GEAR TECHNOLOGY

September/October 2010

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The Journal of Gear Manufacturing

THE GEAR INDUSTRY'S INFORMATION SOURCE

IMTS 2010

Features

- Show Coverage:
  - Conferences & Special Exhibits
  - Booth Previews
  - Updated Booth Listings
- Ultra Light Urban Vehicle Project

Technical Articles

- Angular Gear Drives, Part 2—Straight Bevel Gears
- NASA on Metallic Debris vs. Meshing Gear Teeth—The Battle Joined

Plus

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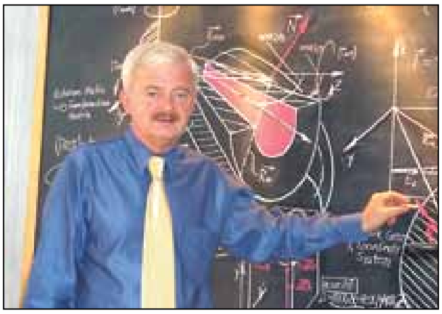

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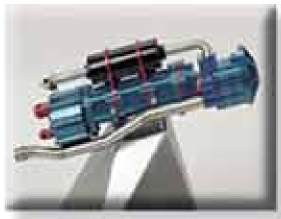

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Forest City Gear helps customers in an extremely diverse group of industrial, medical, aerospace, sporting goods, research lab and high-performance racing markets, plus many others. Some might foolishly suggest this makes us "a jack of all trades, master of none," as that old adage goes.

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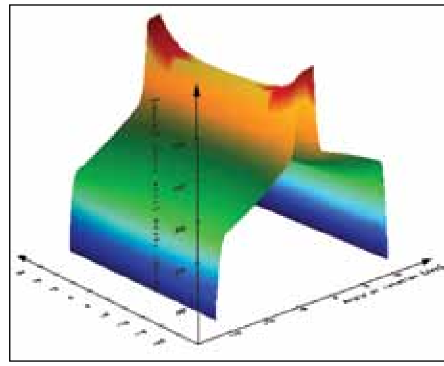

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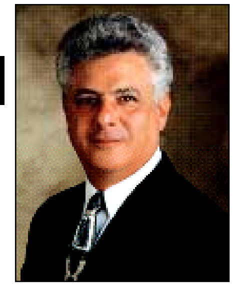


Taking Care of Your "BEST" Customers

When you've been in business for a number of years, it's easy to take some of your best customers for granted. In *Gear Technology*'s case, we've been publishing since 1984—26 years and counting. Some of our subscribers have been loyal readers since the very beginning.

In our business, we're constantly on the lookout for new subscribers, advertisers and authors. I'm sure it's similar in many of your businesses. You need new customers to grow your business. You need new suppliers to make you more competitive, and so on.

But what about those old-timers—the ones who've been with you so long you might tend to forget about them. You assume they'll always be there because they've always been there. Are you taking care of those customers the way you used to?

We recently e-mailed an informal survey to 1,000 of our most loyal readers, each of whom has been a subscriber for at least 15 years. We were hoping to hear that our magazine is just as important to them today as it was when they first signed up. It was gratifying to find out that with most of the respondents, that was the case.

For example, a 17-year veteran of an industrial speed reducer manufacturer told us: "I still receive *Gear Technology* and have a drawer full of every issue that I ever received just in case I need to reference an old article...I have no criticisms at all and thank you for all the magazines through the years."

An engineer at a manufacturer of electric motors said, "What I like about *Gear Technology* is that I can relate many of the articles to my everyday work. I've often used past issues as technical references."

Many others offered similar opinions. They've saved every issue. They've found the magazine useful. They've learned from it, "it's an unbiased technical resource for people searching for solutions and ideas."

And time and time again, readers mention the importance of the information in our advertising as a way to keep informed about products and services available to them.

But there were also many, many useful suggestions for improvement. For example, those who specialize in a certain area tend to want to see articles in that area. Some want articles on small or fine-pitch gears. Some want articles on heat treating. Some want to see more design-related articles "with more graphics," while others want to see more practical, hands-on manufacturing articles. We do our best to provide a wide variety of types of articles, and our goal is to have something for everyone in each issue.

We're taking a close look at the suggestions from our readers. Over the next several months, we'll be developing some of those suggestions into articles, columns or regular departments.

Quite a few of our respondents suggested that they would like to see more "Back to Basics" type articles, and we agree. New gear engineers—or engineers new to gearing—often need a reference on some of the fundamental concepts, and our intention is to provide that basic information. Such articles were a staple of *Gear Technology* for many years, and although we've covered most of the subjects in previous back-to-basics columns, we intend to bring some of those subjects back, refreshing them and publishing them for today's audience.

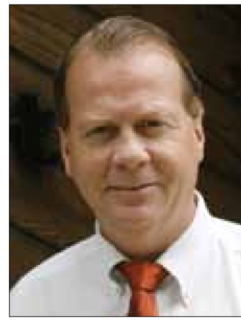
One reader suggested that we start a column to help explain gear standards. In fact, we have already begun that process, with our AGMA Voices column. Over the coming issues, we intend to use AGMA Voices as a forum for the various technical committee chairmen to communicate with the gear industry, giving our audience a better understanding of the standards-making process and the significance of those standards.

Another reader asked that we try to publish more articles from overseas technical conferences that our readers don't have the opportunity to attend. When I started *Gear Technology*, I knew that very few individuals actually got to attend technical conferences, and when they did, they often came home from the conference and put the binder of presentations on a shelf in their office where none of their colleagues and coworkers ever got the benefit of them. One of my goals when I started this magazine was to make that educational reference material available to a much wider audience. With that in mind, we'll continue to make every effort to bring you the best possible technical papers on gearing, from all around the world.

Communicating with our long-time readers in this way has been an important exercise for us. Not only was it personally gratifying ("The industry needs you! Thanks for doing what you do so well."), but it also reaffirmed our mission and gave us an opportunity to find out how we can strengthen our product to ensure that all of you will be reading *Gear Technology* for many years to come.

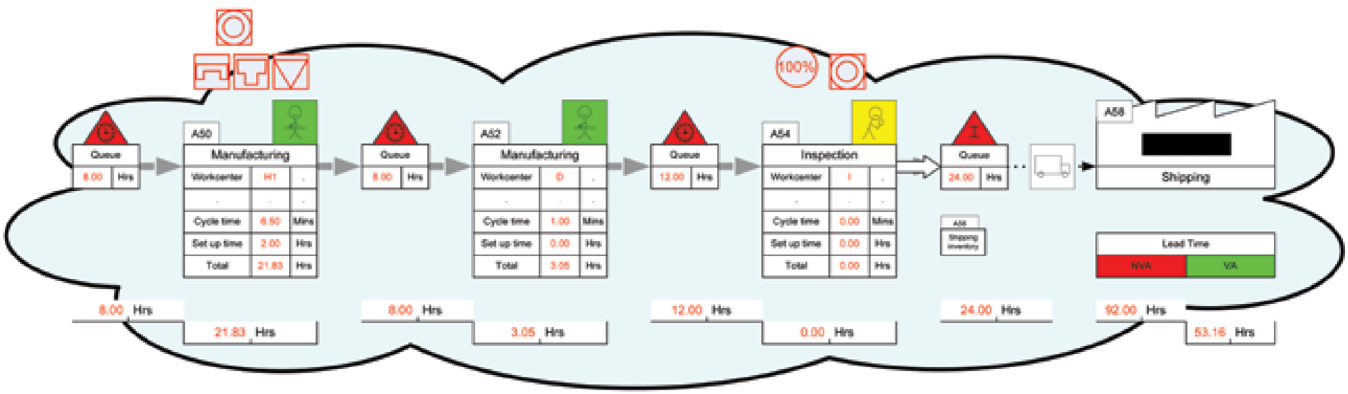
Michael Goldstein,
Publisher & Editor-in-Chief

P.S. If any of you have suggestions for *Gear Technology*, please send them to *publisher@geartechnology.com*. We're interested in your feedback whether you've just read your first issue, or you've been with us since *our* first issue.



Enterprise Excellence: Are We There Yet?

John P. Walter, president and CEO, Precipart Corporation
Abby Dress, associate professor, Long Island University



When the term, "what you see is what you get," is applied in the computer industry, it means that users or customers are able to see their end results without the encumbrances of complicated software code that enables this function. Software works behind the scenes ultimately to produce transparency and the desired effects. In many ways, this concept should be extended to the relationships that exist between suppliers and buyers and even among internal company departments.

Wouldn't it be efficient for customers to qualify new suppliers based on what auditors see in the respective facilities of suppliers? Or, what companies tout as facts are indeed real and do not need to be certified or reviewed periodically? Obviously, the ideal would be for processes throughout the enterprise to be performed to stated specifications. This way the product matches the paperwork, and the paperwork reflects a trustworthy and capable manufacturer. Exacting performance means that employees contribute to profitability and, at the same time, make the company environment flexible, efficient, predictable and safe.

Frequently there are challenges. Perhaps, opportunities arise suddenly, new markets open up, or problems need to be addressed. Other times, new or different technologies require evaluation, adoption or training. To achieve enterprise excellence means thoroughly proofing and transforming an organization so that it can solve and take advantage of quality, cost, schedules and risk issues for current programs, while allowing for the potential of new ones. Some managers today are so mired in the day-to-day battles that they do not have the luxury to take a hard look at their businesses.

However, a deep look within and across programs and departments can be enlightening, so much so that from this visual review an organization can adjust and build the collaborative setting needed. Maybe this observational process should be called company soul-searching. It's easy. Simply take a look around first. Is the company's enterprise or culture right—are the right people with the right skills and responsibilities in place, are the processes right, and are the right technologies in place—to satisfy the customer's needs?

Maybe this is difficult to assess quickly, but observation is the first step, and this can be very revealing. Are materials piling up? Are some machines idle, or are some people standing around awaiting the next run? Are supervisors spending too much time giving instructions on the production floor with the result that actual production times are reduced? Or maybe the inspection department is a bottleneck and actually is holding up product ready to ship due to slow, final inspection requirements. The flow and the capacity for handling materials throughout the manufacturing process itself are critical to enterprise excellence.

When you take a look around, you really see how the business is working. Just as importantly, you also view what perhaps is not working. There is no question that customers and their buyers want to be assured of specific results, and depend on suppliers to provide them. Yet, why should buyers review supplier processes to confirm quality metrics, when this really should be a function performed by the supplier itself? After all, isn't a company supposedly responsible for a finished part or product that is delivered on time and one that measures up?

