher compared to the simulation. Only if the topography of all teeth and the pitch error are considered do the amplitudes decrease and match the measurement.

Procedure for the reduction of tooth mesh amplitudes. Figure 9 shows the derived procedure for the reduction of the tooth mesh amplitudes of the transmission error spectrum via

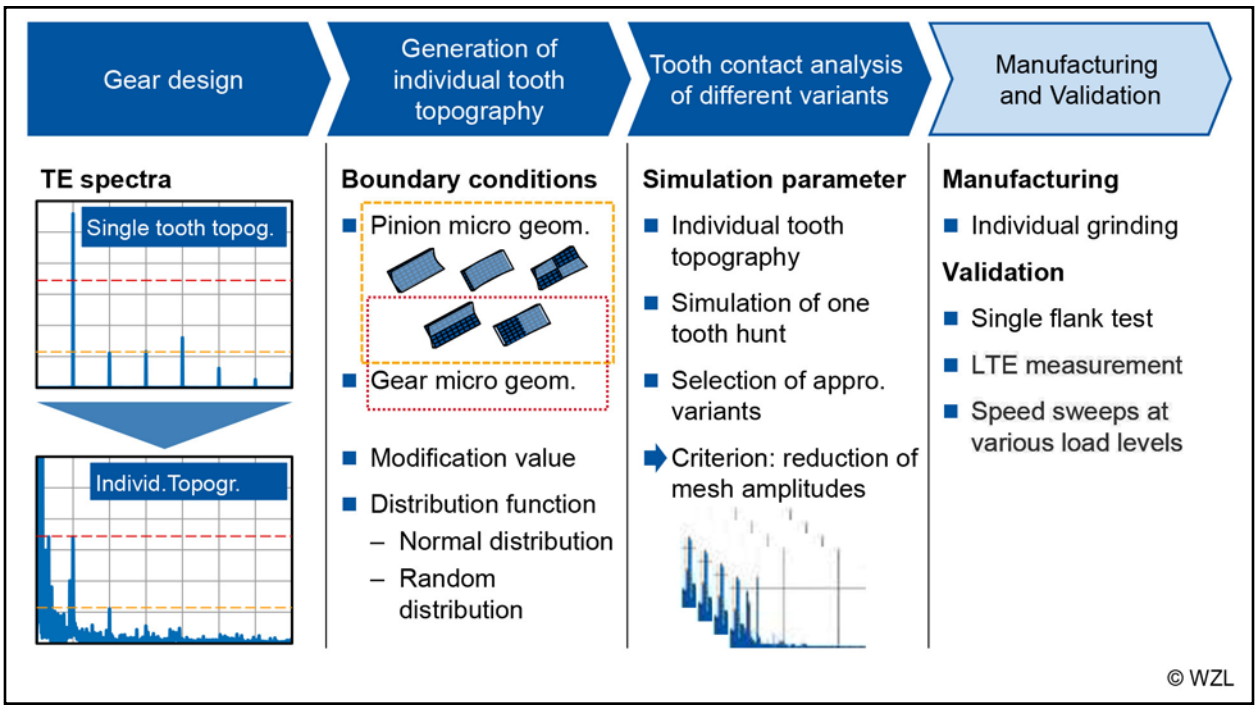


Figure 9 Procedure for reduction of tonality of ground bevel gears via individual tooth topography.

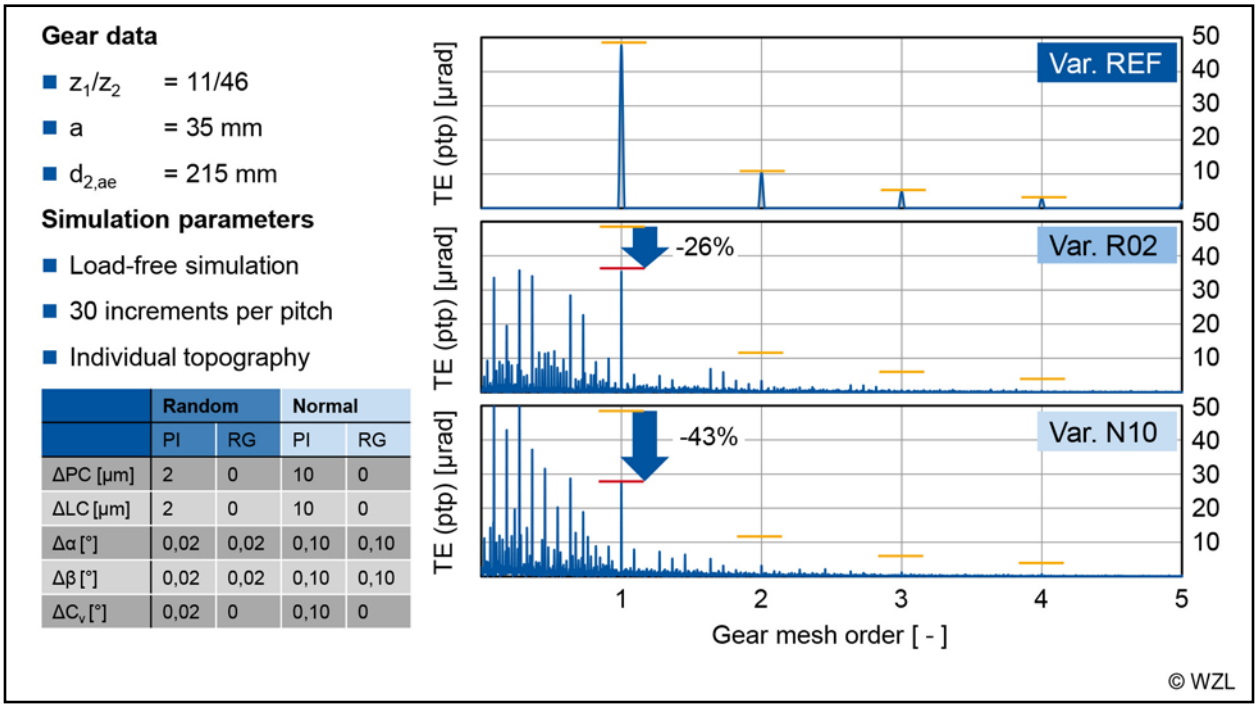
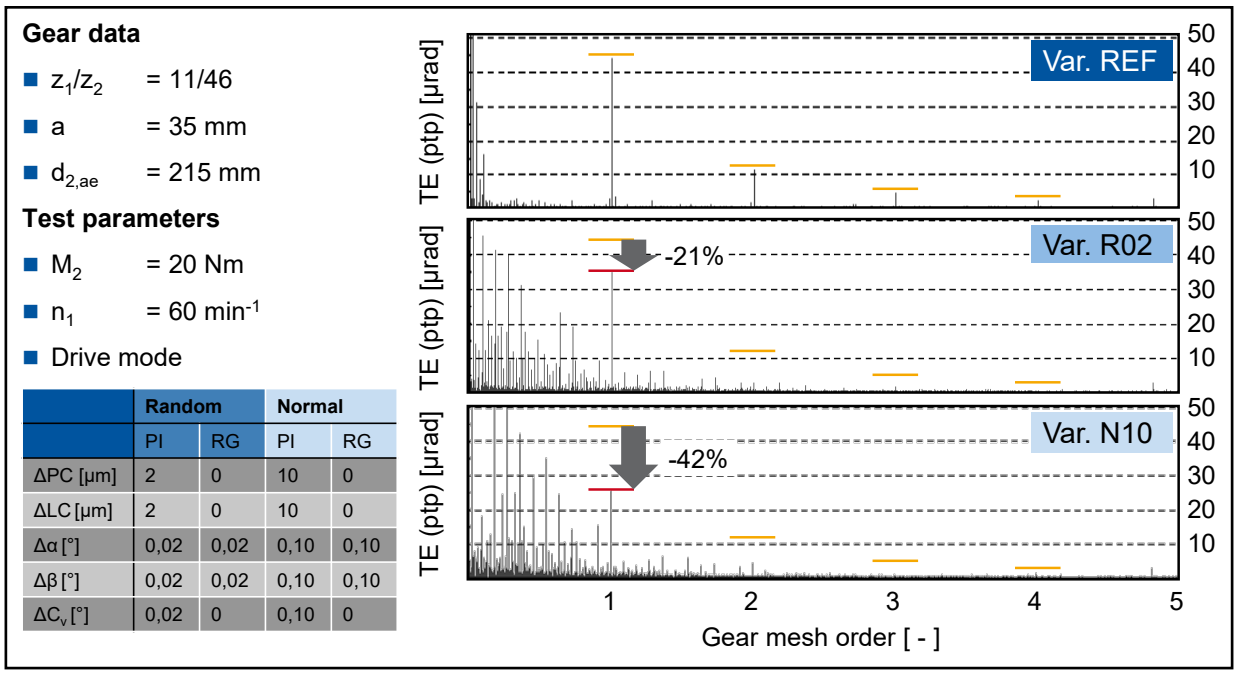


Figure 10 Simulation of transmission error spectra with individual tooth topography.

increase of background noise level. The starting point is the ideal Ease-Off topography of the ground gear set. The simulation of the ideal micro geometry possesses excitation for the gear mesh order and its higher harmonics. Via application of an individual topography deviation from tooth to tooth, the noise spectrum of the ground gear set is approximated to the noise spectrum of a lapped gear set.

The boundary conditions for the design of the individual topography are determined by the grinding process. An additional dressing of the grinding tool during the grinding process needs to be excluded regarding feasibility of the manufacturing process; i.e. all microgeometry changes are realized by the kinematics of the machine tool. For the design of the pinion topography scatter, all modifications are allowed while for the ring gear topography, only spiral and profile angle deviations are permitted. For the investigated gear set the pinion has 11 teeth and the ring gear 46 teeth. Therefore, an additional restriction for the ring gear is defined that means that only 10 different topographies are distributed over the circumference. The topography scatter is varied in terms of the distribution function of the deviations and the deviation absolute value. The absolute values for the crowning deviations are varied in steps of 1 µm and the



	Random		Normal	
	PI	RG	PI	RG
ΔPC [µm]	2	0	10	0
ΔLC [µm]	2	0	10	0
Δα [°]	0,02	0,02	0,10	0,10
Δβ [°]	0,02	0,02	0,10	0,10
ΔC_v [°]	0,02	0	0,10	0

Figure 11 Measurement of transmission error spectra with individual tooth topography.

angle deviations in steps of 0.01°. The considered distributions of the deviations are the normal distribution and the random distribution. Systematic distributions are excluded due to their impact on the sideband characteristic, as it is expected for sinusoidal pitch deviations.

Afterwards, tooth contact analysis for a complete tooth hunt, which means 506 pitches, are performed. In order to limit the calculating time, only load-free simulations are done. The evaluating criteria for selection of the variants manufactured afterwards are reduction of the gear mesh orders of the load-free transmission error.

Finally, the selected variants are manufactured and the procedure is validated via test rig investigations. In the first step of the validation, single flank tests of the gear set are evaluated. In addition, loaded transmission error measurements, as well as speed ramps under loaded conditions, are carried out. The results in the following chapter are limited to the validation of the load-free transmission error spectra.

Simulation and measurement of load-free transmission error. Three variants are chosen for manufacture — the reference variant REF and two variants (R02 and N10) with a topography scatter. The absolute values of the crowning and angle deviations are listed (Fig. 10, bottom left). The variant R02 is characterized by a random distribution of an absolute value of 2 µm, respectively 0.02°. For variant N10 a normal distribution of the topography scatter with absolute values of 10 µm for the crowning and 0.10° for angle deviations is realized. The averaged topography of the variants R02 and N10 is almost equal to the REF variant. The transmission error spectra for the three variants are depicted (Fig. 10, right). Additionally, the amplitude values for the first four gear mesh orders are marked in all three diagrams. Via application of the topography scatter, the amplitude of the first gear mesh order is reduced by 26% for the R02 variant and by 43% for variant N10. But in parallel, the amplitudes of the frequency range up to the first gear mesh order rose. Many of these amplitude peaks are in the range of the first tooth mesh amplitude, and for the variant N10 the amplitudes are even exceeding the first gear mesh amplitude. The amplitudes for the higher harmonics instead are almost eliminated. The characteristic of the transmission error spectra of R02 and N10 are similar to the one shown for the lapped gear set (Fig. 2).

The simulated variants are tested in the following on a bevel gear tester Klingelnberg T50.

For manufacturing, individual topographies are given and translated into corrected machine kinematics. The focus is given to the drive flank of pinion and ring gear. The pitch quality of the pinion is 3 for the single pitch deviation and quality 2 for the cumulated pitch deviation. The achieved quality for the ring gear is quality 3 for both pitch deviations.

Figure 11 shows the transmission error spectra of the measurement of 506 pitches for the various gear set variants. In contrast to the simulated transmission error spectrum of the variant REF, the results from the bevel gear tester provide as well the rotation order and higher harmonics. The higher frequency range is in agreement with the simulation and is only dominated by the gear mesh order and their harmonics.

The measurement of the variants with the topography scatter shows very good correlation for the reduction of the first gear mesh amplitude. The amplitude of the R02 variant is reduced by 21% and for the N10 variant by 42%. Furthermore, the higher harmonics of the gear mesh order are almost eliminated. The characteristic of the increased amplitudes in the frequency range up to the first gear mesh order is also in accordance with the simulation.

Analysis of Dynamic Excitation Behavior and Psychoacoustic Evaluation

The results of the single flank tests are proving that by application of an individual topography scatter from tooth to tooth, it is possible to reduce the amplitudes of the gear mesh order and their higher harmonics. For the chosen variants, the focus is the first gear mesh order of the load-free transmission error.