Of course, delivery schedules sometimes can be delayed unavoidably. Communication is key when this occurs, but what happened to account for the delay? Who is in charge to handle complaints? Did a delay occur because a product was not routed properly or materials were not ordered in time? Maybe the supplier committed to an unfeasible or unreasonable schedule just to acquire the business? Was the timing at the outset determined arbitrarily without regard to when the customer really needed the component? Or, did the customer and supplier negotiate operational capabilities and schedules, using tools like Kanban or other demand flow techniques, so that everything would mesh and arrive in a just-in-time fashion?

Precipart fosters an atmosphere of continuous improvement using a range of quality standards and strategies. From lean and Six Sigma practices to spaghetti diagrams, failure mode and effect analysis, and kaizen events, managers are encouraged to mistake-proof their processes and offer suggestions for improvements, and this includes departments other than manufacturing ones, like sales, too. Buy-in to the process is fully integrated throughout the company due to participation by senior managers and regular meetings dedicated to improvement discussions and decisions. Held every four to six weeks, this quality system team is charged with problem-solving for improvements. Some companies, which do not have senior managers involved for immediate decisions, have representatives to champion the process. At Precipart, a full-time continuous improvement manager facilitates the solutions with the full participation and support of its president. It is a dynamic, ongoing process.

Metrics have helped companies foster collaboration so they can develop plans to achieve enterprise excellence. Motorola was one of the first companies to identify these principles and adopt them. Since then, its methodologies and practices have been embraced by many others around the world as companies have sought to transform themselves into agile organizations of excellence. Precipart regularly compares actual production times with its quoted times and seeks improvements, looking for simple efficiencies to enhance performance. Ultimately, any improvements translate into better customer relations in multiple ways.

In a sense, the idea of enterprise excellence should involve a different mindset; it should transition beyond defect reduction to one of performance improvement. Its approach should be to capitalize on past successes and collectively focus an organization on its strengths. Then a company is equipped and flexible to address problems, capture opportunities, adapt to changing requirements and technologies, and evaluate associated risks.

That brings up some remaining questions: Is your plant such a safe environment you would let your family work there? And, of course, you would buy products from your facility, right?

No matter how good an organization becomes, it cannot become complacent or accept that it is good enough. It must be driven by a never-ending passion for optimizing the customer experience. A passion not just for improvement, but for an understanding of the drivers behind business cost and customer satisfaction and a constant focus on improving those metrics.

Excellence within an enterprise should be visibly evident. Everything has its own place, so that when you look around, it looks like everything is orderly, and the production flow appears to be running smoothly. That is why customers are impressed when they visit any audit supplier plants that have embraced enterprise excellence. Everything is transparent: What you see is what you get.


GEARS-TO-GO.
PRECISION STOCK GEARS

KISSsoft Introduces New Features with Latest Release

Tooth contact under load is an important verification of the real contact conditions of a gear pair and an important add-on to the strength calculation according to standards such as ISO, AGMA or DIN. The contact analysis simulates the meshing of the two flanks over the complete meshing cycle and is therefore able to consider individual modifications on the flank at each meshing position.

The tooth contact analysis (TCA) is therefore mainly used to reduce noise that is caused by the effect of shock load at meshing entry due to elastic bending of the loaded teeth. It is further used to optimize load distribution by analyzing the effectiveness of gear profile modifications considering the misalignment of the gear axis due to shaft and bearing deformation under load.

Basic Calculation Method

The tooth contact analysis simulates the meshing contact assuming a constant nominal torque. The calculation procedure has been defined by Peterson: For a given pinion rolling position (rotation angle ϕ_1) the corresponding gear rolling position ϕ_2 is determined with an iterative calculation (Fig. 1).

The calculation considers the local elastic deformation due to several effects and the corresponding stiffnesses which appear under load: stiffness from bending and shear deformation c_Z, stiffness from Hertzian flattening c_H and bending stiffness of the tooth in gear body rim c_{RK}.

This calculation procedure is repeated for the entire meshing cycle. Comparisons with FE calculations showed a very good correlation.

The final stresses include the load increasing factors calculated by the standard, such as application factor K_A, dynamic factor K_V and load distribution factor $K\gamma$ in planetary gears or gear pairs. For the tooth root stress, the gear rim factor Y_B according to ISO6336 is also considered.

Before the release of *KISSsoft 04-2010*, the load distribution factors $K_{H\alpha}$, $K_{H\beta}$ for Hertzian pressure and $K_{F\alpha}$, $K_{F\beta}$ for root stress were considered. This has been changed for the enhanced tooth contact analysis.

What's New in Version 04-2010?

With *KISSsoft 04-2010*, the TCA for cylindrical gears has improved significantly. In addition to the preceding releases, the stiffness model was extended to better take the load distribution in the width direction into account, which is a significant characteristic of helical gears, but also other effects are now considered, finalizing in the 3-D display of results.

Coupling between the slices. For a tooth contact between helical gears, the meshing field is different than for spur gears. The contact lines for a spur gear are parallel to the root line, and herewith also the load distribution in length direction is uniform. The contact lines for a helical gear are diagonal over the tooth, which means the load is not uniformly distributed over the length of the tooth. Still the unloaded part of the tooth has a supporting effect and influences the deformation of the tooth as well. This supporting effect of the unloaded areas has to be considered for the contact analysis of helical gears.

For this purpose, in *KISSsoft 04-2010*, the gear is in lengthwise direction, divided in slices. The single slices are then connected between each other with the coupling stiffness c_c so that a supporting effect between the slices can be considered (Fig. 2).

$$C_{Pet} = f\,(C_Z, C_{RK}) \qquad (1)$$

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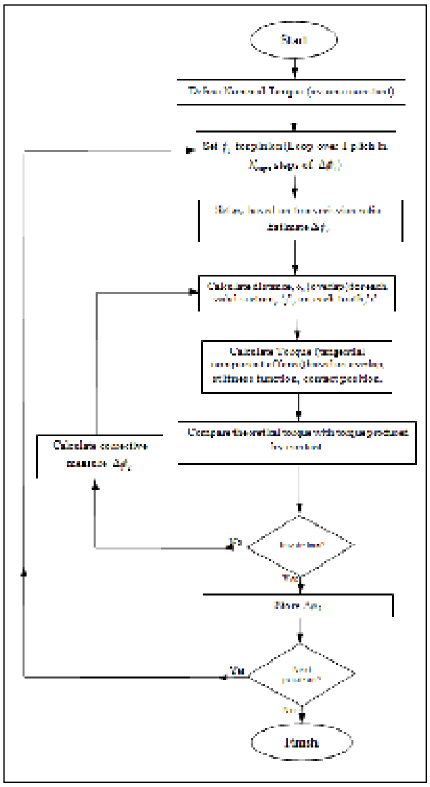

Figure 1—Tooth contact analyses according to Peterson.

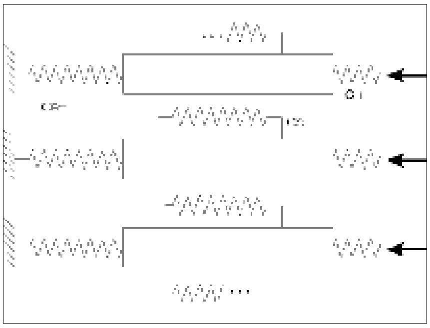

Figure 2—Stiffness model according to Peterson and *KISSsoft 04-2010*.

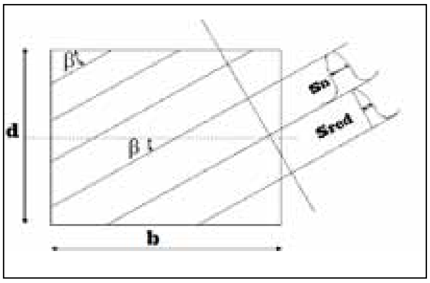

Figure 3—Decreased rigidity on the side borders.

c_{Pet} stiffness tooth root following Peterson

c_Z stiffness from bending and shear deformation

c_{RK} stiffness from deformation through rotation in the gear blank

c_H stiffness from Herztian flattening following Peterson

The coupling stiffness c_C is defined as follows:

$$c_C = 0.04 \cdot A_{sec}^2 \cdot c_{Pet}$$

c_C coupling stiffness

A_{sec} Number of slices

The coupling stiffness is related to the contact stiffness and hence individual for each gear pair, and is verified for different gear types with FE calculations and other established software. The number of slices A_{sec} depends on the accuracy setting which is defined from the user. However, the single coupling stiffness c_C is defined in a way that the system coupling stiffness is independent of the number of slices and therewith also independent of the user settings.

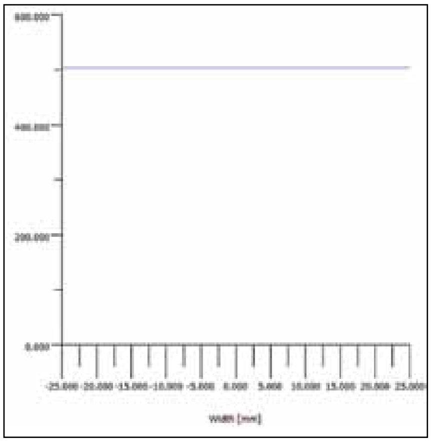

Figure 4a—Previous *KISSsoft* release shows constant normal force (line load) over face width.

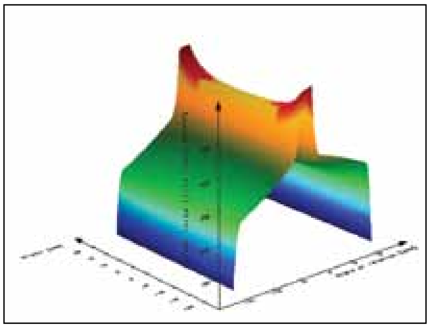

Figure 4b—*KISSsoft 04-2010* shows the increased normal force (line load) at edges of contact area.

In Figure 4, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a spur gear (helix angle β= 0°) with a larger face width for the pinion (b_1 = 50 mm) than for the gear (b_2 = 44 mm). The supporting effect of the unloaded face area outside the meshing contact causes an increased edge pressure within the meshing contact. This effect can now be considered with the coupling stiffness between the slices.

In the previous *KISSsoft* releases, the forces remain constant (Fig. 4a), whereas in *KISSsoft 04-2010*, the normal force at outer ends of meshing contact is increased (Fig. 4b). Note that Figure 4a shows the pinion face width b_2 = 50 mm, whereas in Figure 4b only the common face width b = 44 mm is displayed.

Decreased stiffness on the side borders of helical gears. For helical gears, the tooth may be cut by the cylindrical bodies (Fig. 3), which results in reduced tooth thickness s_{red} compared to a tooth that is not cut having a tooth thickness s_n. Whenever force is applied to the tooth with reduced tooth thickness, it will result in higher deformation due to lower stiffness. This effect is considered with the reduced coupling stiffness c_{Pet_border} for the slices of teeth.

In *KISSsoft 04-2010*, the following formula is applied, which is also verified with FE calculation and other established software.

$$c_{Pet\_border} = c_{Pet} \cdot \sqrt[2]{\frac{s_{red}}{s_n}} \qquad (2)$$

c_{Pet_border} coupling stiffness for slices with reduced tooth thickness

c_{Pet} standard coupling stiffness

s_{red} reduced tooth thickness at border

s_n standard tooth thickness

In Figure 5, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a helical gear (helix angle β = 15°) with the equal face width b = 44 mm. In the previous releases the effect of reduced coupling stiffness at border wasn't considered; therefore the normal force (line load) at border isn't increased. In *KISSsoft 04-2010*, the normal force at the start as well as end of contact is increased.

Revised calculation of tooth stiffness of helical gears. For helical gears, the contact stiffness c_{Pet} following Peterson is calculated based on the effective tooth form in normal section. In earlier *KISSsoft* versions, the tooth form was based on the transverse section multiplied by the factor cos

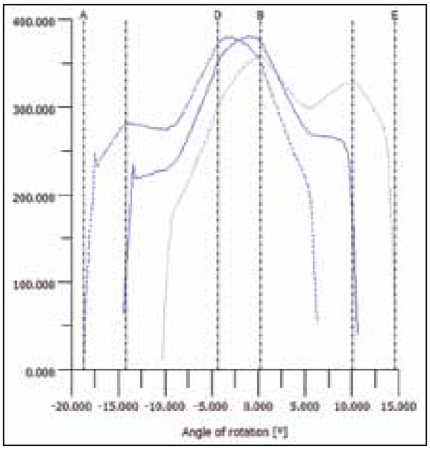

Figure 5a—Previous releases don't show higher normal forces (line load) at ends.

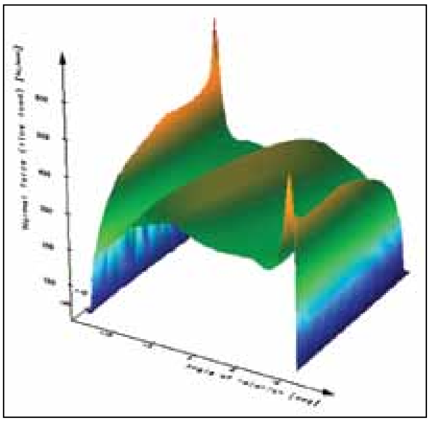

Figure 5b— *KISSsoft 04-2010* shows higher normal forces (line load) at start and end of contact.

β, which is a less accurate procedure. Therefore the results slightly differ between this and older releases.

In Figure 6, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a helical gear (helix angle β = 15°) with the equal face width b = 44 mm. In *KISSsoft 04-2010*, the tooth stiffness is slightly different from the previous *KISSsoft* release. Since the transmission error is strongly related to the stiffness, the transmission error slightly differs, too.

Load distribution considerations. In previous *KISSsoft* releases, it was not possible to consider any unequal load distribution correctly since the slices were not coupled. Therefore the load distribution was added taking the factors KH_α, KH_β as well as KF_α, KF_β (ISO) and K_M (AGMA) from the standards calculation. These were multiplied to the stresses from the tooth contact analysis. In *KISSsoft 04-2010* these factors are no longer used. However, the displayed stresses are still multiplied with the application factor K_A, dynamic factor K_V and load distribution factor K_γ in planetary gears or gear pairs.

In Figure 7, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a spur gear (helix angle β = 0°) with the equal face width b = 44 mm. It's

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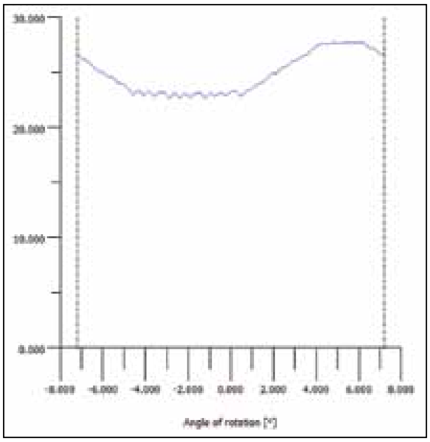

Figure 6a—Previous releases calculate slightly higher tooth contact stiffness.

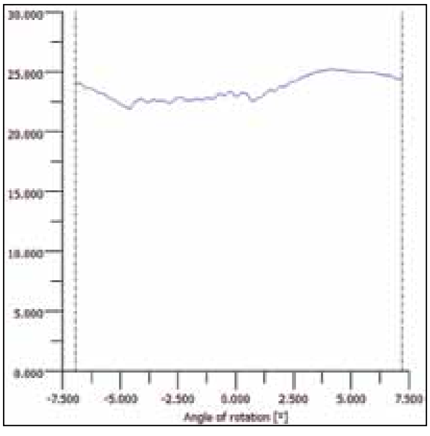

Figure6b—*KISSsoft 04-2010* calculates slightly lower tooth contact stiffness.

an overhang design, meaning the gear is outside the bearings. This results in an increased load distribution factor according to ISO standard calculation with KH_β =1.27 and KH =1.0.

The tooth contact calculation is done without considering any misalignment of the gear axis; values for deviation error and inclination error are set as 0. In *KISSsoft 04-2010*, flank pressure and root stresses are lower compared to the previous release. For a realistic contact analysis, the gear axis misalignments should be defined with shaft and bearing calculations, i.e., from *KISSsys*.

Calculation of Hertzian pressure. The calculation of the Hertzian stress is based on the Hertzian law in the contact of two cylinders. This gives realistic results in most situations. However, a problem is encountered when the contact is on a corner of the flank, i.e., corner at the tip diameter, corner at the beginning of a linear profile modification or corner at the beginning of an undercut. Then

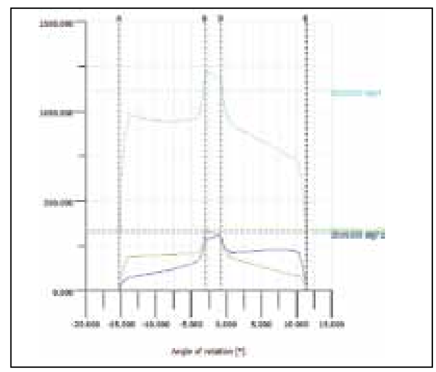

Figure 7a—Previous releases consider load distribution factors in tooth contact analysis.

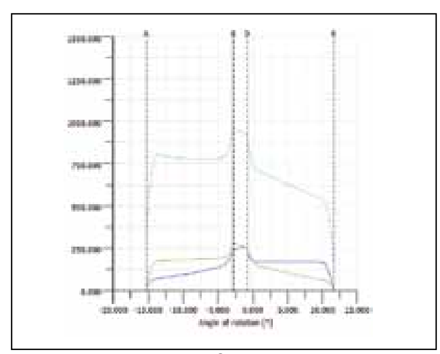

Figure7b—*KISSsoft 04-2010* doesn't consider load distribution factors from standard calculation.

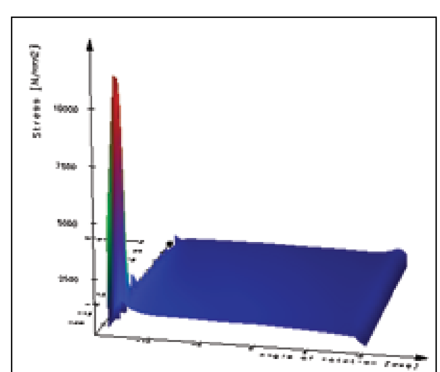

Figure 8a—High pressure peak due to no tip rounding.

the radius of curvature becomes very small, which results in a high peak of Hertzian stress calculation. This is not a realistic issue, because the part of the flank near to the corner will be joined in the contact. An algorithm checking the joining flank parts and increasing the radius of curvature is implemented. However, it may be that high peaks still remain. *KISSsoft* recommends adding a realistic radius to the corners and using circular profile modifications instead of linear.

In Figure 8, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a spur gear (helix angle β = 0°) with the equal face width b = 44 mm. In Figure 8a there is no tip rounding applied, whereas in Figure 8b there is a tip rounding of 0.5 mm. The pressure peaks are drastically reduced with the tip rounding.

3-D Display

With *KISSsoft 04-2010* the graphical evaluation has been enhanced with 3-D graphics. However, the 2-D graphics remain as a good comparison to the previous releases. The 3-D graphics show a three-axis diagram, where the color indicates the stress level. In some cases there may be points where the stress data is missing. In such cases the colors are interpolated directly between two neighboring stress data values. This may result in unequal color display. Figure 9 shows an example of this effect at start and end of contact.

continued

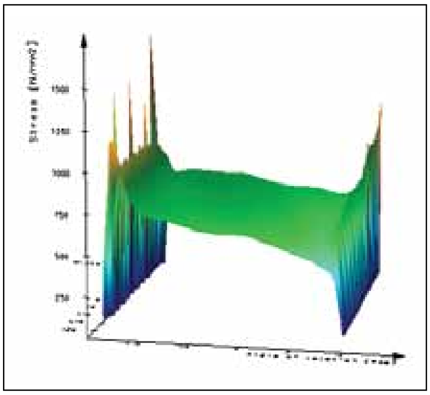

Figure 8b—Much lower pressure with tip rounding of 0.5 mm.

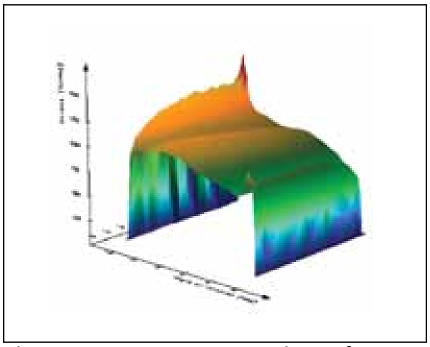

Figure 9—3-D presentation of stress level.