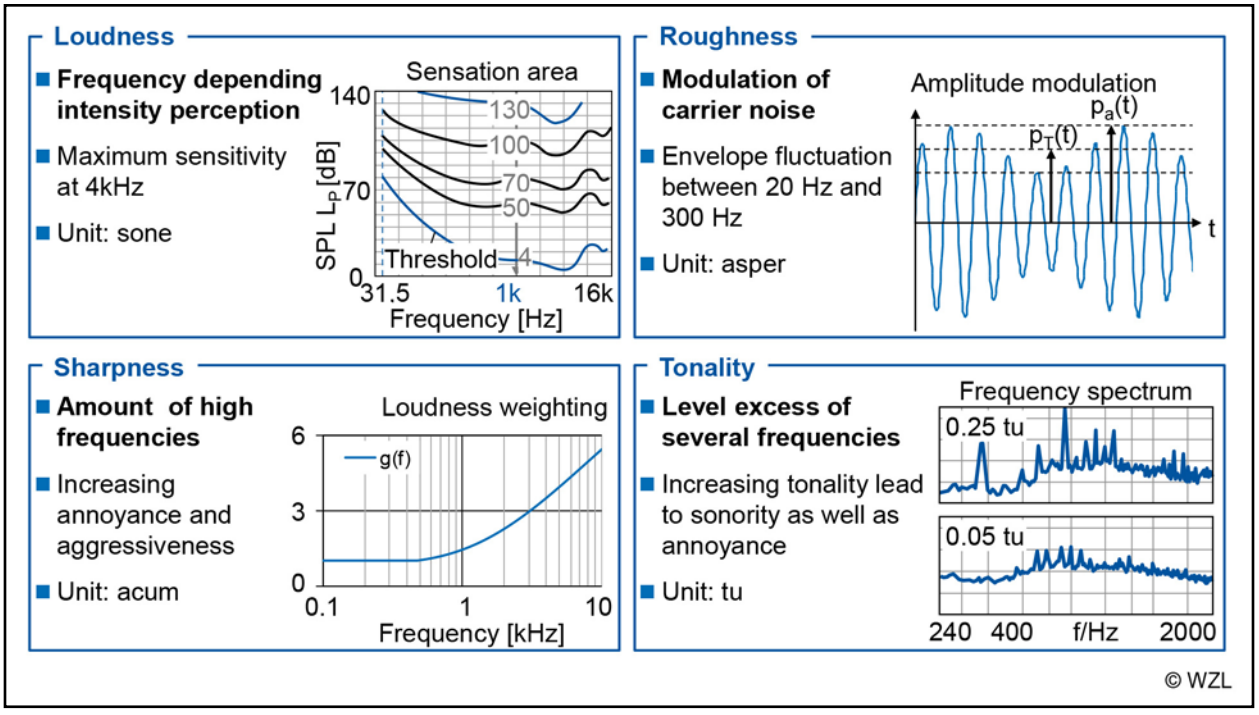


Figure 12 Psychoacoustic parameters.

However, the significant reduction of 20% and 40%, respectively, of the first gear mesh order is offset by an increase in the lower frequency range. Thus the question that must be asked is how the increase in background noise in the lower frequency range impacts the noise impression. Therefore, a dynamic simulation as described (Ref. 4) is performed with a subsequent psychoacoustic evaluation.

Psychoacoustic parameters. The hearing range of the human auditory system is in the frequency range from 16 Hz to 16 kHz. Within this frequency range the volume perception is not constant. Therefore, the objective the objective parameters (*A physical quantity, property, or condition that is measured*) sound pressure and frequency are in contrast to the subjective human noise evaluation. The construction of the human ear influences significantly the noise perception.

The term "psychoacoustics" summarizes parameters that are considering the human auditory system. A spread approach to consider human hearing in noise measurement is the A-evaluation that is used in the airborne noise measurement. Thereby, curves with the same loudness impression (isophones) of the auditory sensation area diagram are imitated. That means that low frequencies cannot be perceived as well as middle-to-high frequencies with the same sound pressure level (Ref. 14).

Initial test rig investigations at the WZL using psychoacoustic noise evaluation were conducted (Ref. 1). Subsequently, Carl conducted comprehensive investigations of the noise behavior of cylindrical gears with various modifications, finishing processes and pitch deviations in order to prove its potential for the evaluation of gear noises (Ref. 7); some main psychoacoustic parameters are summarized (Fig. 12). The loudness evaluates to what extent human hearing perceives sound (Ref. 8). For the statement of the annoyance level of a noise signal, other parameters are defined. The sharpness considers the amount of high frequencies in the total noise signal and describes with increasing sharpness an annoyance or aggressiveness of a noise signal; in Reference 10 a weighting function for higher frequencies is defined.

The roughness describes the influence of patterns by modulation of the noise signal. Noises with a signal envelope fluctuation of 20 to 300 Hz are considered rough. If a tone signal is modulated above 300 Hz, it can be determined as main and side bands of the carrier signal (Ref. 11). Noises are described as tonal if single frequencies or narrow bands of the frequency spectrum are dominant, in comparison to the background level (Ref. 9). Noise signals with a high background noise level have a low tonality in comparison to tone-like noises.

Psychoacoustic evaluation of ground bevel gear variants. The force coupling element that is developed at WZL is used in order to connect the torsional vibration model of the test rig (Fig. 3) and, thereby, allows investigation of the individual topography scatter to the dynamic excitation behavior. The parameterization of the test rig (Ref. 4) is not validated yet and, therefore, the psychoacoustic parameters are normalized. Nevertheless, the simulation can be used for the investigation of the effect of the topography scatter to the different variants. Stiffness matrices are calculated in the FE-based tooth contact analysis *ZaKo3D* for the variants REF and R02 considering the load-caused deflection of the test rig and the individual topography.

In the calculation model — as for the later test rig trial — at the driving end of the drivetrain the speed is controlled and a constant torque is applied at the output shaft. In the following, speed ramps from 0 to 5,000 rpm, with an increase of 100 rpm/s at an output torque of 425 Nm, are discussed. The order spectra of the differential rotary acceleration up to the 110th rotation order of the pinion are shown (Fig. 13).

The order spectrum of the reference variant shows, as expected, the tonal characteristic of the transmission error spectrum; excitation is noticeable up to the 10th gear mesh order. Furthermore, two dominant Eigen frequencies can be identified with a hyper-

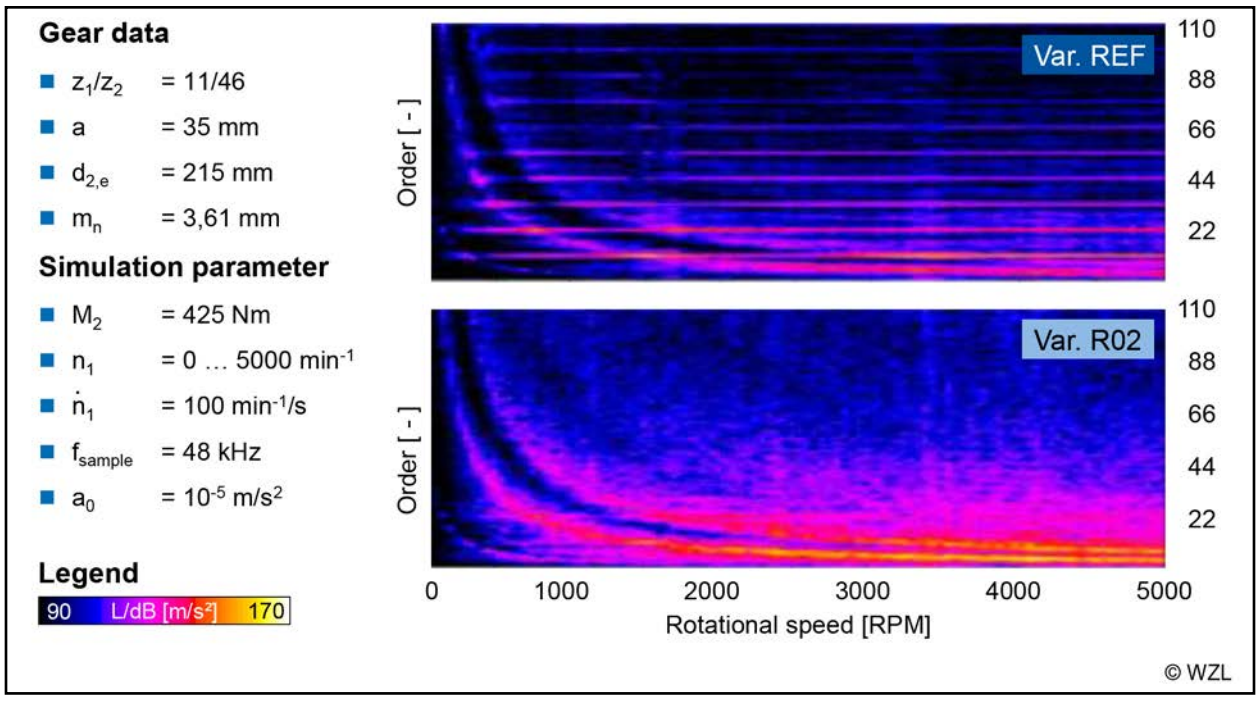


Figure 13 Order spectra of differential acceleration.

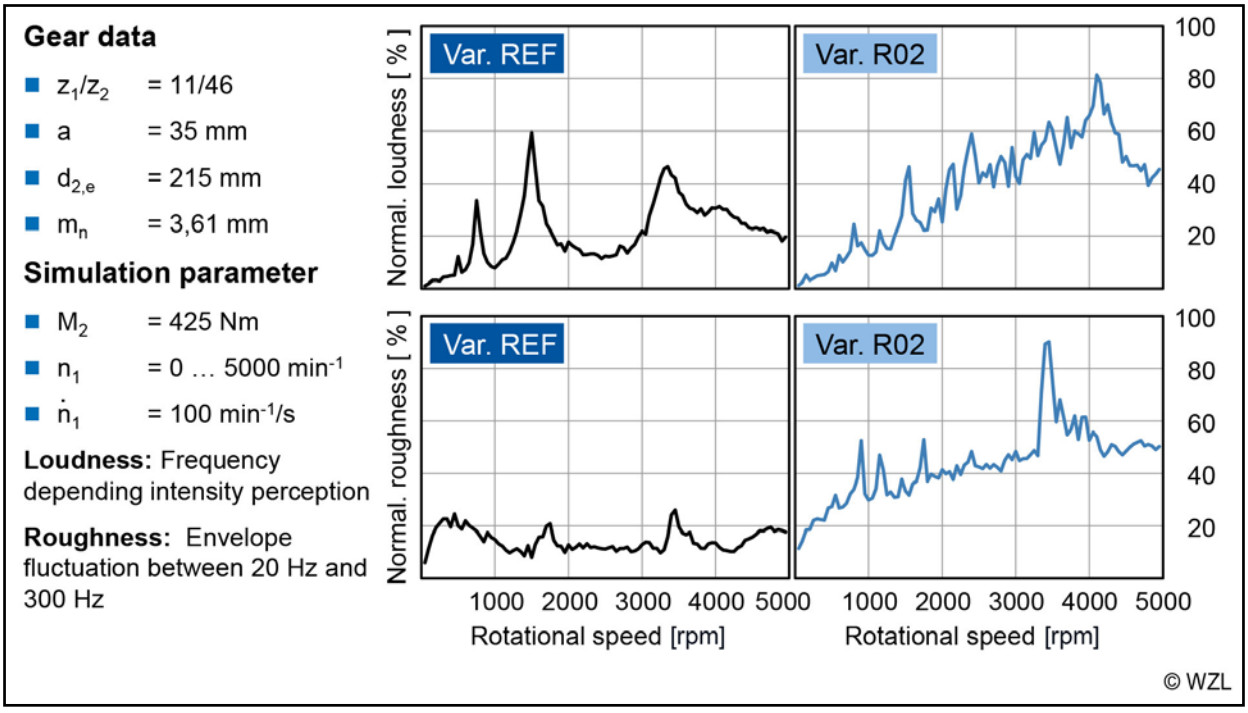


Figure 14 Influence of individual topography deviations on loudness and roughness of differential acceleration.

bolic form in the order spectra. The variant R02 provides completely different noise spectra. Due to the high background noise of the transmission error up to the first gear mesh order, a high excitation of the complete lower order range is given, as the Eigen frequencies are always excited by background noise. The higher harmonics cannot be identified in the spectrum.

The comparison of the order spectra already shows a higher tonal excitation of the reference variant — in contrast to the variant R02 with the topography scatter. In the following, the impact of the different spectra to psychoacoustic parameters is shown.

Loudness is depicted (Fig. 14, top); the loudness for the reference variants provides clear and dominant peaks for the reference variants when the gear mesh excitation of the first and second gear mesh order is meeting the Eigen frequencies of the system. Especially at $n_1 = 750$, 1,500 and 3,300 rpm peak values of the loudness are determined. The loudness graph for the R02 variant instead shows almost a linear relationship between loudness and input speed. The peaks of the Eigen frequencies are almost at the same level of the reference variant, but less dominant. Above 1,750 rpm, the loudness of the R02 variant is constantly higher than the loudness from the reference variant.

The roughness for the reference variant is constantly at a

lower level over the complete speed range and thus provides a lower modulation fluctuation in the signal. The R02 variant instead shows as well a linear behavior for the roughness.

The sharpness evaluates the loudness in higher frequency range (Fig. 15). The graphs for the loudness and the sharpness are almost the same. Small differences are only shown above 3,000 rpm.

The psychoacoustic evaluation of the tonality again reveals clear differences between the reference variant REF and random variant R02. The values range of the tonality of the REF variant is, on average, three times higher compared to the R02 variant. The tonality is the only psychoacoustic parameter that is constantly lower for the variant with the topography scatter. However, the loudness and sharpness parameters provide an almost linear graph over the speed while the reference variant provides peak values. In further investigations based on test rig trials, it is planned to measure the dynamic excitation behavior of the manufactured variants and evaluate it by means of differential rotary acceleration, structure-borne noise and airborne noise. Furthermore, a scientific method is needed in order to find the best compromise between a reduction of gear mesh excitation and an increase of background noise.

Summary and Outlook

With this report a procedure is demonstrated for altering the noise behavior of ground bevel gears by applying an individual topography deviation. As such, the major aspect is the reduction of the amplitudes of tooth mesh harmonics and a rise of background noise. Finally, the impact of the manipulated transmission error spectrum on the psychoacoustic parameters is shown.

In a first step, validation of the FE-based TCA *ZaKo3D* for bevel gears is shown. The results prove the capability to display the load-caused contact ratio increase. In particular, the resulting loaded transmission error graphs of the first four tooth mesh orders for drive and coast flank show good agreement between measurement and simulation. Differences in the amplitude values are explained with gear set position deviations caused by the assembly and load-induced displacements, as well as an incomplete itemization of the gear set.

Next a procedure is presented for the reduction of the tonality of the transmission error spectrum. This approach is derived by results discussed (Refs. 10 and 14), as well as analyses done by Landvogt (Ref. 16). With application of a minor topography deviation, from tooth to tooth the regularity of transmission error graphs is disturbed. Two different distributions of topography deviations are simulated and manufactured, as well as a conventional ground reference variant. The validation of the procedure is first done by means of a comparison of the load-free transmission error spectra from TCA and results from a bevel gear tester.