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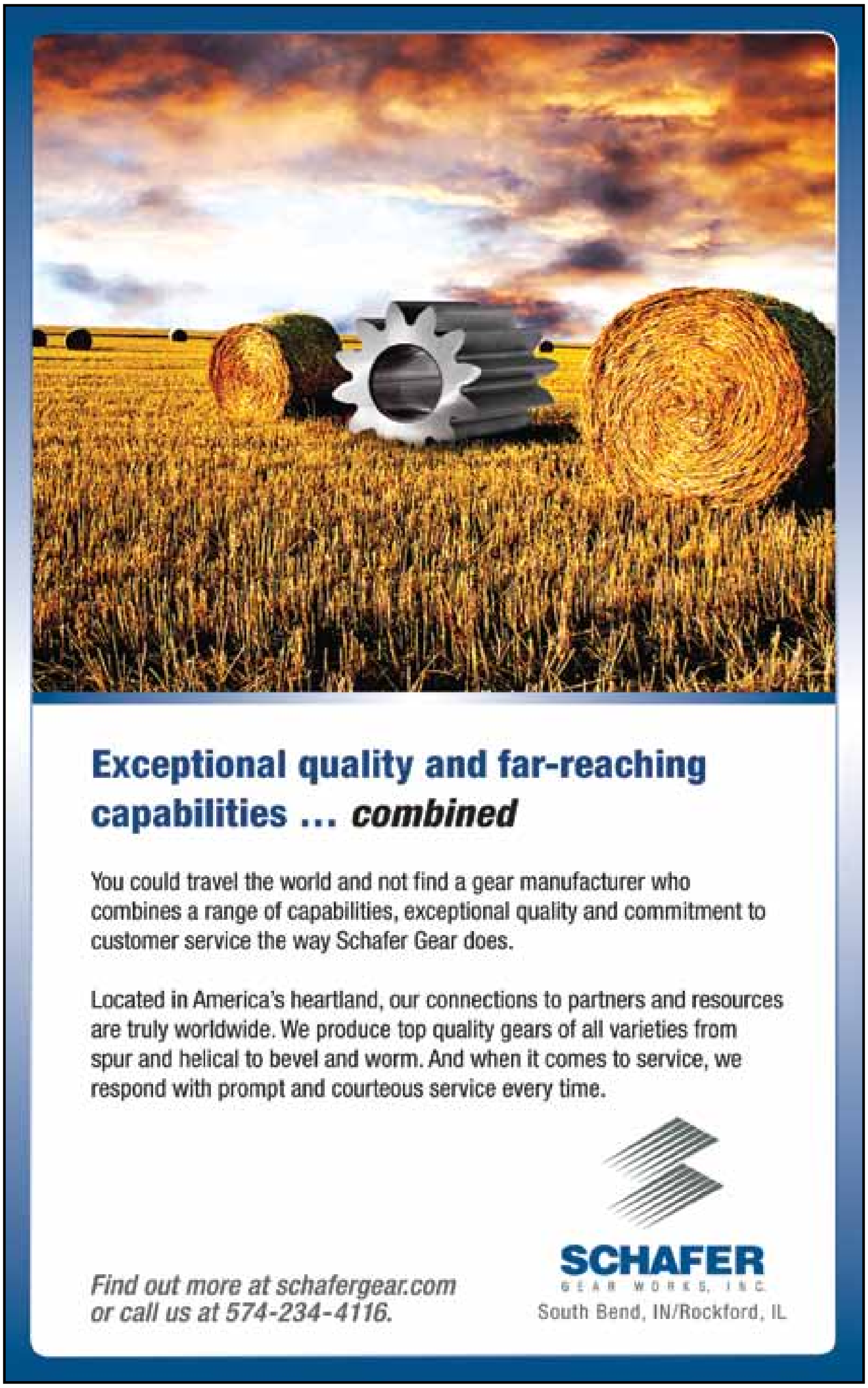
www.kisssoft.com

Shot Peening System

DESIGNED FOR AEROSPACE GEARS



Guyson Corporation has introduced a 7-axis robotic pressure-blast shot peening system that is designed to support compliance with the most demanding process specifications and to enable automated peening of a wide variety of dissimilar components. The Model RB-10 was developed for technical surface treatment of gears and aerospace components.

The 60 x 60 x 60-inch blast cabinet is mated with a 6-axis robot, such as the FANUC M10iA, as a blast nozzle manipulator. The shot peening machine's rotary table has a diameter of up to 52 inches and is servomotor driven to be controlled as a seventh axis of robotic motion.

Locating hardware is provided to allow interchangeable component-holding fixtures to be positively and repeatably positioned on the turntable.

During the shot peening cycle, the orientation of the component and the motion of the robotic nozzle manipulator are synchronized to precisely replicate the programmed tool path, following the contours of complex-shaped parts, yet constantly and accurately maintaining the required angle of shot impingement, the correct offset of the peening nozzle from the target surface and the right dwell or surface speed to control the cold working process.

The peening media delivery system includes an ASME-certified pressure vessel of 3.5 cubic foot capacity fitted with high and low shot level sensors, a 3 cubic foot media storage hopper that automatically adds shot when a low level is detected and, if required, an electronic shot flow controller to continuously maintain the correct blast pressure and shot flow rate specified for the shot peening process.

In addition to a cyclone separator for dust extraction, the shot reclamation system includes a vibratory screen classifier to deliver only shot of the specified size, as well as a spiral separator to remove any peening shot that is not perfectly spherical.

For metallurgical shot peening applications in accordance with SAE aerospace peening specification AMS 2432, Guyson offers a SCADA controls package combined with a custom-designed touch screen human-machine interface (HMI) to enable data verifying all critical process parameters throughout the shot peening procedure to be captured and logged for documentation purposes.

Prospective users of robotic shot peening equipment may submit sample components for evaluation in the application engineering laboratory at the blast machine builder's factory in northeastern New York State.

For more information:
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Low Inertia Couplings

REDUCE CYCLE TIME

Zero-Max's low inertia, lightweight coupling with high rotional stiffness for servo motor applications comes with its aluminum CD model in single and double flex versions.

The CD coupling has a robust though lightweight aluminum design. The working part is made of a composite material. The composite disc design handles the stresses of a servo motor's high acceleration rates and high torque capacity. The result is lower energy requirements, longer life of the motor and other operating components with uninterrupted system operation.

continued

"We surveyed design engineers to find out what was the most desirable feature when specifying couplings for servo motor applications," says Robert Mainz, Zero-Max sales manager. "Low inertia was the most important. These engineers said they continually look for ways to reduce cycle time and improve system productivity. A lightweight yet high strength coupling design will enable the designer to increase the speed of the actuator. The combination of the lightweight aluminum hubs and unique composite disc provides the necessary characteristics to increase speed and cut cycle times. Lightweight couplings will also have an effect on the energy consumption in their designs. The aluminum CD couplings meet those objectives and more."

Applications include automated packaging systems and assembly machinery where precise, high speed positioning is required. The Zero-Max CD couplings are available in single and double flex models with or without keyways. The double-flex version is for precision applications requiring misalignment capacity greater than the single flex design. The single flex models have a torque capacity range from 40 Nm to 1,436 Nm and higher with speed ratings from 4,400 rpm to 17,000 rpm.

For more information:

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Bodine

REDESIGNS W MODEL GEARHEADS

The WX gearhead from Bodine Electric Company is a high-torque gearhead built to provide longer life and higher performance than similar gearmotors in the same size range. It is being introduced in conjunction with its upgraded 34B-frame brushless DC motor. It is designed to drive applications such as conveyor systems, packaging equipment, metering pumps, medical devices, commercial appliances and solar powered outdoor equipment.

The exterior of the WX gearhead is identical to Bodine's old W models, but the inside has been completely redesigned. The gearmotors feature all-steel helical gear trains and synthetic lubricants, so the type 34B-WX can produce up to 65 percent more torque than previous models. The steel gearing is designed to AGMA 9 standards or higher for quiet operation. The lubricant used improves efficiency and allows the gearmotors to operate in a range of temperatures. Forty-eight stock models feature 12 available gear ratios, ranging from 4:1 to 312:1 and rated output speeds from 658 to 8 rpm.

The WX gearhead is available with Bodine's type 34B, TENV, 1/5HP (149 watts) brushless DC motors. The BLDC motors require less maintenance and last longer than other brush-type PMDC motors. They can be used in place of brush-type motors in applications where high starting torque and linear speed-torque characteristics are critical. The 34B-WX gearmotors are available with 130 VDC and 24 VDC windings and are available with or without accessory shafts for external encoder or brake installation.

"Bodine Electric has over 20 years experience in design and manufacturing of brushless DC motor and control systems," says Terry Auchstetter, manager of business development. "We also manufacture a complete line of matched 24V or 130V brushless DC motor speed controls. When customers purchase the 34B-WX with a control, they get a complete drive system from one source."

continued

For more information:
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Fax: (773) 478-3232
info@bodine-electric.com
www.bodine-electric.com

Fluorescent Dye

PINPOINTS OIL LEAKS

Dye-Lite TP-3100 fluorescent dye pinpoints engine oil, hydraulic fluid, lubrication fluid, compressor oil and gearbox oil leaks.

Simply add a small amount of TP-3100 dye to the system and allow it to circulate for several minutes. Wherever there is a leak, the dye escapes with the oil and accumulates. Scan the system with a high-intensity ultraviolet or blue light lamp, and the dye glows a bright yellow color to clearly reveal the location of all leaks—even small leaks undetected by other methods.

After the leaks have been repaired, scan the system with the light again. If there is no glow, it means that all the leaks were fixed properly.

TP-3100 dye can remain safely in the system until the oil is changed, making it ideal for preventive maintenance. Periodic inspections with the lamp will detect leaks before they can cause damage to the system.

For more information:
Tracer Products
956 Brush Hollow Road
Westbury, NY 11590
Phone: (800) 641-1133 or
(516) 333-1254
www.tracerline.com

Height Gage

OFFERS EASY-TO-USE SHOP FLOOR MEASUREMENT

Designed with production personnel in mind, the new Digimar 816 CL Height Gage from Mahr Federal provides highly accurate measurements without complicated procedures.

The Digimar 816 CL incorporates a precision measuring head on stainless steel guideways and a dynamic probing system. Air bearings provide light and smooth movement, while accuracy and reliability are ensured by an optical incremental measurement system with a double-head reader, which is impervious to dust and other contamination. A motorized measuring carriage minimizes operator influence on probe contact, increases accuracy, and simplifies measurement runs.

Key to measurement accuracy in production environments is the Digimar 816 CL's internal temperature compensation system. An integrated temperature sensor measures ambient temperature and automatically compensates for the thermal expansion of the workpiece.

All standard functions can be initiated with a single key stroke, and additional functions are readily available through the menu. Measured values are clearly displayed on the control unit's high-contrast, back-lit graphic display, along with the current function being measured. Users may also retrace the measuring procedure in the list of measured values directly below the current value. Dynamic functions, such as Max-Min for parallel deviation and roundness deviation, and calculation functions, such as the distance between measured values, are also included.