Finally, the gear set variants are virtually tested at operational-relevant parameters with a dynamic simulation (Ref. 4). In the order spectrum of the speed sweep it can be seen that the reference gear set is exciting up to the tenth gear mesh order. In comparison, the variant with fluctuating topography deviation does not provide a dominant excitation by the tooth mesh, but has a higher background noise level. This effect can be even better understood by evaluating the psychoacoustic parameters. On one hand, the loudness shows clear peak values for the reference variant when the gear mesh excitation meets the Eigen frequencies. For the variant with the topography fluctuation there is an almost linear relationship between loudness and rotary speed. Conversely, the higher background noise level of the variation with topography fluctuation has a huge impact on tonality and is three times lower in average compared to the reference variant.

In future research projects the results of the dynamic simulation must be validated by means of test rig trials measuring the differential acceleration, as well as the structure-borne and airborne noise. Furthermore, a method for the reduction of ampli-

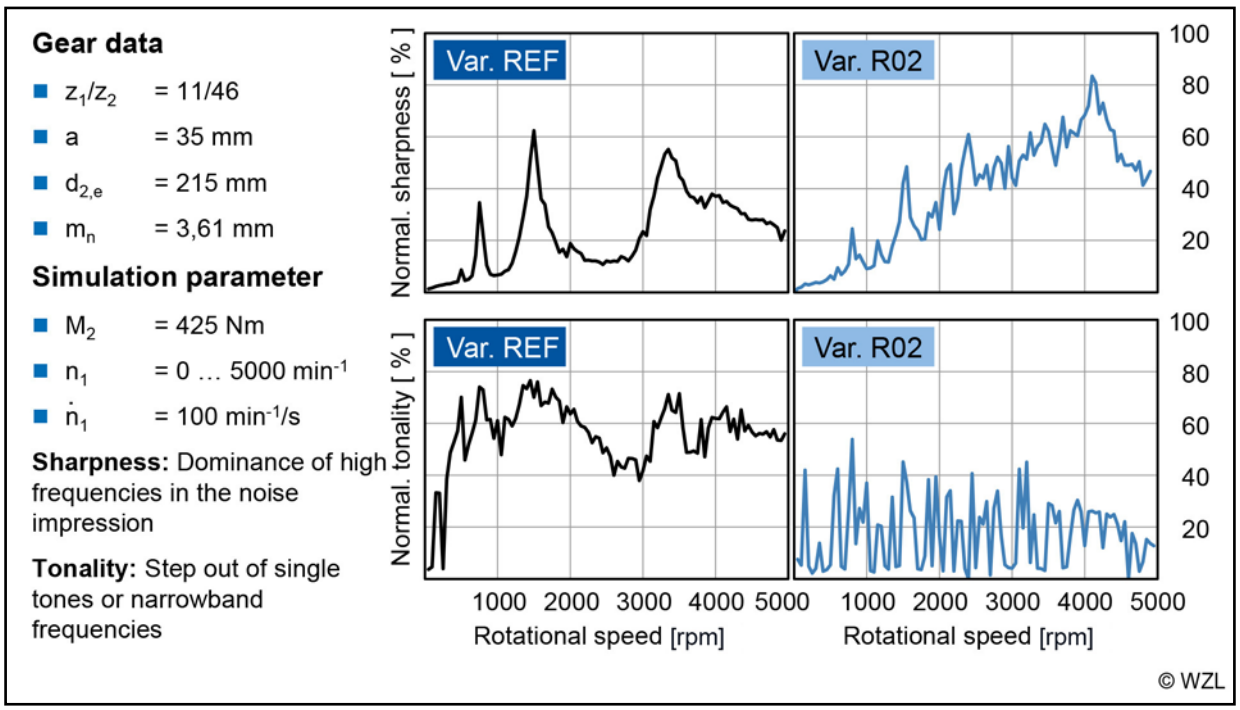


Figure 15 Influence of individual topography deviations on sharpness and tonality of differential acceleration.

tudes of the tooth mesh frequency and the higher harmonics, together with an increase of the background noise level, must be developed. The initial results presented in this report prove that the dominance of gear mesh excitation can be reduced by narrow disturbance of the regularity of the transmission error.

Acknowledgement. *The authors gratefully acknowledge financial support by the WZL Gear Research Circle and the companies Daimler and Klingelnberg for the support in the gear set manufacturing for the achievement of the project results.*

References

1. Brecher, C., M. Gorgels and M. Brumm. "Psychoakustik: Sinnvolle Kennwerte für die Bewertung von Geräuschemissionen von Verzahnungen. In: Tagungsband zur 49. Arbeitstagung," Zahnrad und Getriebeuntersuchungen, WZL, RWTH Aachen, 2008.
2. Brecher, C., M. Gorgels and M. Brumm. "Bewertung des Laufverhaltens geläppter Hypoidverzahnungen durch 3D Zahnkontaktanalyse. In: *Tagungsband zum Seminar Innovationen rund ums Kegelrad*," Aachen, 13-14, April 2010 4-19 WZL Gear Conference in the USA.
3. Brecher, C., M. Brumm and P. Knecht. "Analyse und Simulation der Höherharmonischen Geräuschanregung von Geschliffenen Kegelrädern," In: *Tagungsband zum Seminar*, *Innovationen rund ums Kegelrad*, Aachen, 12.-13, März 2014.
4. Brecher, C., C. Löpenhaus and P. Knecht. "Development of a Dynamic Simulation of Hypoid Gears Considering Flank Topography," In: *6th International VDI Conference on Gears* 2015, München, 5-7. Oktober 2015, S. 183-194.
5. Brecher, C., C. Löpenhaus and P. Knecht. "Analyse des dynamischen Anregungsverhaltens von Kegelradgetrieben," In: Tagungsband zur 56, Arbeitstagung Zahnrad und Getriebeuntersuchungen, WZL, RWTH Aachen, 2015.
6. Brumm, M. "Einflankenwälzprüfung von Hypoidgetrieben," Diss. RWTH Aachen, 2012.
7. Carl, C. "Gehörbezogene Analyse und Synthese der vibroakustischen Geräuschanregung von Verzahnungen," Diss. RWTH Aachen, 2014.
8. Norm DIN 45631. Berechnung des Lautstärkepegels und der Lautheit aus Geräuschspektren, Beuth Verlag, Berlin, 1991.
9. Norm DIN 45681. Akustik-Bestimmung der Tonhaltigkeit von Geräuschen und Ermittlung eines Tonzuschlages für die Beurteilung von Geräuschimmissionen,Beuth Verlag, Berlin, 2005.
10. Norm DIN 45692. Messtechnische Simulation des Hörempfindung Schärfe. Beuth Verlag, Berlin, 2009.
11. Fastl, H. and E. Zwicker. "Psychoacoustics – Facts and Models," 3 Aufl. Berlin, Heidelberg, Springer Verlag, 2006 Psychoacoustics of Ground Bevel Gears 4-20.
12. Gacka, A. "Entwicklung einer Methode zur Abbildung der dynamischen Zahneingriffsverhältnisse von Stirn und Kegelradsätzen," Diss. RWTH Aachen, 2013.
13. Hohle, A. C. "Auswirkungen von Rauheit, Oberflächenstruktur und Fertigungsabweichung auf das Lauf- und Geräuschverhalten Hartfeinbearbeiteter hochüberdeckender Zylinderräder," Diss. RWTH Aachen, 2003.
14. Norm ISO 226. Akustik – Normalkurven gleicher Lautstärke Beuth Verlag, Berlin, 2003.
15. Klingelnberg, J. (Hrsg.) Kegelräder. Grundlagen und Anwendungen. Springer Verlag, Berlin, Heidelberg, 2008.
16. Landvogt, A. "Einfluss der Hartfeinbearbeitung und der Flankentopographieauslegung auf das Lauf- und Geräuschverhalten von Hypoidverzahnungen mit Bogenförmiger Flankenlinie," Diss. RWTH-Aachen, 2003.
17. Plewnia, C. "Drehübertragungs- und Geräuschverhalten bogenverzahnter Kegelradgetriebe," Diss. RWTH Aachen, 1992.
18. Stadtfeld, H. J. *Handbook of Bevel and Hypoid Gears*, Rochester, NY USA, Gleason Corp, 1993, Firmenschrift.
19. Stadtfeld, H. J. "Gleason Kegelradtechnologie — ingenieurwissenschaftliche Grundlagen und modernste Herstellungsverfahren für Winkelgetriebe," Expert Verlag, Renningen, 2013.

For Related Articles Search
bevel gear grinding
at www.geartechnology.com

Dipl.-Ing. Peter Knecht studied mechanical engineering at RWTH Aachen University and Politecnico di Milano. In 2011 he began working as a scientific research assistant in the gear department of the Laboratory of Machine Tools and Production Engineering (WZL). Since 2014 he is team leader of the gear testing research group. Knecht's fields of research are tooth contact analysis and NVH behavior of gears and transmissions.

Dr.-Ing. Dipl.-Wirt.-Ing. Christoph Löpenhaus is a 2010 industrial engineering graduate of RWTH Aachen; he received his Ph.D. (local strength and friction models for gears) in 2015. Upon graduation he worked as a research assistant in the gear testing group of the Laboratory for Machine Tools (WZL) of RWTH Aachen and in 2011 was named the group's team leader. Löpenhaus has since 2014 worked as chief engineer of the department for gear technology at WZL.

Prof. Dr.-Ing. Christian Brecher has since 2004 served as ordinary professor for machine tools at the Laboratory for Machine Tools and Production Engineering (WZL) of the RWTH Aachen, as well as director of the Department for Production Machines at the Fraunhofer Institute for Production Technology IPT. Upon receipt of his engineering degree he began his career as a research assistant and later as team leader in the Department for Machine Investigation and Evaluation at the WZL. From 1999–2001 Brecher worked as a senior engineer with responsibility for machine tools and as director (2001–2003) for development and construction at the DS Technologie Werkzeugmaschinenbau GmbH, Mönchengladbach. Brecher has received numerous honors and awards, the Springorum Commemorative Coin and the Borchers Medal of the RWTH Aachen among them.

Optimal Flank Forms for Large Bevel Gears

Dr.-Ing. Hartmuth Müller

At first sight the appearance of 5-axis milling for bevel gears opens new possibilities in flank form design. Since in comparison to existing machining methods applying cutter heads no kinematic restrictions exist for 5-axis milling technology, any flank form can be machined.

Nevertheless the basic requirements for bevel gears did not change. Specifications and functional requirements like load carrying capacity and running behavior are still increasing demands for design and manufacturing. This paper describes the demands for gear design and gives an overview about different design principles in the context of the surrounding periphery of the gear set.

Free-Forming Tooth Forms

During the past years many papers had been published showing completely different approaches to flank shapes of gears. A so called S-type was presented on several machine tool shows worldwide claiming a significantly higher load carrying capacity compared to conventional spiral bevel gears (Ref. 1).

The S-type gear returns to mind the principle of herring bone gears (Fig. 1). The special lengthwise shape of the teeth will increase the contact ratio and reduce axial forces. Allegedly the load carrying capacity is to be 35% higher compared to a spiral bevel gear with same outer dimensions.

A detailed loaded tooth contact analysis of the S-type gear shows a significant disadvantage of such designs. Since the loaded contact is split into two contact patterns the possibility for spreading the contact with increasing load is rather limited. Therefore the Hertzian pressure distribution shows two excessively high maxima (Fig. 2). Another disadvantage is the course of the root bending stress. Conventional spiral bevel gears show the maximum in the middle and a decrease to the outer ends. The tooth root stress at the heel and the toe is very low. The S-type gear shows a lower maximum, but rather high values at the outer limits of the tooth. This is due to the very high stiffness of the tooth in the middle section caused by the S-type shape. In real applications the fear is that cracks will initiate in the root at the heel and toe area and propagate rather quickly.

Beside this rather exotic design of a spiral bevel gear set, old mathematical principles are considered for flank forms of bevel gears in another design study. A spherical involute tooth lengthwise in shape is considered (Ref. 2). Figure 3 shows a spherical involute bevel gear set.

The characteristic of any involute curve is its equidistance to itself. With cylindrical involute gears, a change in the axis distance will not affect the tooth mesh conditions. With spherical involute bevel gears, a change in the shaft angle will not change the contact conditions of meshing teeth. Any other displacement will be sensitive to the contact conditions.

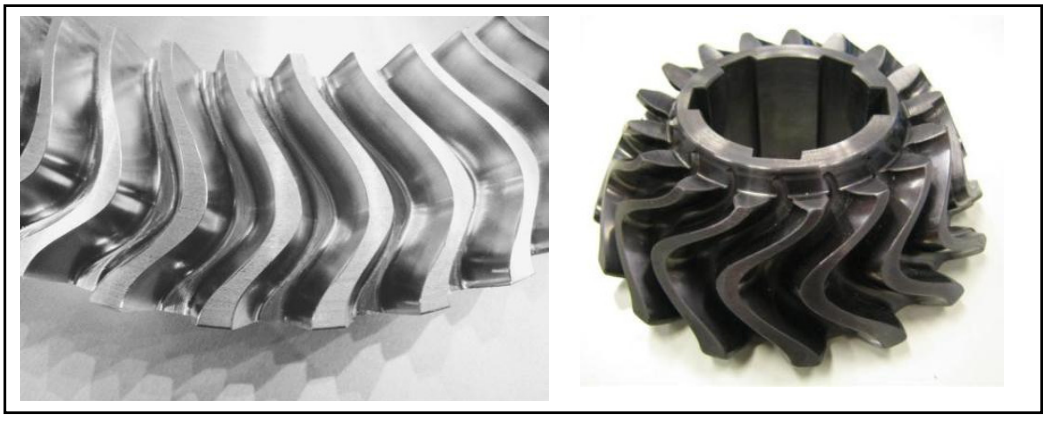


Figure 1 S-type gear (Courtesy Bierens).