Operation of the Digimar 816 CL Height Gage is intended to be nearly self-explanatory, with function keys clearly defined with easy-to-understand icons. The icon for "Contact surface from above," for example, is a simple line with an arrow pointing down. "Contact from below" has the arrow pointing up. Repetitive measuring procedures can easily be automated. Complex measuring routines can be programmed using the Digimar 816 CL's teach-in mode, and can then be initiated with a single key.

The memory on the Digimar 816 CL Height Gage can store up to 99 measured values. Data can be output via USB or OPTO RS232. An integrated, rechargeable battery provides long operating time for independent measurement in addition to the main power adaptor. The Mahr Federal Digimar 816 CL Height Gage is available in two measuring ranges, 350 mm (14 in.) and 600 mm (24 in.).

For more information:
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1144 Eddy Street
Providence, RI 02905
Phone: (800) 343-2050 or
(401) 784-3100
Fax: (401) 784-3246
information@mahr.com
www.mahr.com

RoboMax System

AUTOMATES QUALITY CONTROL

The RoboMax system, developed by Carl Zeiss, does not require an operator and can run fully automatically 24 hours a day, 7 days a week. Parts are automatically fed, measured and sorted. Measurement logs permit verification of the quality at any time.

RoboMax can be configured as

needed. Different coordinate measuring machines (CMM) and surface measuring machines from Carl Zeiss can be integrated. Equipped with standardized controllers and interfaces, the measuring machines receive the parts being inspected via loading systems.

Data matrices and RFIDs are used to clearly identify the parts. Depending on the part, *FACS* (Flexible Automation and Control System) software loads the corresponding measuring program from *CALYPSO* measuring software from Carl Zeiss.

Such systems are intended for automotive customers and others with high part throughput and automation levels.

Because the loading systems and robots on the market today can move very quickly, the speed of the measuring machine is particularly important for part throughput. The inline CMMs in the MaxLine from Carl Zeiss—GageMax and CenterMax—are equipped with probes featuring Navigator technology. They not only measure the features more accurately, but also up to 50 percent faster than conventional probes, according to the company. These measuring machines, which work reliably at temperatures from +15°C to +40°C, are thus suitable for integration into RoboMax.

For more information:

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IMTS2010
CONNECTING GLOBAL TECHNOLOGY

WHAT'S THE BIG ATTRACTION? IMTS 2010!

The great thing about a trade show the size of IMTS is the amount of options available to attendees. If you're into cars, fighter jets, machine tools, fighting robots, manufacturing relics or simply the latest technology advancements in a particular industry, you'll find it at IMTS 2010. From discussions on the state of manufacturing in the United States to former Michigan governor and current National Association of Manufacturing president John Engler speaking on how to create a manufacturing climate that encourages innovation, the six-day event has the entire scope of manufacturing and industry covered. Along with the 1,100+ exhibiting companies on hand, attendees can check out a variety of special programs and demonstrations throughout the week.

Emerging Technology Center (Booth N-650)

Everyone comes to IMTS to see "the next big thing." You can see four of these at the Emerging Technology Center (ETC) at IMTS 2010 in Chicago. The four featured technologies this year are cloud computing, MTConnect, nanotechnology/micro manufacturing, and additive manufacturing. Get a brief overview by checking out a cool 3-D video that discusses these leading-edge technologies and take a tour of the ETC for some in-depth demonstrations. MTConnect, the open, royalty-free standard developed to foster communication between machine tools, made its debut in the ETC at IMTS 2008. More companies have begun pilot programs with MTConnect, and the standard is beginning to garner international attention. Cloud computing is a technology that has gained popularity by leaps and bounds over recent years using remote, large Internet farms to collect data. Nanotechnology is the development of materials and devices sized 100 nanometers or smaller, important especially in the fields of electronics and medicine. Additive manufacturing, the process of building objects from 3-D model data, allows design flexibility previously unknown and impossible in traditional subtractive processes. It allows for a much more rapid production process, as well as materials flexibility. The ETC is located at Booth N-650 in the North Building.

Advanced Manufacturing Center (Booth W–160)

The center will feature a 3-D, virtual reality presentation that allows visitors to operate and interact with the Rolls Royce Trent 1000 engine used to power the Boeing 787 Dreamliner. Additionally, Rolls Royce will present a fan blade set from the Trent 900 engine and several machined components from the Trent engine series. Multimedia displays, giveaways and interactive presentations will also be on hand. The Advanced Manufacturing Center debuted at IMTS in 2008 and is located in Booth W-160 in the West Building.

Robot Combat Arenas (Booth E–5066, Booth B–6875)

Back by popular demand are the Robot Combat Arenas, sponsored by ThomasNet. Attendees can go head-to-head in some serious robotic warfare against co-workers at Booth E-5066 in the East Building. If destroying inanimate objects is more your cup of tea, Booth B-6875 in the North Building allows guests to use their robotic machines to destroy microwaves, dishwashers and other household appliances.

The Tesla Roadster (Booth W–100)

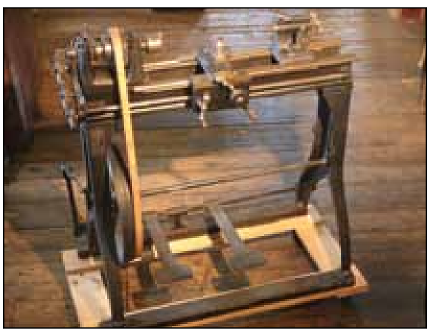
The facts are simple; this automobile stands alone as the most efficient, high-production sports car on the planet, according to Tesla representatives. The statistics help the argument as the Roadster features a 248 hp (185 kW) 3-phase electric motor; can go 0-60 mph in 3.9 seconds with a top speed of 125 mph; carbon fiber body; single-speed transmission; 200+ miles per charge; zero emissions. Full recharging of the automobile can be completed in as little as 3.5 hours. In an effort to show off the vehicle's practicality, Tesla sent one of its Roadsters around the world. Starting at the Geneva Auto Show in March, the automobile is scheduled to end its journey at the Paris Auto Show on September 28, 2010. The Tesla Roadster will be on display in Booth W-100 in the West Building.

continued

The Tesla Roadster will be on display at IMTS 2010 (courtesy of Tesla Motors).

Manufacturing Museum (Booth E–4771)

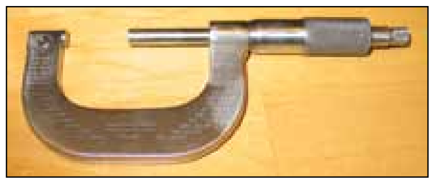
Artifacts on loan from the American Precision Museum, located in Windsor, Vermont, will entertain and engage visitors on the history of manufacturing. Attendees will see how far industry has advanced through the years. Exhibits appearing at IMTS from the American Precision Museum include historic lathes, sewing machines, typewriters, milling machines, hand-powered planers and a tiny model steam engine.



This metal working lathe with two foot pedals was donated by the Carroll-Jamieson Machine Tool Company in Batavia, OH.

This hand-powered model of a non-circular lathe, built by Peter Fernleigh Jones in England, was donated to the museum by his son, Mike Jones.

Ann Lawless, executive director at the American Precision Museum, is excited about the opportunity to share some history with IMTS. "The machine tool industry developed from the interchangeable parts used in gun making initially. It's the same process that was used for sewing machines, bicycles, even automobiles. Everyone knows the work that Henry Ford did to create the assembly line, but he couldn't have done it without interchangeable parts."



This micrometer was made by Brown & Sharpe Mfg Co., Providence, RI, and was a gift from Charles W. Dodge (courtesy of the American Precision Museum).

In addition to the artifacts, the museum will have information regarding its education programs and some history of the museum itself. "We're going to have a beautiful exhibition set up for IMTS that really illustrates the work we do at the museum. It's a wonderful opportunity for us and we're grateful for the help the Association for Manufacturing Technology (AMT) has done during this process."

The Manufacturing Museum at IMTS will be located at Booth E-4771 in the East Building.

F-35 Lightning II Joint Strike Fighter (Booth W-100)

Lockheed Martin has agreed to exhibit a full-scale model of its F-35 Lightning II Joint Strike Fighter during the show. The F-35 Lightning II is a 5th generation fighter, combining advanced stealth with fighter speed and agility, fully fused sensor information, network-enabled operations, advanced sustainment, and lower operational and support costs. Lockheed Martin is developing the F-35 with its principal industrial partners, Northrop Grumman and BAE Systems. Two separate, interchangeable F-35 engines are under development: the Pratt & Whitney F135 and the GE Rolls-Royce Fighter Engine Team F136. "While the manufacturing technology featured at IMTS stands alone as a must-see, what's really exciting is seeing the end result from some of those machines," says John Krisko, IMTS Director - Exhibitions. "Everyone at the show will have the opportunity to learn about the plane's construction and the manufacturing technology behind it. We are thrilled to have this amazing example of an end product featured at IMTS." GIE Media was instrumental in working with IMTS to secure the fighter for exhibit. The F-35 is intended to be the world's premiere strike aircraft through 2040. The United States intends to buy a total of 2,443 aircraft with a total of more than 4,000 F-35s forecast to be built for U.S. and foreign customers combined. The F-35 program's overall value is estimated $323 billion, making it the largest defense program ever. The F-35 will be on display in the front of McCormick Place's West Building in Booth W-100. Plans are also in the works to have photo opportunities with the plane available to attendees.

For more information on these or other IMTS 2010 exhibits and attractions, visit *www.imts.com*.

IMTS 2010 Industry & Technology Conference

Five topic tracks will be the focus of a wide range of industry sessions at IMTS 2010 including materials engineering, machining technology and trends, alternative manufacturing processes, metrology and plant operations. The industry and technology conference begins Monday, September 13, with Industry Inspiration Day and ends Friday, September 17, by noon. Here's a brief rundown of the conference schedule:

Industry Inspiration Day–September 13 (Room S100)

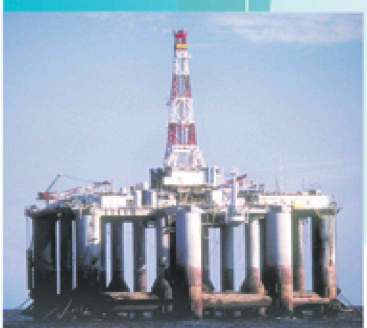
Keynote speakers from four different industries will be presenting programs at the first ever Industry Inspiration Day at IMTS. Allan McArtor, chairman and CEO of Airbus Americas, will

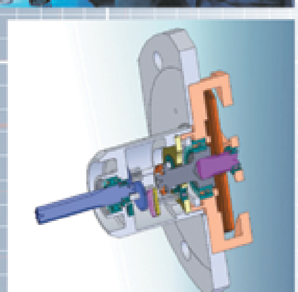
continued

Solutions For The World Around Us

Engineered Motion Control

Precision Parts and Components





Precipart is more than just a gear company. Our engineered motion control devices explore the surface of Mars and visualize the human body in diagnostic probes.

A leader in developing motion control solutions, Precipart has served the medical/surgical, dental, optical, robotics, oil field, aviation, avionics, telecommunications, scientific instrumentation and defense industries since 1979.

We design and manufacture all types of gears and gearboxes for actuators, gear motors, RVDTs, and instrumentation used for demanding applications in varying environments. Through our expertise and experience supported by comprehensive resources, we're ready for your next challenging assignment.

Our total value-added approach also is a win-win. You can take advantage of our technical capabilities in advance of your quote with a feasibility study. Our experience in design, materials and manufacturing through a detailed assessment can provide you with an optimum solution that saves you time and cost.

Try us on your next program. We offer prototypes for your qualification needs. Precipart is ready for you.

Quality With Pride.
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gem network

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Precipart
Means Precision Parts

lead the aerospace segment; automotive will be presented by Jim Tetreault, vice president of North American Manufacturing, Ford Motor Company; Denise Bode, president/CEO of the American Wind Energy Association, will present an energy program; Rene van de Zanda, president/CEO of Emergo Group will examine the medical industry. A roundtable panel discussion will close the special program, and registrants of the IMTS Industry & Technology Conference will be admitted. Industry Inspiration Day programs will take place in the South Grand Ballroom, S100.

Tuesday, September 14

Alternative Manufacturing Processes

Non-Traditional Look at Wire EDM in Modern Manufacturing
(11:00 a.m. – 11:55 a.m.) Ann Mazakas, DP Technology, Room W192B

Machining Technology & Trends

Innovative Multitasking Concepts for Turbine Blade Manufacturing
(9:00 a.m. – 9:55 a.m.) Mike Finn, Mazak, Room W192B

Cycle-Controlled Lathes
(9:00 a.m. – 9:55 a.m.) Andreas Schulz, Weiler NA Inc., Room W192A

Advanced Grinding Technology Leads to Measurable Gains
(9:00 a.m. – 9:55 a.m.) C. Stine, United Grinding Technology, Room W192C

Cutting Tools Engineered for Power Generation
(9:00 a.m. – 9:55 a.m.) Thomas Raun, Iscar Metals Inc., Room W194B

Metalworking Fluid Performance in Aluminum High-Speed Machining
(11:00 a.m. – 11:55 a.m.) Dr. Robert Evans, Quaker Chemical Corp., Room W192C

Cutting Tools Engineered for Medical
(1:00 p.m. – 1:55 p.m.) Thomas Raun, Iscar Metals Inc., Room W194B

Materials Engineering

Machine Tool Design Elements for Machining Triple-Nickel Titanium
(1:00 p.m. – 1:55 p.m.) Scott Walker, Mitsui Seiki USA, Room W193B

Metrology

Multi-Sensor Metrology
(11:00 a.m. – 11:55 a.m.) Tom Groff, Optical Gaging Products, Room W192A

Plant Operations

The Machine Part Cost and Process–Management Dilemma
(10:00 a.m. – 10:55 a.m.) Jerry LaChapelle, MES, Room W193B

Lean Safety–Transforming Your Safety Culture with Lean Management
(10:00 a.m. – 10:55 a.m.) Robert Hafey, RBH Consulting LLC, Room W195

Increased Capabilities and Flexibility Equals Higher Productivity
(1:00 p.m. – 1:55 p.m.) T. Economan and J. Reinert, Index Corp., Room W195

MTConnect
(2:00 p.m. – 2:55 p.m.) William Sobel, System Insights, Inc., Room W192B

Greening Up the Industrial Parts Cleaning Process
(2:00 p.m. – 2:55 p.m.) Chuck Sexton, Kyzen Corp., Room W192A

Capital Equipment Justification–The Truth about ROI
(2:00 p.m. – 2:55 p.m.) J. Reinert and Klaus Voos, Index Corp., Room W192C

Utilizing New Software Algorithms to Improve CAM Programming, Shorten Mill Times and Increase Security
(3:00 p.m. – 3:55 p.m.) Jeff Jaje, Sescoi USA, Inc., Room W194B

The Information Age of Manufacturing
(3:00 p.m. – 3:55 p.m.) Kevin Bevan, GBI, Room W193B

Discussions on Manufacturing Issues Today
(3:00 p.m. – 3:55 p.m.) Steven Stokey, Allied Machine & Engineering Corp., Room W195

Wednesday, September 15

Alternative Manufacturing Processes

Laser Ablation Extends Machining Options for Complex Free-Form Surfaces
(9:00 a.m. – 9:55 a.m.) G. Ledvon, AgieCharmilles, Room W192B

Expand Your Capabilities with the Versatility of Waterjet
(10:00 a.m. – 10:55 a.m.) S. Szczesniak, Mitsubishi Waterjet, Room W195

Use of Abrasive Waterjet Cutting for Improving Manufacturing Flexibility and Efficiency
(2:00 p.m. – 2:55 p.m.) Laird Perry, OMAX Corp., Room W192A

Machining Technology & Trends

The True Cost of Setup on a CNC Machine
(9:00 a.m. – 9:55 a.m.) G. Vacio, BIG Kaiser Precision Tooling Inc., Room W192A

Productivity Efficiencies in Difficult Materials Require Consideration of the Machine Tool, the Spindle and the Cutting Tool
(9:00 a.m. – 9:55 a.m.) Sean Holt, Sandvik Coromant, Room W192C

Gaining 50% Productivity with Workholding
(11:00 a.m. – 11:55 a.m.) Tim Winard, Kitagawa-Northtech Inc., Room W192B

Green Manufacturing Techniques and Machine Designs–Practical Technology Available and in Use Today
(11:00 a.m. – 11:55 a.m.) Richard A. Curless, MAG Americas, Room W192A

Manufacturing Economics
(1:00 p.m. – 1:55 p.m.) Brian Norris, Sandvik Coromant, Room W193B

Metrology

3-D Volumetric Calibration of Multi-Axis Stage Motion for Machine Tools
(10:00 a.m. – 10:55 a.m.) Dr. H. Schwenke, Etalon, Room W193B

Plant Operations

LMPC–Lean and Machining Practices: Make the Connection
(10:00 a.m. – 10:55 a.m.) Larry Schwartz, Okuma, Room W194B

Smart Operation Starts with Automation
(11:00 a.m. – 11:55 a.m.) Bill Vejnovic, Toyoda Machinery, Room W192C

TTCT–Takt Time Versus Cycle Time: What's More Important?
(1:00 p.m. – 1:55 p.m.) Jeff Estes, Okuma, Room W194B

Lean Manufacturing and the Production-On-Demand Model
(1:00 p.m. – 1:55 p.m.) Bernard Schawe, Mazak, Room W195

Preventative Maintenance: What You Don't Know Can Hurt You
(2:00 p.m. – 2:55 p.m.) Steve Reed, KSolutions, Room W192C

U.S. Government Actions and Policies on Top Manufacturing Issues
(2:00 p.m. – 2:55 p.m.) Harry Moser, ISTMA Americas Region, Room W192B

Developments in CAD/CAM for Composites
(3:00 p.m. – 3:55 p.m.) Peter Dickin, Delcam, Room W193B

Automatic Tool ID Saves Big Bucks
(3:00 p.m. – 3:55 p.m.) Mark Sippel, Balluff Inc., Room W194B

Thursday, September 16

Machining Technology & Trends

New Metal Cutting Techniques Applied to Current Market Trends
(10:00 a.m. – 10:55 a.m.) Don Graham, Seco Tools, Inc., Room W194B

How Do Small Shops Break Into the World of Automation?
(10:00 a.m. – 10:55 a.m.) John Lucier, Methods Machine Tools Inc., Room W195

Increased Productivity by Effective Thermal Management in Metal Cutting of Titanium
(2:00 p.m. – 2:55 p.m.) Dr. Paul Prichard, Kennametal, Inc., Room W192B

Materials Engineering

Machine Tool Design Elements for Machining Triple-Nickel Titanium
(9:00 a.m. – 9:55 a.m.) Scott Walker, Mitsui Seiki USA, Room W192B

Metrology

CAD/CMM: A New Category in the CMM Industry
(11:00 a.m. – 11:55 a.m.) Sam Golan, PAS Technology, Room W192C

Top Reasons Visions Fail
(1:00 p.m. – 1:55 p.m.) Joe Freud, KSolutions, Room W193B

Catch Part Defects Before They Happen
(1:00 p.m. – 1:55 p.m.) Paul Hogendoorn, OES, Inc., Room W194B

Plant Operations

Advantages of an Integrated NC Programming and Simulation Strategy
(9:00 a.m. – 9:55 a.m.) NC Kishore, Dassault Systémes DELMIA, Room W192A

Cost-Cutting Scrap Handling Solutions: Innovative ways to Improve Processes, Cut Costs
(9:00 a.m. – 9:55 a.m.) Del Butler, Magnetic Products, Inc., Room W192C

MTConnect
(10:00 a.m. – 10:55 a.m.) William Sobel, System Insights, Inc., Room W193B

CAM Software and Your Profitability
(11:00 a.m. – 11:55 a.m.) Bill Gibbs, Gibbs and Associates, Room W192A

The Information Age of Manufacturing
(11:00 a.m. – 11:55 a.m.) Kevin Bevan, GBI, Room W192B

Get All the Facts Before You Select Your Next CNC Control
(1:00 p.m. – 1:55 p.m.) Karl Kleppek, FANUC CNC America, Room W195

Motors, Drives and Motion Control–Global Market Update
(2:00 p.m. – 2:55 p.m.) Alex Chausovsky, IMS Research, Room W192A

Using PLM to Enhance Value Stream Management for Competitive Advantage
(3:00 p.m. – 3:55 p.m.) David Segal, Dassault Systémes, Room W193B

Leveraging CAD/CAM Automation
(3:00 p.m. – 3:55 p.m.) Steve Sivitter, Planit Software, Room W194B

Friday, September 17

Materials Engineering

Composite Material and Production Technology Developments Enabling Game Changing Designs for Aircraft, Automotive and Wind Energy to be Practical Today
(9:00 a.m. – 9:55 a.m.) Randy Kappesser, MAG Cincinnati, Room W192A

Plant Operations

Case Study Evidence that Sustainable Design Practices Help Manufacturing Increase Profits and Growth
(9:00 a.m. – 9:55 a.m.) Robert Kross, Autodesk Manufacturing Industry Group, Room W192B

Getting it Right on the Money: Best Practices in Job Costing
(10:00 a.m. – 10:55 a.m.) R. Winger, Epicor Software, Room W193B

Ultra-High Performance Toolpath Technology Can Transform U.S. Manufacturing
(10:00 a.m. – 10:55 a.m.) Glen Coleman, Celeritive Technologies, Room W193B

New Technologies for Machine Tool Automation
(11:00 a.m. – 11:55 a.m.) Andreas Schuhbauer, Kuka Robotics, Room W192A

Mitsubishi Heavy Industries America

Booth N-6837

Mitsubishi will display two gear cutting machines at IMTS 2010: the ST25CNC gear shaping machine and an automated GE20A gear hobbing machine.