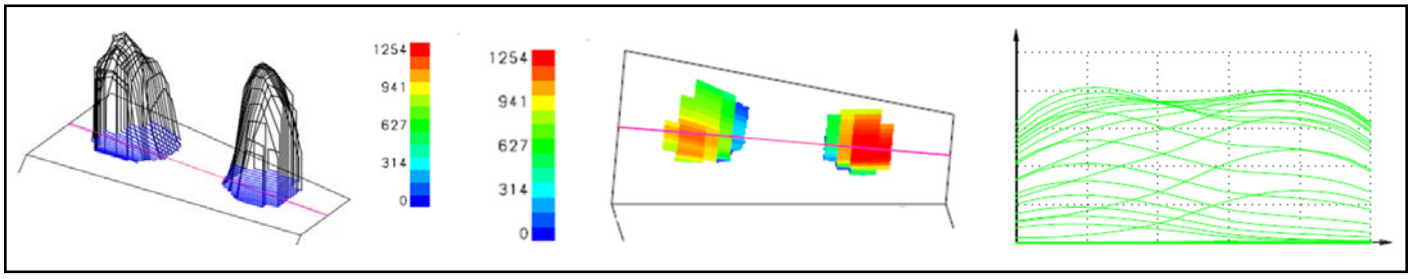


Figure 2 Loaded contact and root bending stress of S-type gear.

This paper was initially presented at the 6th WZL Gear Conference in the USA, Ann Arbor, MI, June 2016. Reprinted with permission.

Load Conditions

Typical gear stresses are always cyclical and are divided into bending stress, contact stress, compressive stress and shear stress. The material therefore needs to have a hard surface layer with residual, compressive stress, being well connected to a more ductile core handling the shear and bending stress. The larger the contact area, the lower will be the contact stress — and the more load that can be transmitted. Bending stress requires material properties like toughness and ductility. This is contradictory to the requirements for contact stress. Therefore carburizing and quenching offer the best conditions for designing a graded material.

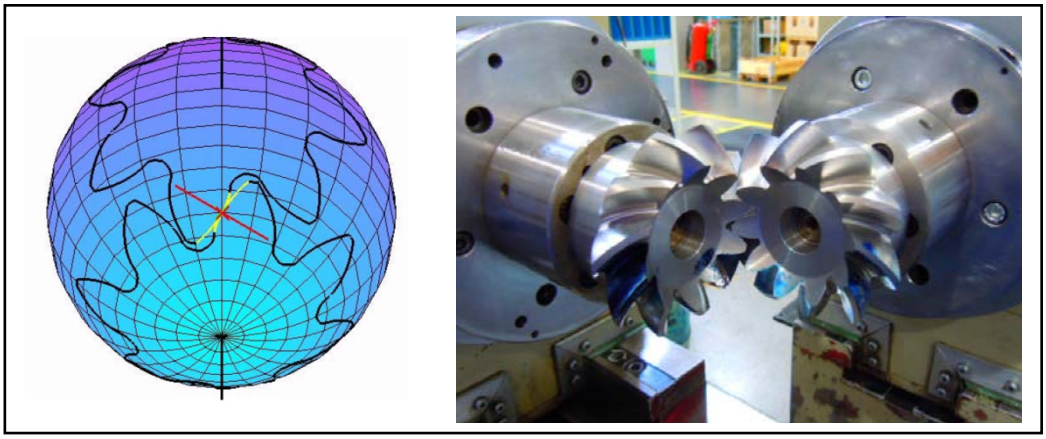


Figure 3 Spherical involute bevel gear set.

Design-relevant aspects of load handling properties are maximizing the tooth contact area and avoiding any stress maxima at the edges of the tooth; any tooth form being favorable to this aim will be reasonable. In addition, a high contact ratio is favorable since this will distribute the load to more teeth and consequently reduce the load-per-tooth pair.

Displacements

When transmitting torque the teeth will be deformed elastically. The higher the torque, the wider the loaded contact patter will be. Also, beyond tooth deflection, all components of a gearbox will be deflected. This load-induced deformation is caused by the tooth forces being perpendicular to the tooth flank surface when friction is negligible.

Balancing the safety factors for bending stress and contact stress is done by selecting the module and mean spiral angle. Any spiral angle other than zero will cause axial tooth forces. The general case of load-induced displacements of a bevel gear set is shown (Fig. 4). The tooth forces will move ring gear and pinion axially (*H* and *J*), in direction of the hypoid offset (*V*) and will change the shaft angle (Σ).

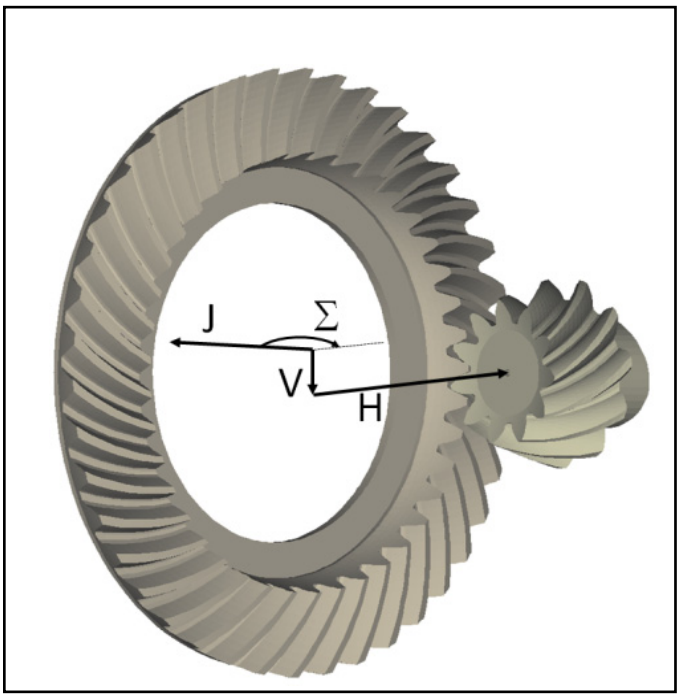


Figure 4 Load-induced displacements of a bevel gear set.

For achieving an optimal flank form for bevel gears there are two targets to meet:

- Using the complete flank area for the loaded contact pattern
- Insensitivity of contact pattern position under tooth-force-induced displacements

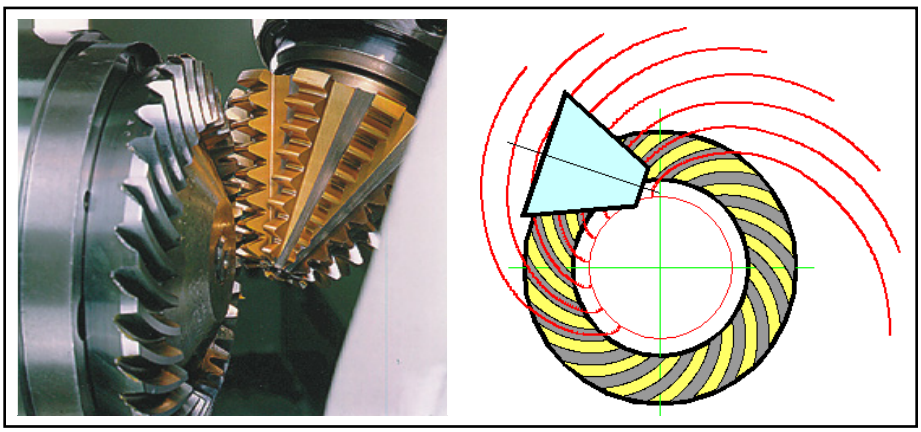


Figure 5 Palloid method with involute shape of tooth trace.

Considering the first aspect will exclude any flank shape that does not allow to loaded contact to spread over the complete flank area. S-type gears for example do not fulfill this requirement and will not help improving the load carrying capacity. The potential of spherical involute bevel gears with the insensitivity in shaft angle displacements will only bring improvements as long as displacements in *V*, *H* and

J are negligible in relation to Σ displacements.

Different Lengthwise Shapes

Even new flank forms are possible with 5-axis milling, while the advantages of classical spiral bevel gears still predominate. The loaded contact pattern can spread all over the flank area; the spiral angle increases the contact ratio and spreads the load to several pairs of teeth, and the root bending stress has its maximum in the middle of the face width. In the following, five different bevel gear principles are shown and compared to each other.

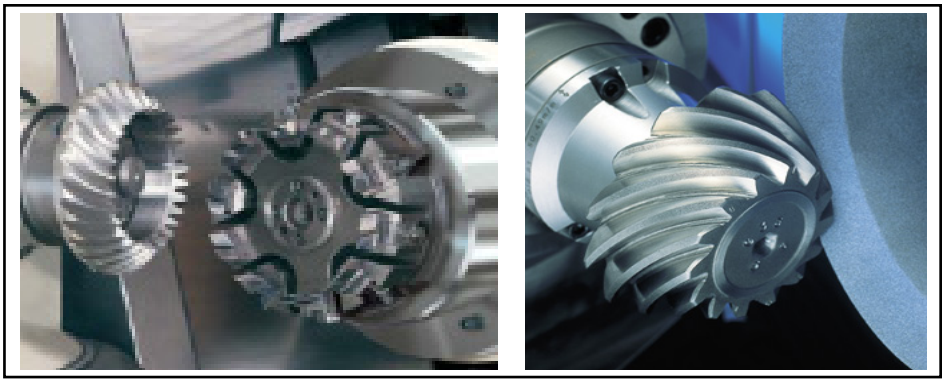


Figure 6 Cyclo-Palloid and Wiener methods.

Palloid. For the Palloid method a tapered hob is the cutting tool. The motion of the hob relative to the work piece creates an involute tooth lengthwise profile (Fig. 5). The involute tooth trace form is very insensitive to *H* and *J* displacements.

Cyclo-Palloid and Wiener. These gearing systems shown in Figure 6 use a face cutter-type tool to cut or grind the teeth of the bevel gear. The tooth trace shape for Cyclo-Palloid is an elongated epicycloid and an arc for Wiener.

Both systems show the same displacement behavior, depending on the tool diameter (Fig. 7).

The left part shows a large tool diameter and the right figure a small tool diameter. Since the tooth forces of a spiral bevel gear set will increase the horizontal position of the pinion $\Delta H > 0$ and the ring gear $AJ > 0$ and decrease the offset $\Delta V < 0$ the advantage of the small tool radius becomes obvious. If $\Delta H = -\Delta V$ the position of the contact pattern of the right part (Fig. 6) would not change at all. This situation is called the rectangular case (Ref. 3).

Comparison

The comparison of different gear designs is done for the gear data shown (Fig. 8). For all five designs the Ease-Off geometry is identical. Gear set No. 1 is the Palloid design; No. 2 is a Cyclo-Palloid design with a tool radius of 84 mm corresponding to the rectangular case; No. 3 is a Cyclo-Palloid design with a tool radius of 100 mm; No. 4 and No. 5 are Wiener designs in which No. 4 is a rectangular case. The differences in these designs are the different tooth trace shapes.

Figure 9 shows the course of the spiral angle over the face width. It can be seen that the involute lengthwise shape of the Palloid design has the biggest change in spiral angle, whereas

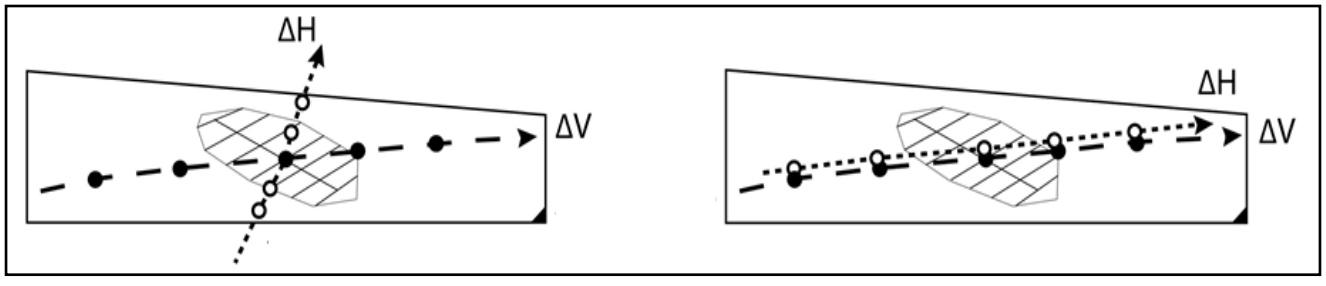


Figure 7 Influence of the tool radius on V and H displacements.

	Pinion	Gear	
Number of teeth	19	36	-
Shaft angle	90.0000		deg.
Hypoid offset	0.0000		mm
Mean normal module	5.4176		mm
Outer transverse module	8.0000	8.0000	mm
Mean spiral angle	36.8664	36.8664	deg.
Pitch cone angle	27.8241	62.1759	deg.
Nominal pressure angle	20.0000	20.0000	deg.
Profile displacement factor	0.0000	0.0000	-
Tooth thickness factor	0.0123	-0.0441	-
Mean whole depth	12.2121	12.2121	mm
Mean addendum	5.4276	5.4276	mm
Mean dedendum	6.7845	6.7845	mm
Outer normal backlash	0.3300		mm

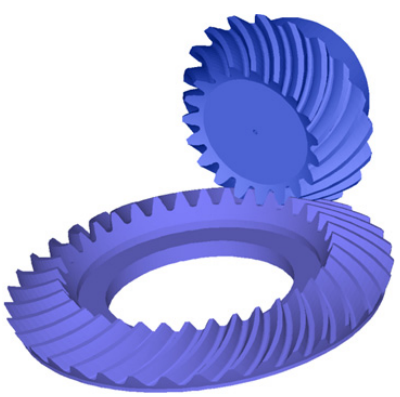


Figure 8 Gear data for design comparison.