The ST25CNC shaper is one of Mitsubishi's "programmable lead guide" shaping machines. Mitsubishi was the originator of this technology in the middle 1980s. They have developed the ST25CNC as an entry-level machine for shaping gears up to 250 mm diameter and helix angles up to +/-35 degrees.

The GE20A hobber is one of many machines Mitsubishi maintains in stock. This model offers wet and dry hobbing capabilities. The GE20A on display will be equipped with a precise positioning ring loader for fast, efficient loading and unloading of workpieces up to 200 mm diameter.

Both machines will be available for customer delivery directly after the show.

For more information:

Mitsubishi Gear Technology Center
46992 Liberty Drive
Wixom, MI 48393
Phone: (248) 669-6136
Fax: (248) 669-0614
www.mitsubishigearcenter.com

American Broach & Machine (including American Gear Tools and QC American)

Booth N-7027

American Broach will feature two of its new Table Top (TT) models—the Model TT-2-24 and Model TT-SP-2-24. Both models were invented and patented in 2009.

The TT machines are equipped with electromechanical dual-screw drive systems that eliminate the cadence (pounding) associated with hydraulic broaching machines. The twin-screw drive system is designed to provide smooth and steady power, increased tool life and part quality and reduced perishable tooling cost per part.

American Broach's design features a simple, flat table-top broaching area with crossing T-slots to accommodate fast, accurate setup. This one-piece, solid table top has been designed to attach to a fabricated main box assembly, which is mounted on top of a coolant sump box base.

The modular design keeps the cost of build and maintenance service low, while maintaining structurally robust physical attributes by design, without the traditional girth used by broaching machines.

The Table Top Broaching Machine also features an unguided pull bridge powered by two spindles (roller or planetary); they are mounted under the table in a compact design to eliminate the need for guide rods or bearing ways that will not tolerate being mounted in areas with chips and coolant under the table. These spindles are fully enclosed by slide covers to prevent chip interference and coolant damage.

The spindles are powered by a tooth belt by way of oversized tooth drive pulleys; this over sizing allows a single motor to drive both spindles simultaneously and with extreme accuracy without positioning the drive belt in line in the space where the cutting tool travels. Tool location is monitored through motor rotation position tracking by a simple encoder, and the drive system is enclosed and sealed into the hollow bottom under the broaching table.

Mike Casto, American's Sales Manager will also be there touting American Broach's expanded CNC broach tool resharpening services. Casto will be sharing methods for "reducing the cost of broaching by using better broach tools and CNC resharpening" and "putting a price on the hassle factor that often accompanies the lowest price tooling and resharpening."

American Gear Tools is a newly launched division of American Broach, which will be displaying gear cutting tools in the same booth. American Gear Tools designs and delivers all types of gear cutting tools incuding hobs, shaper cutters, shaving cutters, milling cutters, straight and spiral bevel cutters, rack type cutters and spline rolling racks.

For more information:
American Broach & Machine Company
575 South Mansfield Street
Ypsilanti, MI 48197
Phone: (734) 961-0300
Fax: (734) 961-9999
www.americanbroach.com

MAG Americas

Booth S-8519

Stop by the MAG booth to see gear grinding and hobbing integrated on a vertical turning center. The VTC 2500 will be equipped with a new automatically changed grinding attachment. Combined with built-in gear hobbing capability, this setup is designed to dramatically increase the multi-processing capabilities of MAG's vertical turning centers. The VTC is designed to produce large bearings, gearboxes and gears needed in heavy machinery applications. The show machine features machine vibration monitoring system (MVM), two-axis programmable rail height and a live spindle, C-axis right-angle attachment.

For more information:
MAG Americas
Olympic Corporate Center
13940 Olympic Boulevard,
Suite 500
Erlanger, KY 41018
Phone: (859) 534-4600
Fax: (859) 669-1897
www.mag-ias.com

Emuge Corp.

Booth W-1536

Emuge Corp. will showcase its line of clamping solutions. Emuge's work-holding division specializes in providing solutions for applications from low-volume job shops to high-volume automotive production environments. In addition, acting as exclusive North American agent for The Hohenstein Company, Emuge will also offer high-quality, special purpose workpiece clamping fixtures.

"Our workholding group stays close to our customers to learn about their unique challenges and production environments. Doing so helps us develop the best solutions for their applications," says David Jones, precision workholding manager at Emuge Corp.

The precision workholding lineup will include Emuge's System SG, which is used in many machining operations such as hobbing, shaping, and shaving for gear production, as well as milling and inspection. The System SG's large surface area contact with the workpiece provides a clamping solution which is very rigid, accurate and repeatable.

When the eccentricity between pitch circle and seating bore is very small, System SM diaphragm clamping can be used. It allows clamping of the gear wheel at the pitch circle for machining the seating bore. The gear wheel is clamped in both axial and radial directions.

For more information:

Emuge Corporation
1800 Century Drive
West Boylston, MA 01583-2121
Phone: (800) 323-3013
www.emuge.com

ITW Rocol

Booth W-2135

Rustlick PowerCool Green and PowerCool Green CF coolants from ITW Rocol are new, long-lasting water-soluble oils made from naturally derived, vegetable-based oils. These premium coolants are specially formulated to be operator-friendly and to give maximum lubricity and biostability in heavy-duty cutting and grinding applications.

PowerCool Green and PowerCool Green CF deliver extended tool life and physical lubricity in tough operations. The advanced technology used to formulate these plant-based coolants ensures the highest fluid performance, dramatically increases sump life, and decreases overall fluid use, according to the company's press release. PowerCool Green coolants are safe for all metals, including ferrous/nonferrous metals, aluminum, brass, bronze and copper.

These products can be used for a range of light- to heavy-duty applications, including machining, cutting, grinding, milling, drilling, broaching, turning, threading and tapping. PowerCool Green is available in two versions, chlorinated and chlorine free. PowerCool Green contains chlorinated EP additives; PowerCool Green CF contains non-chlorinated EP additives and is also recommended for use on titanium. PowerCool Green and PowerCool Green CF are available in five- or 55-Gallon containers.

Accu-Lube Gel Paste is a natural-based, environmentally safe lubricant, which is made from renewable resources. This lubricant is well suited to horizontal applications because it won't run or drip. The gel texture of this non-toxic product makes it easy to apply to small and large tools with a soft brush without risk of damaging the tool.

Accu-Lube Gel Paste is designed to eliminate the mess and waste causes by other lubricants. No cleaning is required before heat treating and it is great for short-run machining, reaming, tapping and drilling. This dark blue gel is a neutral product that does not cause contamination or discoloration of products and is safe for use on all metals. Since it is biodegradable and non-hazardous, no special disposal is required.

Accu-Lube Gel Paste is supplied ready to use and is available in 8 oz. jars and 5 gal. pails.

For more information:

ITW Rocol North America
3624 West Lake Avenue
Glenview, IL 60026
Phone: (847) 657-5343
www.itwrocol.com

Mahr Federal

Booth E-5048

The MarForm MMQ 200 Formtester, which provides measurement of surface finish parameters according to accepted ISO, ASME and JIS standards, is offered with a combined hardware/software option. The new option package allows operators to reduce setup time and measurement cycle time, as well as reduced cost by requiring a single piece of equipment for both form and surface measurements.

The MarSurf UD 120 can generate both surface and contour measurements in a single pass. The system is designed for economy for high accuracy over a large measuring range in nanometer resolutions. Both automated motorized operation and joy-stick control are included in the MarSurf UD 120, along with a patented magnetic probe mounting feature that prevents probe damage and allows probe changes quickly, without additional tools.

The Digimar 816 CL Height Gage provides accurate measurements without complicated procedures. A robust design and user-friendly operation combine with advanced features and functionality to improve dimensional measurement on the shop floor or in the lab.

The Precimar Linear 100 is a universal, user-friendly length measuring instrument for quick, precise internal and external measurements up to 100 mm, directly in the manufacturing environment. The unit includes the SarCheck Display, which makes it simple to transfer measured data to PCs.

The 800 EW Digital Test Indicator is shockproof, anti-magnetic, protected against coolants and lubricants to IP65, offers data ouput via USB or OPTO or RS 232C and battery life up to two years.

A full range of other handheld gauges and other dimensional metrology products will be on display.

For more information:
Mahr Federal Inc.
1144 Eddy Street
Providence, RI 02905
Phone: (800) 343-2050
www.mahrfederal.com

Supertec Machinery

Booth N-6945

The PG-400CNC gear profile grinding machine marks Supertec Machinery's first foray into the U.S. gear grinding market.

Other machines Supertec Machinery will have on display in the grinding pavilion include the G25P-50CNC cylindrical grinder with conversational language control; the G25A-35CNC anglehead cylindrical grinder, which offers a small footprint without sacrificing the machine's travel of 10 x 14 inches; the Grindmaster GM-45CNC ID/OD grinder delivers versatility to operators with two X-axis slideways that can be set up in various configurations, such as one OD and one ID wheel or two ID wheels—one for roughing and one for finish grinding; the Master-818CNC surface grinder is an inexpensive, entry-level CNC

continued

surface grinder in both two-axis (slicing) and three-axis (contour) grinding capability; the G15I-CNC ID grinder; the STC-2008NC single-axis automatic centerless grinder; and an operational scale model of a two-axis CNC vertical surface grinder.

For more information:
Supertec Machinery
Phone: (562) 220-1675
Fax: (562) 220-1677
info@supertecusa.com
www.supertecusa.com

Globetec International

Booth S-9453

The GHO-500 is a 5-axis gear hobbing machine manufactured by S&T Dynamics (formerly Tongil) of Korea. The machine is capable of cutting spur and helical gears up to 19.6" diameter with modules up to 12.