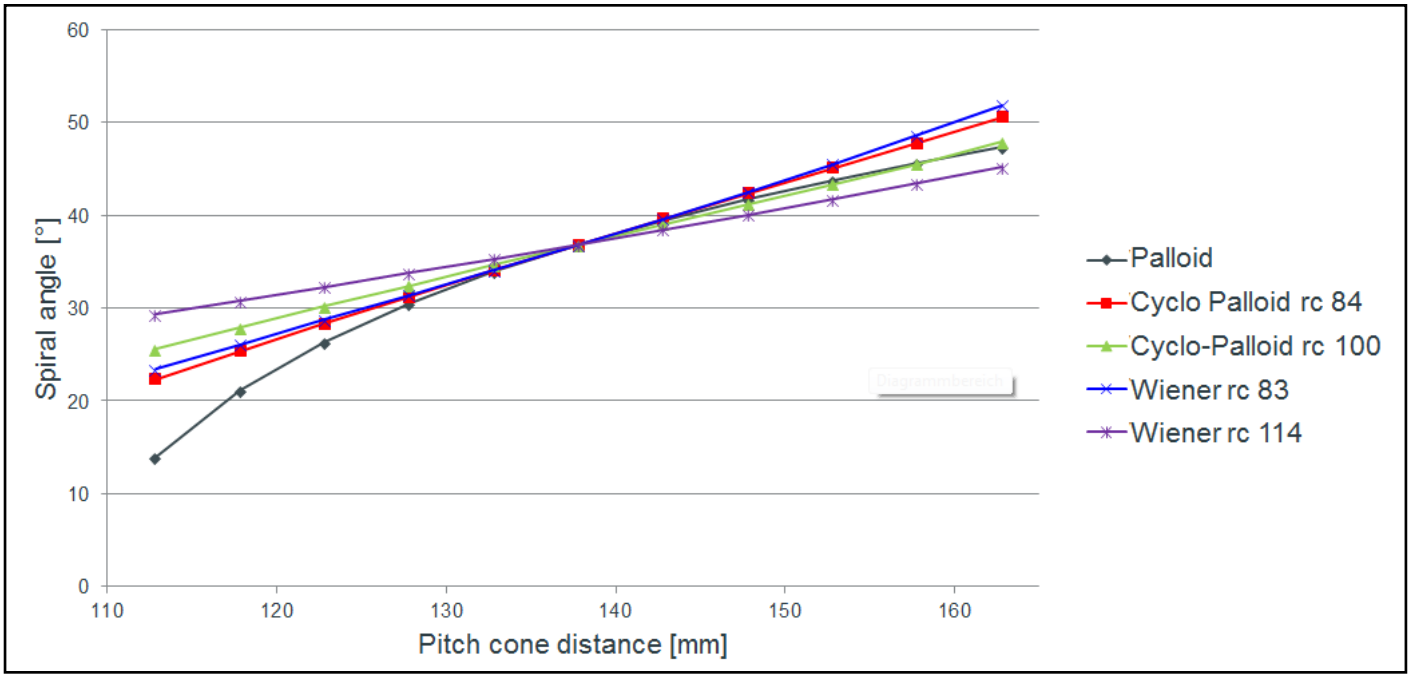


Figure 9 Spiral angle comparison.

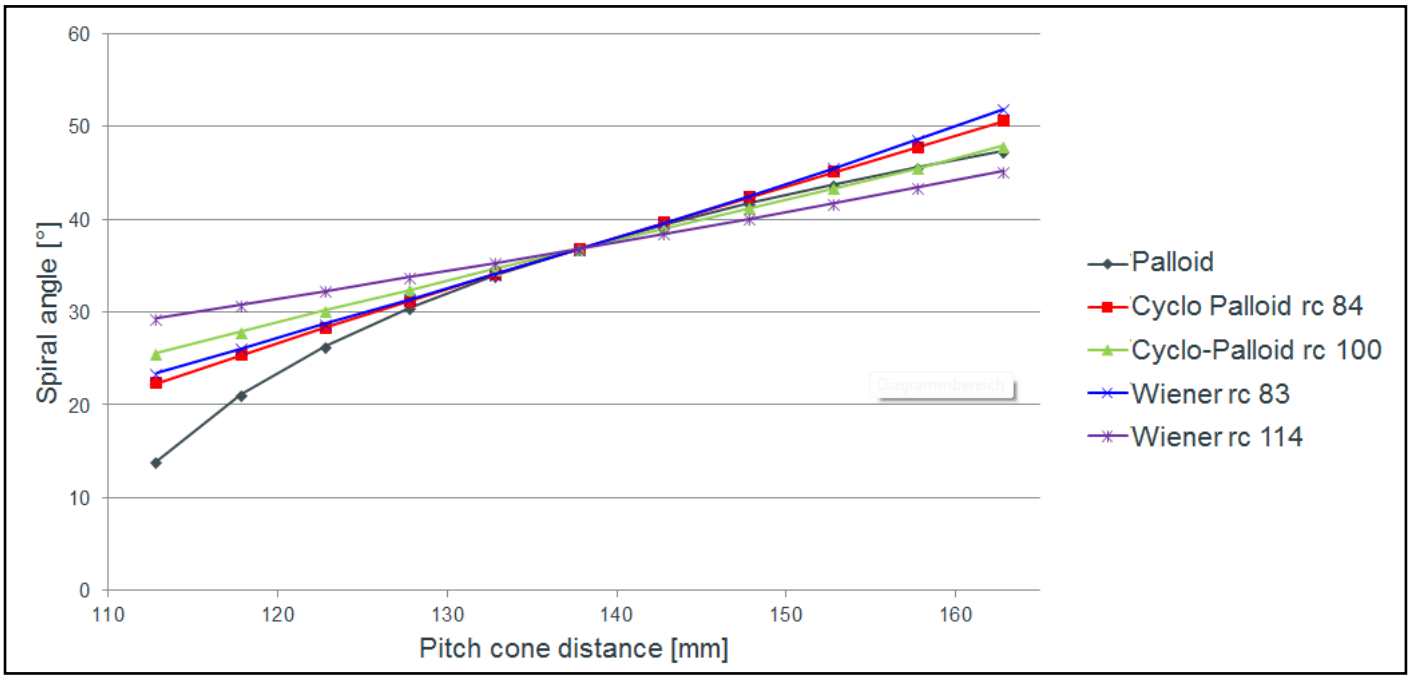


Figure 10 Lengthwise curvature comparison.

the Wiener designs have the smallest.

Comparing the course of the lengthwise curvature shows no change for the Wiener designs, a small change for the Cyclo-Palloid designs and a significant change for the Palloid design. Figure 11 shows the course of the normal module over the face width. It is interesting to see that for all rectangular case designs the normal module has its maximum in the middle of the teeth. For non-rectangular designs the maximum is at the heel or close to it. By changing the tool diameter it is possible to place the maximum normal module on nearly any position along the face width.

Another interesting characteristic can be seen for the Palloid design. The normal module does not change along the face width. Palloid designs have the unique feature of constant tooth height and constant slot width.

Since a bigger normal module gives a stronger tooth, it is obvious that the load carrying capacity will be influenced. Another effect influencing the load carrying capacity is the sensitivity of the contact pattern to load-induced displacements. This sensitivity is shown (Fig. 12) for the unloaded contact pattern and (Fig. 13) for the loaded contact pattern.

For the loaded TCA a torque of 2,000 Nm was applied.

The root bending stresses without displacements are very comparable to each design. The variation of the maximum bending stress for the pinions is from 446 MPa for the Wiener 114 design, up to 486 MPa for the Cyclo-Palloid 100 design. The ring gear shows maximum bending stresses from 440 to 452 MPa.

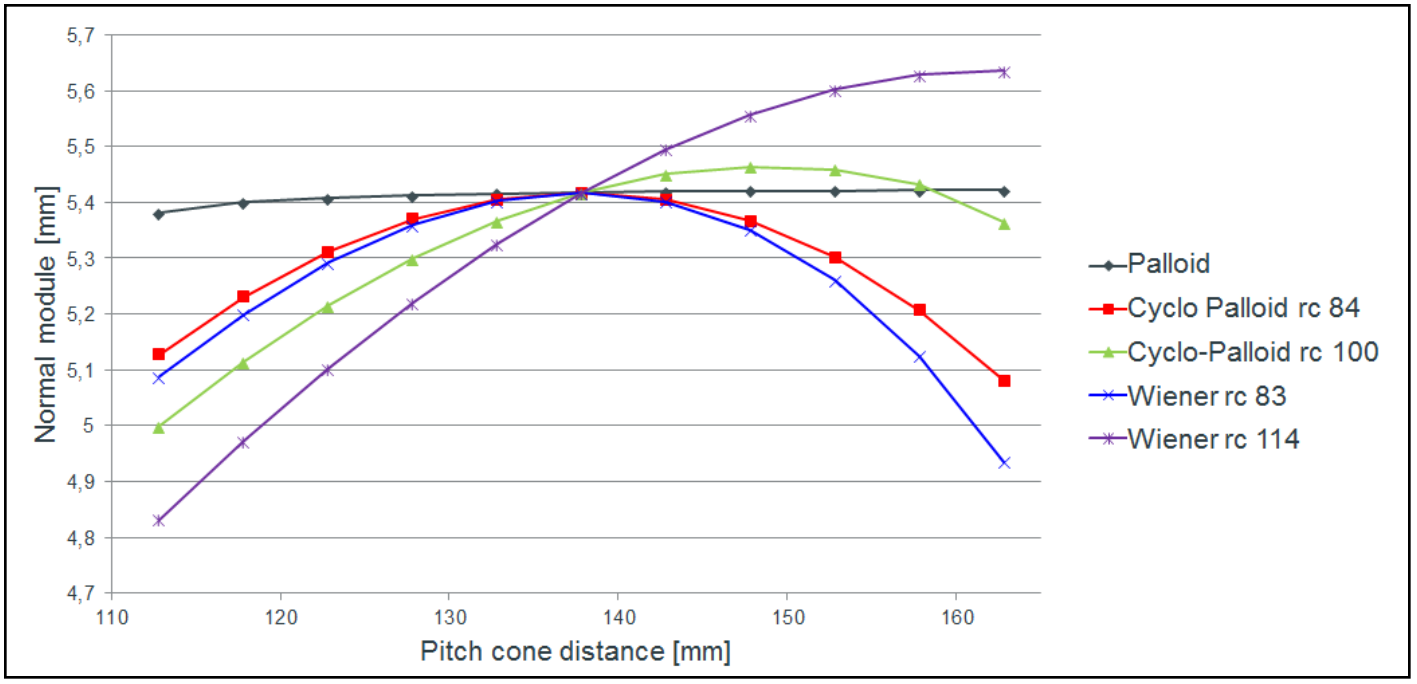


Figure 11 Normal module comparison.

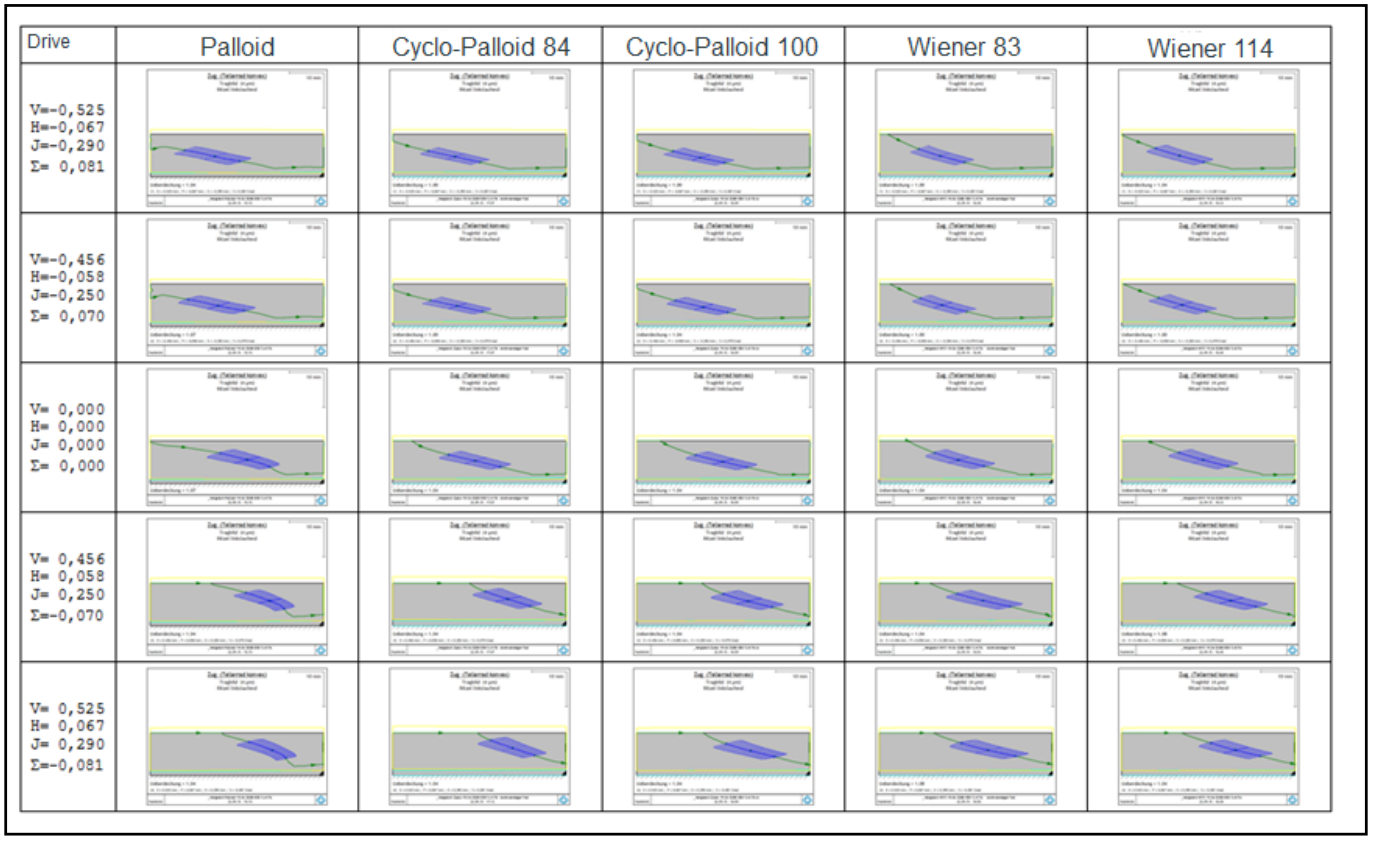


Figure 12 Unloaded contact pattern position with displacements.

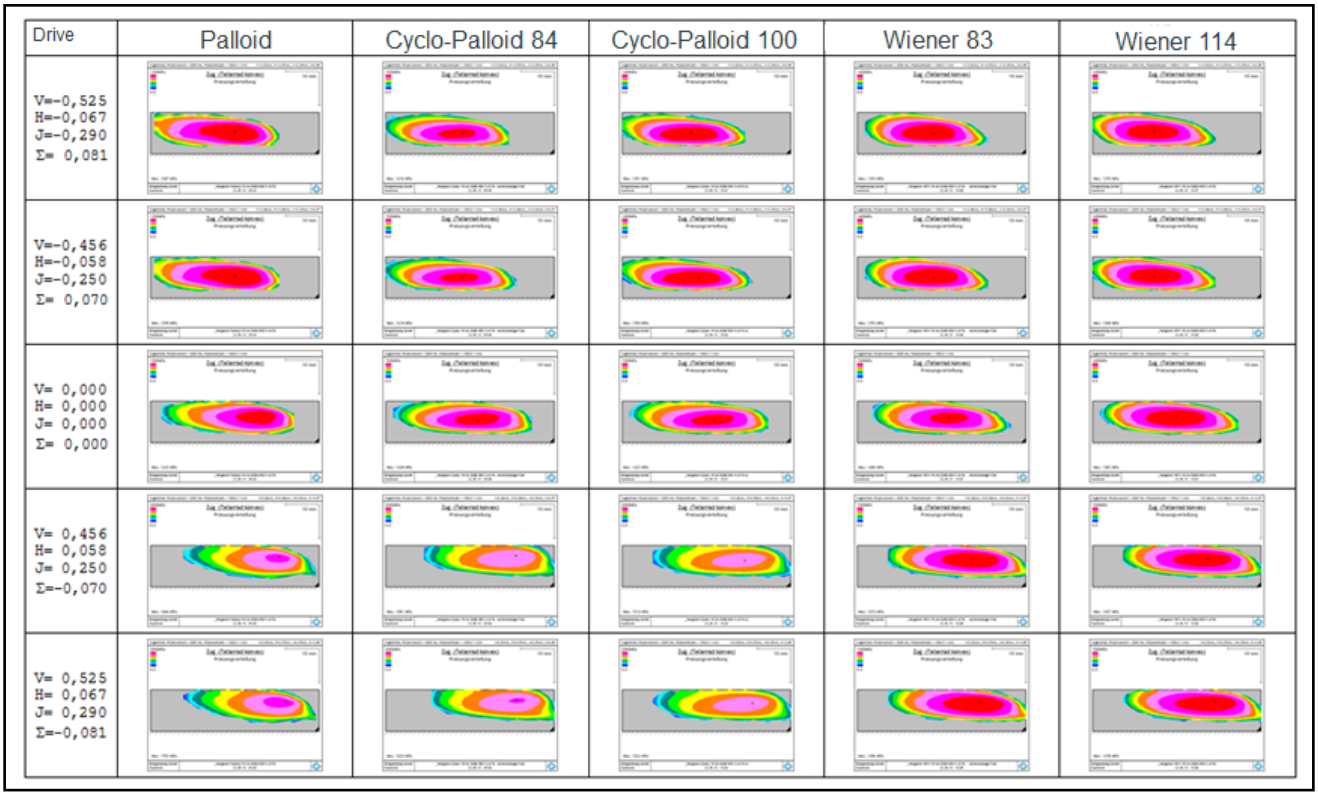


Figure 13 Loaded contact pattern position with displacements.

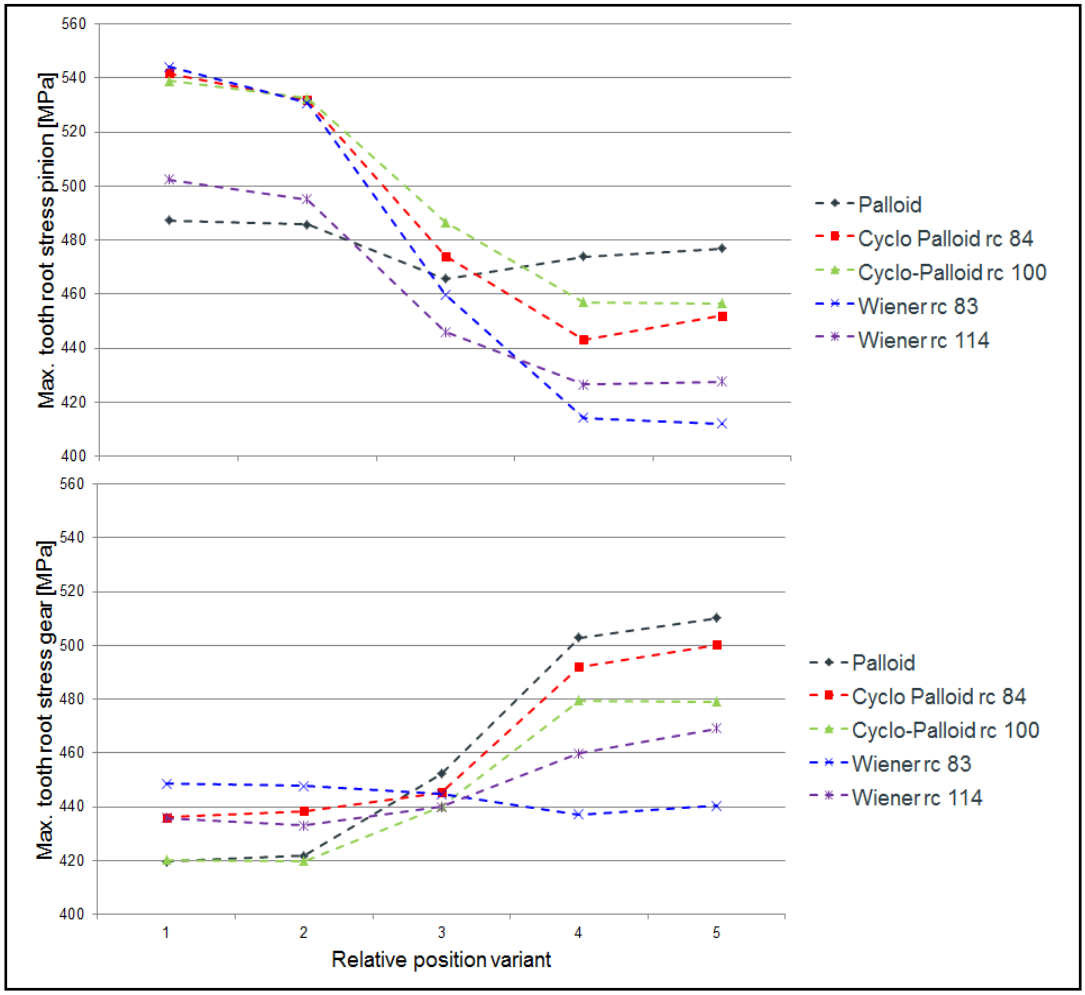


Figure 14 Maximum root bending stress with displacements.

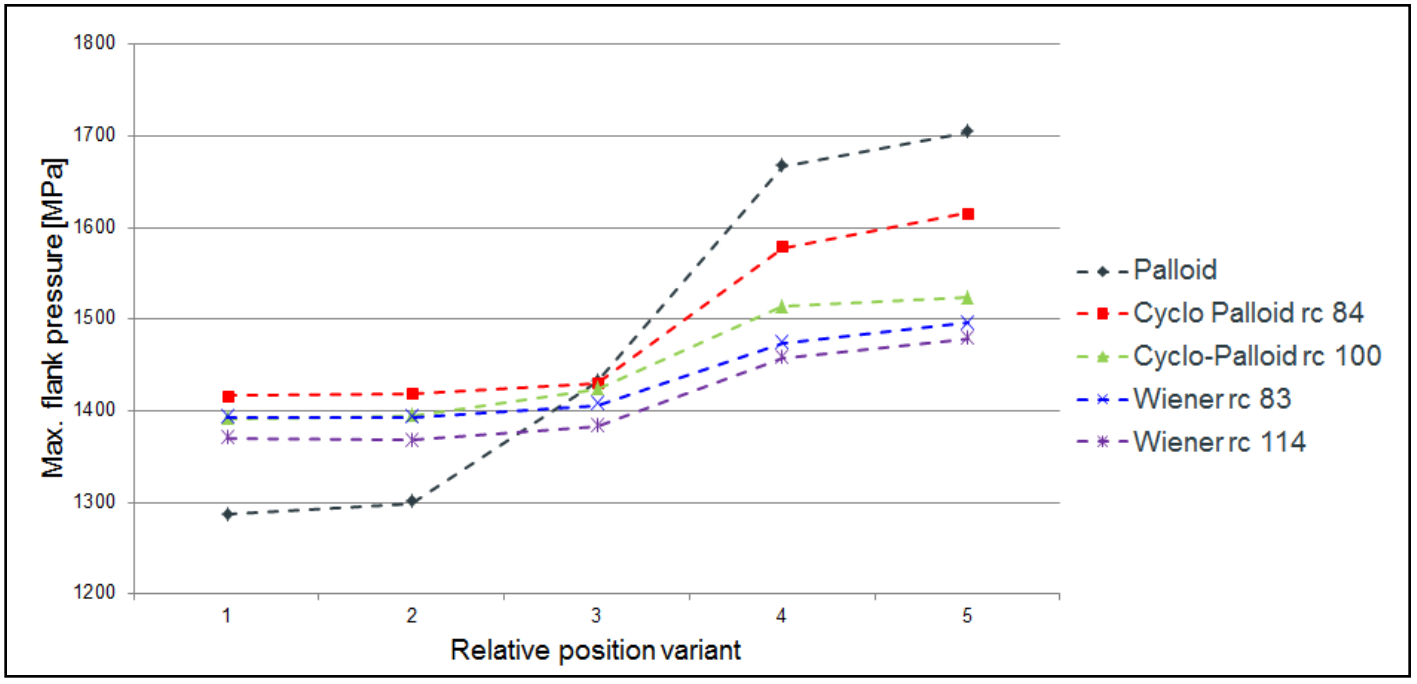


Figure 15 Maximum contact stress with displacements.

Similar to the root bending stress, the maximum of the Hertzian pressure without deflections is very similar. The Wiener 114 design has the lowest value with 1,390 MPa, the Palloid design the highest at 1,430 MPa.

The main differences in load carrying capacity can be seen when displacements are taken into account. Figure 14 shows the maximum of the root bending stresses of pinion and gear for the displacements used in Figures 12 and 14. Since the displacements move the contact pattern in tooth height and tooth lengthwise direction, the bending stresses will change significantly for the different designs. The most variation shows the Palloid design for the ring gear with a variation from 420 to 510 MPa.

The variation of the contact stress under displacements is shown (Fig. 15). For the Palloid design the values vary from 1,280 to 1,700 MPa. This is caused by the extremely localized loaded contact pattern near the tip of the ring gear. This also explains the high root bending 3-9 WZL stress. The Wiener 114 design has the lowest variation in contact stress, changing from 1,380 to 1,480 MPa.

Summary and Outlook

Gear design requires tooth forms that are able to handle contact stress as well as bending stress.

- This can be achieved by flanks allowing the contact pattern to grow with increasing torque.
- The other aspect is the insensitivity to load-induced displacements; the smaller the contact pattern movement under load, thus less of an increase in root bending stress can be seen.
- A similar effect includes stress; i.e. — better centering means less variation in maximum pressure.
- For designing higher-rated gears in terms of load carrying capacity, flank forms are required that guarantee the above-mentioned behavior.
- Whether entirely different shapes of gear teeth have this potential seems very questionable.

References

1. Bierens Machinefabrieken B.V. S-type gears; *www.bierens.com*.
2. Dort, F. "Explizite Berechnung Kugelkonjugierter Kegelradpaare Durch das Sphärische," Verzahnungsgesetz Dissertation Fachbereich Mathematik und Informatik, Physik, Geographie, Justus-Liebig-Universität, Gießen, Germany.
3. Klingelnberg, J. *Bevel Gears*, Springer Verlag, ISBN 978-3-662-43892-3.

Dr. Hartmuth Müller is head of technology & innovation for Klingelnberg. Upon earning both his degree in electrical engineering (1980) and his Ph.D. (1990) at University Karlsruhe, he joined Klingelnberg Ettlingen (1990) as head of software development and was later (1997) named head of the Klingelnberg Ettlingen Technical Center. Mueller in 2001 became Klingelnberg GmbH managing director and subsequently (2003) Klingelnberg Group CTO.

gear TECHNOLOGY

Gear Technology's Statement of Ownership, Management and Circulation

Additional information about *Gear Technology* and its audience can be found in our 2017 media kit. Download it at *www.geartechnology.com/adinfo.htm*

UNITED STATES POSTAL SERVICE® — **Statement of Ownership, Management, and Circulation (Requester Publications Only)**

1. Publication Title	2. Publication Number	3. Filing Date
Gear Technology, the Journal of Gear Manufacturing	0 7 4 3 - 6 8 5 8	10/1/16
4. Issue Frequency	**5. Number of Issues Published Annually**	**6. Annual Subscription Price (if any)**
Monthly except February, April, October & December	8	$70.00

7. Complete Mailing Address of Known Office of Publication (Not printer) (Street, city, county, state, and ZIP+4®): 1840 Jarvis Ave., Elk Grove Village, Cook County, IL 60007-2440 — Contact Person: WILLIAM R. STOTT; Telephone (Include area code):

8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not printer): 1840 Jarvis Ave., Elk Grove Village, Cook County, IL 60007-2440

9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor (Do not leave blank)

Publisher (Name and complete mailing address): Michael Goldstein, 1840 Jarvis Ave., Elk Grove Village, Cook County, IL 60007-2440

Editor (Name and complete mailing address): Michael Goldstein, 1840 Jarvis Ave., Elk Grove Village, Cook County, IL 60007-2440

Managing Editor (Name and complete mailing address): Michael Goldstein, 1840 Jarvis Ave., Elk Grove Village, Cook County, IL 60007-2440

10. Owner (Do not leave blank. If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.)

Full Name	Complete Mailing Address
Michael Goldstein	1840 Jarvis Ave. Elk Grove Village, Cook County, IL 60007-2440

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box. → ☒ None

Full Name	Complete Mailing Address

12. Tax Status (For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
☐ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months (Publisher must submit explanation of change with this statement)

PS Form **3526-R**, July 2014 (Page 1 of 4 (See instructions page 4)) PSN: 7530-09-000-8855 **PRIVACY NOTICE:** See our privacy policy on www.usps.com.

13. Publication Title: Gear Technology, the Journal of Gear Manufacturing — 14. Issue Date for Circulation Data Below: AUGUST 2016

15. Extent and Nature of Circulation			Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies (Net press run)			11,026	11,694
b. Legitimate Paid and/or Requested Distribution (By mail and outside the mail)	(1)	Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing, and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	5,150	4,972
	(2)	In-County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing, and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	–	–
	(3)	Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid or Requested Distribution Outside USPS®	303	354
	(4)	Requested Copies Distributed by Other Mail Classes Through the USPS (e.g., First-Class Mail®)	–	–
c. Total Paid and/or Requested Circulation (Sum of 15b (1), (2), (3), and (4)) ▶			5,453	5,326
d. Non-requested Distribution (By mail and outside the mail)	(1)	Outside County Nonrequested Copies Stated on PS Form 3541 (include sample copies, requests over 3 years old, requests induced by a premium, bulk sales and requests including association requests, names obtained from business directories, lists, and other sources)	4,876	5,138
	(2)	In-County Nonrequested Copies Stated on PS Form 3541 (include sample copies, requests over 3 years old, requests induced by a premium, bulk sales and requests including association requests, names obtained from business directories, lists, and other sources)	–	–
	(3)	Nonrequested Copies Distributed Through the USPS by Other Classes of Mail (e.g., First-Class Mail, nonrequestor copies mailed in excess of 10% limit mailed at Standard Mail® or Package Services rates)	–	–
	(4)	Nonrequested Copies Distributed Outside the Mail (Include pickup stands, trade shows, showrooms, and other sources)	449	930
e. Total Nonrequested Distribution [Sum of 15d (1), (2), (3) and (4)]			5,325	6,068
f. Total Distribution (Sum of 15c and e) ▶			10,778	11,394
g. Copies not Distributed (See Instructions to Publishers #4, (page #3)) ▶			248	300
h. Total (Sum of 15f and g)			11,026	11,694
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100) ▶			51%	47%

* If you are claiming electronic copies, go to line 16 on page 3. If you are not claiming electronic copies, skip to line 17 on page 3.

PS Form **3526-R**, July 2014 (Page 2 of 4)

UNITED STATES POSTAL SERVICE® — **Statement of Ownership, Management, and Circulation (Requester Publications Only)**

16. Electronic Copy Circulation	Average No. Copies Each Issue During Previous 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Requested and Paid Electronic Copies ▶	2,294	2,464
b. Total Requested and Paid Print Copies (Line 15c) + Requested/Paid Electronic Copies (Line 16a) ▶	7,747	7,790
c. Total Requested Copy Distribution (Line 15f) + Requested/Paid Electronic Copies (Line 16a) ▶	12,978	13,108
d. Percent Paid and/or Requested Circulation (Both Print & Electronic Copies) (16b divided by 16c × 100) ▶	59%	59%

☒ I certify that 50% of all my distributed copies (electronic and print) are legitimate requests or paid copies.

17. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the November/December 2016 issue of this publication.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner: Michael Goldstein — Publisher — Date: 10/1/16

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

PS Form **3526-R**, July 2014 (Page 3 of 4) **PRIVACY NOTICE:** See our privacy policy on www.usps.com.

Blaser Swisslube

CELEBRATES 80TH ANNIVERSARY

"Serving comes before earning" — This is the motto under which the lubricant manufacturer Blaser Swisslube is celebrating its 80th company anniversary. It all started back in 1936 with "Blaha-Glanz" — a shoe polish. A lot has happened since that time, and the family-run company in Hasle-Rüegsau (Switzerland) has developed from a small regional company into the global player. In the company's own technology center, the focus is squarely on research and development. This focus has resulted in a breakthrough being achieved in a current civil aviation project.

The first successful product produced by the former Blaser+Co. AG was Blaha-Glanz, a water-repellent shoe polish that was sold on the surrounding farms. Willy Blaser laid the foundation for today's company group in the crisis year, 1936. As a 20-year-old who had been unable to find work in the painting trade he had trained in, he founded a one-man company in his parent's house where he produced lubricants and chemical-technical products especially for agriculture.

Perseverance was the order of the day due to the shortage of raw materials during the war years.

The real upturn in the company's fortunes began after the war when the customer base expanded to include, besides farmers, mechanical workshops, the construction industry, the wood and metal processing industries and the first industrial factories. "With the same pioneering spirit that was present when the company was founded, tireless work was done to continue to expand the company, to increase and modernize the manufacturing facilities, as well as to increase the level of research and development," explains the grandson and current Managing Director, Marc Blaser.

Step-by-step to becoming a global player

In 1974, Peter Blaser (chairman of the board of directors since 2010) took up the torch and became the second generation to manage the company. As a mechanical engineer, he took steps to introduce metal processing in the company's repertoire as well as to establish and expand the sales network in Europe and abroad. Due to the international orientation of the company, the company name was also changed to Blaser Swisslube. In 1981, Blaser Swisslube Inc. was founded in White Plains, New York with the first US production plant opened in Goshen, New York in 1986. In 1995 and 1996, subsidiaries in Germany, the Czech Republic and Japan followed. Today, Blaser has its own subsidiaries and agents close to its customers in around 60 countries across the globe and employs a total of 600 employees, with 300 of those being in Switzerland.

From metalworking fluid to liquid tool

The company continued to develop its expertise in all things to do with metalworking fluids. This involved the research and development laboratory being further expanded. With a surface area of around 3,500 m2, 70 chemists, microbiologists and laboratory technicians work on creating coolants of the best quality, as well as on analyzing metalworking fluid samples from customers around the world.

In order to be able to offer customers an effective added value when it comes to machining, the company inaugurated its very own technology center in 2009. "Since then in the state-of-the-art processing centers we have been able to offer customers practical depictions of their machining operations, as well as to carry out stringent tests on newly developed coolants. For us, this is the technological advantage that we wish to continue to expand," said Marc Blaser. "The factors productivity, economic efficiency and machining quality depend a great deal on the choice and quality of the metalworking fluid and on the expertise of machining specialists. Thanks to the in-house concentration of expertise, we are in a position to offer our partners a coolant solution that is tailored exactly to their needs — a liquid tool."

Doubling of the tool life

In a recent project, Blaser experts in the technology center optimized tool life. A renowned partner filled the role of international supplier and manufactured aircraft parts from a high-

strength titanium alloy. In the technology center in Hasle-Rüegsau, a range of tests were started with the goal of optimizing the tool life during pocket machining.

The specialists at Blaser reconstructed the partner's situation on the DMG MORI DMU 65 monoblock and began comprehensive tests using a trochoidal milling strategy. This involved a conventional metalworking fluid from an earlier generation being compared with a coolant solution that has been adapted exactly to the partner's needs. The series of width of wear tests were conducted up to 0.30 mm. With the optimally adapted fluid tool from Blaser Swisslube, 11 instead of just five pockets could be milled until the wear on the tool forced the processing to be stopped. The result achieved was confirmed in a series of various tests, and corresponds to a doubling of the tool life. (*www.blaser.com*)

Emuge Corp.

OPENS NEW TECHNOLOGY CENTER IN MASSACHUSETTS

Emuge Corp. has announced the opening of a new technology center, located at the company's North American headquarters in West Boylston, Massachusetts. The center, designed to be a full-service resource for manufacturers to apply cutting tool application strategies, is equipped with the latest 3 and 5-axis vertical machining centers, precision measuring devices and tool monitoring, in addition to an interactive classroom for

training and seminars. The technology center will serve customers across the U.S. and Canada, enabling manufacturing professionals to test cut their applications and develop milling, drilling, and threading strategies to optimize tool life and performance and reduce cycle times.

"Our new Technology Center was conceived as a resource for manufacturers to test new machining concepts and tools without tying up their valuable machines and manufacturing time," explained Bob Hellinger, president of Emuge Corp. "Our tooling engineers work directly with customers to replicate actual machining processes and develop new tooling and application parameters with complete documentation."

Three major services offered at the Emuge Corp. Technology Center include Test Cuts, CNC Programming Assistance and Comprehensive Training:

For the Test Cuts Program, customers can provide Emuge sample parts and prints for evaluation by experienced Emuge tooling engineers. Once approved, test cuts are performed and documented, along with optimal recommended solutions and strategies developed by Emuge.

For CNC Programming Assistance, Emuge programmers work closely with industry leading CAD/CAM provides such as Mastercam, Open Mind and others, to help the user generate maximum machining performance and incorporate optimal tool designs. Emuge will provide customers programing assistance, a wide range of CAM tools for solving complex applications, efficient toolpaths, sub routines and optimization.

Emuge also provides Training and Development in an interactive classroom supported by CNC machining equipment for hands-on, real-time training. Training and seminars will be offered throughout the year on various topics, or custom training can be provided to meet the needs of individual companies. (*www.emuge.com*)

Star SU and Neher Group

ENTER JOINT VENTURE

Star SU LLC and Neher DIA GmbH & Co. KG have entered a joint venture partnership that appoints Star SU to sell Neher's PCD tooling portfolio in North America. The addition of Neher's comprehensive line of diamond tools, including finish reamers, combination tools and PCD/CBN inserts, compliments Star SU's current cutting tool offering to provide a full service turnkey solution.

Star SU LLC president David Goodfellow, Neher Group president Gerd Neher, and Star Cutter Company chairman Brad Lawton.

David Goodfellow, president of Star SU LLC, is very pleased with the new partnership. "Star SU is elated to team together with Neher to bring world-class engineering and PCD cutting tool quality to the North American market. Neher carries a strong presence in automotive, aerospace and woodworking in Europe, and we are excited to expand our product line to best support our customer base."

Neher Group president, Gerd Neher agreed: "By combining Star SU's extensive network in the North American industry and Neher's technological expertise in the field of precision tools, we formed a very powerful cooperation to serve the American market." (*www.star-su.com*)

AGMA

AWARDS MAIURI WITH THE TECHNICAL DIVISON COMMITTEE AWARD

It has been a tradition of AGMA's Technical Division to acknowledge the outstanding contributions of individual committee members with the Technical Division Executive Committee (TDEC) Award.

The award recognizes the countless hours of dedicated work that lead to the development of the standards that have benefited our industry over the last 100 years. The 2016 recipient is **Buzz Maiuri** from Gleason Works. Maiuri has spent his career in the industry, recently celebrating 50 years of service for Gleason this past July. He is currently the chair of the AGMA TDEC. His many years of dedication and countless hours of service to the industry through his leadership was acknowledged at the AGMA Fall Technical Meeting. (*www.agma.org*)

LMC Workholding

WELCOMES VICE PRESIDENT OF MACHINE TOOL PRODUCTS

LMC Workholding recently announced **Pat Klein** as the new vice president of machine tool products. Klein has a diverse manufacturing sales background, selling in multiple channels including phone, field and commercial sales, as well as high volume sales management.

Klein graduated from Albion College with a B.A in Economics and Management and from Arizona State University with an MBA, an Emphasis in Supply Chain Management. He has worked in the telesales and field sales departments for a large metalworking distributor before joining LMC and also held the position of district sales manager.

"We are excited about the addition of Pat to the LMC Workholding leadership team and look forward to great things from him and the team as he grows into the role," said Jay Duerr, president of LMC Workholding. "He will be an asset to the company and we look forward to the growth and strategy development that he will add." (*www.lmcworkholding.com*)

Klingelnberg

SHOWS OFF CYLINDRICAL GEAR TECHNOLOGY IN GERMANY

Klingelnberg presented its wide range of Höfler cylindrical gear machines during a recent event in Germany. (photo courtesy of Klingelnberg).

At a two-day event, gear industry experts from Europe, Asia and the United States had the opportunity to take a close look at the Höfler cylindrical gear machines from Klingelnberg. At the in-house show on November 9-10, the company's latest innovation, direct networking of a Höfler cylindrical gear machine with a Klingelnberg precision measuring center, was the center of focus.

During the two-day in-house show (Ettlingen Oberweier, Germany), the machine manufacturer Klingelnberg presented its wide range of Höfler cylindrical gear machines – and therefore cutting-edge technology in the cylindrical gear machining sector. 100 gear experts from Europe, Asia and the USA were invited and took the opportunity to take a look behind the scenes and talk shop with the Klingelnberg specialists. A total of 13 exhibition areas at the Ettlingen works were dedicated to showcasing the innovative and versatile solutions as well as the very latest technological processes.

The latest development from the system provider enables direct networking of a closed loop cylindrical gear machine with a measuring device. This technology was previously only possible with bevel gear machines. "By transferring the established Klingelnberg closed loop concept for cylindrical gears, we link the machining centers with the measuring machine and are therefore driving digitization of gear manufacturing firmly forward," explains Dr. Christof Gorgels, head of the precision measuring center product line. "The closed loop concept for cylindrical gears is based on an open interface and automates machine correction," he continues.

To demonstrate how the latest Industry 4.0 compliant development can be used for practical production, a Viper 500 cylindrical gear grinding machine was networked with the P 40 measuring machine at the works. "We have been waiting for this interface!" comments a delighted Willi Humbel, chairman of the board of directors of Humbel Zahnräder AG. "This development will help us tremendously to simplify production of our toothed gears and improve the quality of our components at the same time."

Digitization in production was the main topic at the two-day event. Höfler cylindrical gear grinding machines are not only hallmarked by reliable and highly-developed hardware, but the company's own GearPro software also guarantees convenient machining and ensures maximum efficiency in daily use.

In addition, attendees were able to obtain information about the wide range of services of the machine construction company. With the "Höfler Service Gate" remote maintenance concept, a global communication network will be established in the future from the Ettlingen Oberweier site. At the beginning of the technology show, visitors examined a customized eight meter high Höfler HF 6000 cylindrical gear cutting machine at the plant entrance. This cylindrical gear cutting machine for workpieces with a diameter of up to six meters is nothing less than the largest cutting machine in the world with an automated deburring and chamfering unit. (*www.klingelnberg.com*)

Gear Motions

RELAUNCHES PRO-GEAR DIVISION

The Pro-Gear Division of Gear Motions Inc. is being relaunched as a gear grind only division. Pro-Gear will focus exclusively on providing high precision, high quality gear grinding services with quick turnaround time and low tooling cost. This service will appeal to gear manufacturers that need additional capacity and machine shops that require external gear grinding services. Pro-Gear's extensive range of state-of-the-art equipment ensures precision ground gears that adhere to tight customer specifications.Pro-Gear Co. Inc. was acquired by Gear Motions Inc. in 2012 and resides within the company's Oliver Gear Division in Buffalo, NY. As part of the Gear Motions network, Pro-Gear's capabilities are matched with years of experience to bring its customers high quality gear grinding services to meet even the most demanding schedules. (*www.gearmotions.com*)

December 8–10—PRI 2016 Indianapolis, Indiana. Performance Racing Industry 2016 features 1,200 companies that will display the latest advances in racing products and race engineering. Technologies include engine parts, suspension components, data acquisition, safety gear, new metal alloys and coatings, machining equipment, race electronics and racing fuel. The high performance testing and computing zone will draw racing squad owners as well as the world's top racers to test and try the latest models in racing cars. Arriving from 70+ countries and all 50 states, buyers will scour the displays to source the new technology that will be winning races next year. Conferences and seminars include information on vehicle dynamics, advanced engineering, fuel pump design and performance, software, the essentials of operating a shop, lubrication and more. For more information, visit *www.performanceracing.com*.

December 13–15—Power-Gen International 2016 Orange County Convention Center, Orlando, Florida. Power-Gen International provides comprehensive coverage of the trends, technologies and issues facing the generation sector. More than 1,400 companies from all sectors of the industry exhibit each year to benefit from the exposure to more than 20,000 attendees. Displaying a wide variety of products and services, Power-Gen International represents a horizontal look at the industry with key emphasis on new solutions and innovations for the future. Conference sessions include energy storage, the digital power plant, emissions control, gas turbine technologies and more. For more information, visit *www.power-gen.com*.

January 9–13—SciTech 2017 Grapevine, Texas. From its creation in 1963, the American Institute of Aeronautics and Astronautics (AIAA) has organized conferences to serve the aerospace profession as part of its core mission. Spanning over 70 technical discipline areas, AIAA's conferences provide scientists, engineers, and technologists the opportunity to present and disseminate their work in structured technical paper and poster sessions, learn about new technologies and advances from other presenters, further their professional development, and expand their professional networks that furthers their work. The AIAA Science and Technology Forum and Exposition (AIAA SciTech) has continued to grow in each succeeding year, drawing participants from around the globe. SciTech participants tackle the most pressing issues impacting the future of aerospace, while the technical program presents innovative research and technologies that offer solutions. For more information, visit *www.aiaa-scitech.org*.

January 17–20—World of Concrete 2017 Las Vegas, Nevada. Original equipment manufacturers from around the world and exclusive U.S. distributors of equipment, tools, products and services for the commercial construction, concrete and masonry industries attend World of Concrete. The show attracts approximately 1,500 exhibitors and occupies more than 700,000 net square feet of indoor and outdoor exhibit space. World of Concrete is the premier event for the commercial construction trades. Education tracks include engineering, safety and risk management, general business, business and project management and concrete 101. Interactive workshops include trainer training, construction boot camp, sales and more. For more information, visit *www.worldofconcrete.com*.

January 26–February 1—IMTEX 2017 Bangalore International Exhibition Center, Bangalore, India. IMTEX 2017 provides a range of metal-cutting machine tool technologies, products and solutions to meet the demands of the manufacturing industry. With global focus shifting towards the country's "Make in India" initiative, the manufacturing industry is poised for growth. The event attracts visitors from a wide spectrum of manufacturing and ancillary industries starting with key decision and policy makers sourcing the latest technologies and manufacturing solutions for their production lines. Products include milling, turning, gear manufacturing, grinding, honing machines, flexible manufacturing systems, machining centers, and more. Co-located with IMTEX is ToolTech 2017, the 19th International Exhibition of Cutting Tools, Tooling Systems, Machine Tool Accessories, Metrology and CAD/CAM. For more information, visit *www.imtex.in*.

February 7–8—Internet of Manufacturing Business Conference Munich, Germany. The Internet of Manufacturing Business Conference will demonstrate how Industry 4.0 can benefit your business. This two day conference includes case studies, cutting edge debates and a variety of speakers from organizations including Siemens, RWTH Aachen University, Airbus, Caterpillar, Rolls Royce, the VDMA and more. Attendees will learn about cost savings of connecting machine tools, how intelligent machines can optimize production and how technology today will better prepare everyone for manufacturing in the factories of the future. An exclusive workshop presented by Professor Frank Piller, RWTH Aachen University will introduce a methodology to better understand, design, and test models for Industry 4.0. For more information, visit *www.internetofbusiness.net*.

February 7–9—Advanced Manufacturing Expo & Conference 2017 Anaheim Convention Center, Anaheim, California. Advance Manufacturing Expo & Conference is a three-day event that includes admission to ATX West, MD&M, Electronics West, Plastec West and WestPack. This year's conference offers industry-focused programs composed of technical sessions, real-world case studies and hands-on workshops that cover the trending hot topics, methodologies and tools in the manufacturing, fabrication, repair and maintenance industries. The show boasts 150+ industry experts, 2,200 exhibiting suppliers and the opportunity to network with 20,000+ peers. For more information, visit *Anaheim.ubmcanon.com*.

February 7–9—Ipsen U Cherry Valley, Illinois.Ipsen U is a practical course for building and refreshing knowledge of thermal processing equipment. Ipsen U addresses all levels of experience in a casual, open-forum environment that encourages attendees to ask questions about their equipment and processes. The class's modular format allows participants to directly interact with several Ipsen experts and ask questions about their specific needs and concerns. Ipsen U also provides customers direct access to information that transfers furnace maintenance and upkeep into their own hands. Information covered includes terminology, theory, processes, metalllurgy and more. For more information, visit *www.ipsenusa.com*.

February 22–24—AGMA 2017 Gear Materials Clearwater Beach, Florida. Learn what is required for the design of an optimum gear set and the importance of the coordinated effort of the gear design engineer, the gear metallurgist, and the bearing system engineer. Investigate gear-related problems, failures and improved processing procedures.Gear design engineers, management involved with the design and manufacture of gearing type components; metallurgists and materials engineers; laboratory technicians; quality assurance technicians; furnace design engineers; and equipment suppliers should attend. The course is instructed by Ray Drago and Roy Cunningham. For more information, visit *www.agma.org*.

gear TECHNOLOGY

FREE SUBSCRIPTION

Gear Technology, is the world's leading publication on gear design, engineering and manufacturing. To sign up or renew your **FREE SUBSCRIPTION** use the form below.

FIND THE EXACT SUBJECTS YOU ARE LOOKING FOR: Subscribers now get access to the 30 years of searchable articles in our online archive.

1

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

☐ No thank you.

Name:_____ JobTitle/Position: _____
(print)

Signature _____ Date: _____
(required)

2 → E-mail _____
(So we can notify you when the online edition is available)

SAVE a TREE!

☐ I ONLY want the digital edition (e-mail required)

3 → Please update your contact information or attach you business card here. (No Staples)

Company Name: _____

Address: _____

_____

_____

City: _____

State/Province: _____ ZIP+4/Postal Code: _____

Country: _____

Telephone: _____ Fax:_____

E-mail: _____

Website: _____

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

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

5 → My company's principal product or service is:_____

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

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

Is there a colleague within your company that might benefit from having their own copy of ***Gear Technology*** magazine?

Name: _____

Title: _____

DIGITAL SUBSCRIPTIONS

❑ **YES, I want to be notified each issue when *Gear Technology* is available online**

❑ **YES, I would like to receive *Gear Technology*'s monthly e-mail newsletter**

❑ **YES, I would like to receive *Gear Technology*'s twice monthly e-mail Product Alerts**

❑ **YES, I would like to receive 3rd-party e-mails from *Gear Technology*'s advertisers and partners**

❑ **YES, I would like to receive subscription renewal notices by e-mail**

❑ **No, I do not wish to be contacted by e-mail.**

Building Gears, Building Communities

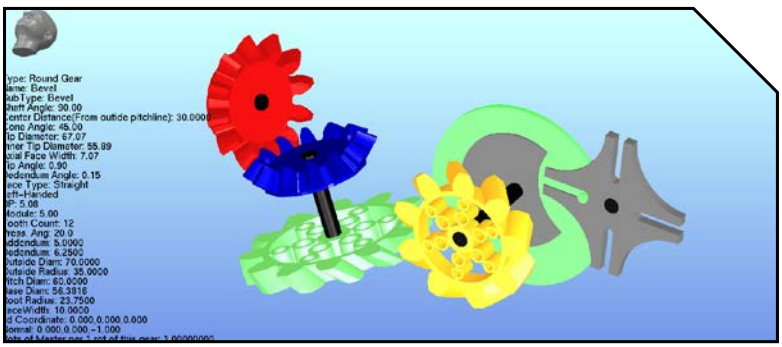
Art Fenerty's Gearotic software is making it easier for hobbyists to build both their dream gear designs and friendly communities.

Alex Cannella, News Editor

Outside of our industry, there's a whole slew of hobbyists working with gears to make clocks, art pieces, watches and all manner of bizarrely shaped gears (you know, all the people that usually end up featured right here in our Addendum section).

But it's no secret that gear manufacturing is pretty technical stuff. You need a very specific set of skills to properly design a gear, and if our magazine is anything to go off of, our understanding of how to make gears better is always growing. We may take it for granted sometimes, but the fact of the matter is that a lot goes into making a gear, and for hobbyists, the sheer amount of time and knowledge you need to properly design a gear can be an overwhelming barrier to entry.

Enter Gearotic, a program designed specifically to allow those hobbyists to make the gears they need with the least fuss possible. The program's designer, Art Fenerty, created it to offer a simpler alternative to CAD programs, one of the many hurdles of knowledge hobbyists need to get over to design their own gears. Gearotic is designed to lower that barrier to entry and let hobbyists spend less time worrying about the technical side of things and more time creating.



"It takes a great deal of time and energy and focus to learn how to draw in CAD," Fenerty said. "And it sticks with you just like learning a foreign language. As long as you use it constantly, you'll become a very good designer and you can make gears and so on with all kinds of CAD packages. But what I've found is for a lot of hobbyists, they don't have the time to dedicate to learning a CAD package."

Fenerty initially created the program to help facilitate his own hobby. After retiring, Fenerty turned to making wooden clocks to fill up his time, but he quickly found that there wasn't a satisfying program out there to work with, so he ended up making his own.

"I wrote the software for myself, but then decided I'd put it online and see if I could build a hobby community around it," Fenerty said.

He didn't stop there, though. As Gearotic has attracted more and varied fans, Fenerty has been growing the program to meet their needs. The program's grown from a basic gear template program to simulate an "eclectic mix" of other design projects such as sculpting designs for 3d printing, full gear assemblies, clock escapements, non-circular gears, Celtic knots and more, and he comes out with more features every year.

"I don't really have a vision for its end result, but I'm always aiming for a next short-term goal," Fenerty said.

Fenerty has a set production schedule where he works on a major feature from fall through spring, then "takes a break" in the summer to code a smaller project. This past summer, Fenerty made it possible for users to add flourishes, aesthetic touches for clocks, to their designs. Currently, he's working on a system that can simulate gravity for kinetic art pieces. He wants to offer kinetic artists a chance to simulate their designs and see what they'll look like before the construction phase.

"I try to focus on modules that no one else does, specifically because there are a lot of good CAD programs out there and there's a lot of really good drawing programs," Fenerty said. "So I don't want to reinvent the wheel. I'm just trying to make little modules like a toolbox. You may not use those tools every day, but it's kind of handy to have one in your back pocket."

But even beyond building clocks or a software program, Fenerty's in the business of building a community. Gearotic draws in like-minded craftsmen of all walks, and many of the software's most recent features come from community demand. Kinetic artists, for example, make up a sizeable portion of Gearotic's community since most kinetic art is based on the same principles as clock escapements, something the program already lets users work with. So expanding features specifically intended for kinetic artists makes sense as a direction for Fenerty to go next.

Occasionally, Gearotic even attracts a few businesses that come in looking for a particular non-circular gear design, as well. And according to Fenerty, everyone who comes through the community's virtual doors is friendly.

"With Gearotic, it's been very relaxing," Fenerty said. "Most people react enthusiastically when I release something...It's one of the few forums I've been on that nobody's insulting each other. There's no darkness in there."

Gearotic's community may not be the most well-populated community on the Internet, but it's certainly one of the most positive. I'd even go so far as to say that out of all the different things Fenerty's built over the years, a genuinely genial and upbeat online community is perhaps the most impressive of all.

For more information:
Gearotic
www.gearotic.com

Buying a Heat Treatment Furnace

Call Our Sales Team

1-800-727-7625

International: +1-815-332-4941

Replacing a Door Seal on an Atmosphere Furnace

Checking and replacing a door seal on a regular basis is an easy way to maintain your atmosphere furnace and keep it in peak condition. Overall, inspecting the door seal is important as it may crack, fray or gap over time, which can then cause the furnace to leak. The most common indication the seal needs to be replaced is leaking gas or smoke.

Throughout this video, we walk you through the quick, step-by-step process for replacing the door seal on an atmosphere furnace. Some important tips to remember include …

Bit.ly/ReplacingDoorSeals

Read the full blog post here:

Essential Questions To Ask

Buying a vacuum or atmosphere heat-treating system is much like purchasing a new car or a home – a lot of thought, research and careful consideration should go into the decision. However, unlike buying a car or home, it might be difficult to know all of the key items you should consider before making such a purchase.

Our Ipsen experts have compiled a list of 11 essential questions every furnace buyer should ask themselves before committing to a furnace, as well as a few key considerations for reducing downtime and extending the lifespan of the furnace.

Buying a Furnace

1. What is your budget? Make sure to do some research and acquaint yourself with the general cost of different furnaces, as well as the cost of optional features, auxiliary equipment, transportation and installation. Then decide on a budget that will best meet your needs.
2. Will your parts be processed in vacuum or atmosphere?
3. What types of processes will you run in the furnace?
4. How many parts do you want to process per month? This number will help determine …

Read the full blog post here:
Bit.ly/FurnaceBuyingConsiderations

www.IpsenUSA.com

Ipsen

TEAMPLAYER.

GEAR MANUFACTURING SOLUTIONS FOR MAXIMUM PERFORMANCE BY KLINGELNBERG

KLINGELNBERG	OERLIKON	HÖFLER
MEASURING TECHNOLOGY	BEVEL GEAR TECHNOLOGY	CYLINDRICAL GEAR TECHNOLOGY

A winning team has a system. It is perfectly tuned and balanced. It acts with the utmost precision. The strengths of each individual work together like perfect gears.

Klingelnberg's divisions are true team players:
Ground breaking solutions for an optimal production process of Bevel and Cylindrical Gears give manufacturers worldwide a leading edge in gear manufacturing.

SUBJECT TO CHANGES

NEXT FAIRS:

IMTEX 2017
Hall 3, Booth B-111
January 26 - February 01
Bangalore, India

Win the match:
www.klingelnberg.com
www.hofler.com

KLINGELNBERG America, Inc.
p. +1 734 470 6278
e. usa.sales@klingelnberg.com

BEVEL GEAR TECHNOLOGY | MEASURING TECHNOLOGY | CYLINDRICAL GEAR TECHNOLOGY | DRIVE TECHNOLOGY