The machine can accommodate hobs up to 11.8" length and 11.8" diameter. It comes equipped with a 30 hp spindle motor, capable of hob speeds up to 400 rpm. It also comes with conversational programming via either FANUC or Siemens controls.

For more information:
Globetec International, Ltd.
403 Joseph Drive
South Elgin, IL 60177
Phone: (847) 608-9300
Fax: (847) 608-9301
staff@globetec.com

Riten Industries

Booth W-1336

A specialist in workholding products for more than 75 years, Riten Industries has a number of new products on display.

Sprint 4 and 5 Morse Taper live centers are completely redesigned with ± .00004" accuracy and the highest bearing capacity in their class. These live centers are designed for extended service life, with rigidity to handle workpieces up to 5,000 lbs. with speeds up to 6,000 rpm.

C4T live centers include all the benefits of the new Sprint design with an exclusive labyrinth seal for permanent bearing protection. C4T live centers are especially suited for operations requiring high pressure and flood coolants.

Riten will display a broad selection of spring-loaded linear compensating live centers that self-adjust for thermal expansion and significantly reduce setup time. The company will also show bell head live and dead centers with interchangeable heads up to 13.5" diameter.

Finally, visitors can come to the Riten booth with their workholding questions to "Ask the Colonel." Riten's senior design engineers will be present to answer technical questions regarding products and services for maintaining or restoring lathes and grinders to centerline. A free brochure will be available describing solutions to actual customer problems, addressing both application and machinery repair issues.

continued

For more information:
Riten Industries, Inc.
1100 Lakeview Avenue
Washington Court House, OH
43160
Phone: (800) 338-0027
www.riten.com

Euro-Tech Corporation

Booth W-2453

Euro-Tech Corporation will feature INO System Spline Gauges by Frenco of Germany. The spline gage product line provides a quick method of inspecting involute splines, serration splines and straight sided splines to ensure interchangeability of parts even between different manufacturers. Frenco's INO system is an internal standard for the external dimensional measurement of spline gages developed based on national and international standards, making it suitable for even the most highly sensitive and complex components and systems. Frenco spline gages are constructed of extremely wear-resistent high alloy powder steel called HX. Chromium and vanadium alloy content, as well as the hardness of the material, determines the wear resistance of the spline gage. Use can determine the appropriate time intervals between wear inspections depending on this wear resistance. For example, highly wear resistant materials allow the inspection intervals to be significantly extended.

Along with more advanced diagnosis than the currently applicable standards, Frenco spline gages offer traceability to PTB-certified parts, ensuring reliable measuring results. The Frenco calibration laboratory is a DKD calibration station for helix and profile parts. Certification for runout, pitch and dimensions over measuring circles is under development.

The quoted price for Frenco spline gages always includes comprehensive gage drawings (also available in electronic form) as well as "new" certification from the Frenco laboratory. All spline gages are clearly and permanently labeled with profile data, user identification numbers, manufacturer's drawing and drawing number, material, serial number and date of manufacture. Spline gages are reusable and worn gages can be rebuilt.

Special steels are available for added durability, reduction of test equipment monitoring costs, reduced manufacturing or wear tolerances. These have a higher alloy content and hardness. Special delivery is offered for emergency situations.

In addition, Euro-Tech will display Mytec-Hydraclamp expansion arbors and chucks, which feature unusually high clamping forces achieved through high internal pressures. Extremely high torque values are possible due to the absolute friction grip and centered tension. This torque rating can be up to three times greater with a special hard coating at the clamping sleeve. Hydra expansion elements from Mytec-Hydraclamp can be expanded without a workpiece because the expansion elements are permanently adjusted within the maximum expansion of 0.3 percent. Over-expansion is not possible due to an integrated stroke limiter. A closed expansion system, which is absolutely impervious to dirt and chips, combined with high wear resistance, guarantees a long service life. If space permits, Hydra expansion elements from Mytec-Hydraclamp are generally equipped with an adjustment piston. This makes it possible to set expansion for fine clamping, particularly in the case of thin-walled workpieces.

Tools have a hardness of 56 HRC with a center hardness of 64 HRC. An optional highly wear-resistant coating may be applied, which will result in a surface hardness of 80 HRC. Mytec-Hydraclamp guarantees a minimum of 50,000 expansion cycles for its expansion tools and 12 months of function.

For more information:
Euro-Tech Corp.
N48 W14170 Hampton Ave.
Menomonee Falls, WI 53051
Phone: (262) 781-6777
Fax: (262) 781-2822
www.eurotechcorp.com


PRECISION
Induction Gear Hardening
INDUCTOHEAT
An Inductotherm Group Company

IMTS2010
CONNECTING GLOBAL TECHNOLOGY

The following IMTS exhibitors are suppliers of products or services that may be of interest to gear manufacturers who visit the show. The Booth numbers include a letter indicating which building the booth is in (N=North, S=South, E=East, W=West).

Alphabetical Listings

BOOTH	Company
N-7115	Accu-Cut Diamond Tool Co., Inc.
N-7027	American Broach & Machine Company
N-7027	American Gear Tools - Division of American Broach (DBA)
N-6437	American Stress Technologies, Inc.
E-4245	American Wind Energy Association
N-7514	AMT - The Association For Manufacturing Technology
N-6548	AMTDA
N-7414	ANCA Inc.
N-6454	Andantex USA Inc.
N-6322	Atlanta Drive Systems, Inc.
E-5747	Baldor Electric Company
E-4942	Bosch Rexroth Corporation
W-1271	Boston Centerless
N-6924	Bourn & Koch Inc.
N-7112	Broach Masters/Universal Gear
N-7229	Broaching Machine Specialties Co.
E-5115	Brown & Sharpe
E-5510	Carl Zeiss IMT Corporation
W-2446	Ceratizit USA, Inc.
N-7046	Cosen Saws, USA
S-8900	DMG America Inc.
N-7240	Dr. Kaiser
N-6536	DTR Corporation
W-1272	Dura-Bar
N-7124	Elmass Broaching Technologies, L.L.C.
N-6918	EMAG L.L.C.
N-6918	EMAG Maschinenfabrik Gmbh
W-1536	Emuge Corp.
N-7546	Engis Corporation
W-2168	Erasteel Inc.
N-6830	Erwin Junker Machinery, Inc.
W-2453	Euro-Tech Corporation
E-5435	Faro Technologies, Inc.
N-6924	Federal Broach
W-2453	Frenco GmbH
N-7220	Frömag
S-9430	Fuji Machine America Corporation
N-7127	*Gear Solutions* Magazine
N-7572	*Gear Technology / Power Transmission Engineering*
N-6740	Gehring LP
N-7000	Gleason Corporation
N-7030	Gould & Eberhardt Gear Machinery
N-6144	Gudel Inc.
S-8119	Haas Automation, Inc.
W-2338	Hainbuch America Corporation
N-7451	Hamai Company
W-2334	Hassay Savage / Magafor
S-8050	Havlik International Machinery Inc.
E-5115	Hexagon Metrology, Inc.
N-6737	Höfler Maschinenbau GmbH
N-7030	Hoglund Technology
E-4952	Hommel - Etamic America Corp.
N-7425	I-TECH International Corp.
W-1822	Ingersoll Cutting Tools
W-1916	ITW Workholding
N-6938	J. Schneeberger Corporation
N-7036	Kapp GmbH
N-6930	Klingelnberg GmbH
N-6918	Koepfer America, L.L.C.
N-6746	Leistritz Corporation
N-6930	Liebherr Gear Technology, Inc.
W-1314	LMC Workholding
E-5048	Mahr Federal Inc.
E-5521	Marposs Corporation
N-7170	Mijno Precision Gearing
E-4924	Mitsubishi Electric Automation, Inc.
N-6837	Mitsubishi Heavy Industries - MI
S-8548	Mitsubishi Heavy Industries America, Inc.
N-7220	Mitts & Merrill L.P.
S-8061	Mitutoyo America Corporation
E-5126	Mitutoyo Corporation
N-6918	Monnier + Zahner AG
W-2453	Mytec GmbH
W-1653	Nachi America Inc.
N-7036	NILES Werkzeugmaschinen GmbH
W-2108	Northfield Precision Instrument Corp.
E-4851	NSK Precision America Inc. - U.S. HQ
N-7425	Ort Italia
N-7577	Osborn International
N-7027	QC American LLC - Division of the Qinchuan Machinery Develpoment Co.
N-7030	R.P. Machine Enterprises, Inc.
N-6454	Redex-Andantex
N-7018	Reishauer Corporation
N-6571	Renold Gears
N-6918	Richardon GmbH
W-1336	Riten Industries, Inc.
N-6840	Roto-Flo
N-7240	S.L. Munson & Company
N-7329	Saacke North America, LLC
E-5806	Saint-Gobain Ceramics
N-6924	SAMP S.p.A.
W-1500	Sandvik Coromant
W-2000	Schunk, Inc.
N-6625	Setco
N-6924	Sicmat S.p.A.
E-4933	Siemens Industry Inc.
E-4763	SKF USA Inc.
W-2151	Slater Tools Inc.
N-6300	Smalley Steel Ring Company
N-6414	Solar Atmospheres
N-6414	Solar Manufacturing
N-6924	Star SU LLC
S-9476	StarragHeckert SIP
W-1352	Suhner Industrial Products Corporation
N-7400	Sunnen Products Company
N-7000	The Gleason Works
N-6840	U.S. Gear Tools
E-5610	Timken - Positioning Control
N-6800	United Grinding Technologies
W-1306	Von Ruden Manufacturing Inc.
N-7436	Wenzel America, Ltd.
E-5457	Wittenstein
N-7436	Xspect Solutions
N-6600	Yaskawa Electric America, Inc.

Listings by Booth Number

BOOTH	Company
W-1271	Boston Centerless
W-1272	Dura-Bar
W-1306	Von Ruden Manufacturing Inc.
W-1314	LMC Workholding
W-1336	Riten Industries, Inc.
W-1352	Suhner Industrial Products Corporation
W-1500	Sandvik Coromant
W-1536	Emuge Corp.
W-1653	Nachi America Inc.
W-1822	Ingersoll Cutting Tools
W-1916	ITW Workholding
W-2000	Schunk, Inc.
W-2108	Northfield Precision Instrument Corp.
W-2151	Slater Tools Inc.
W-2168	Erasteel Inc.
W-2334	Hassay Savage / Magafor
W-2338	Hainbuch America Corporation
W-2446	Ceratizit USA, Inc.
W-2453	Euro-Tech Corporation
W-2453	Frenco GmbH
W-2453	Mytec GmbH
E-4245	American Wind Energy Association
E-4763	SKF USA Inc.
E-4851	NSK Precision America Inc. - U.S. HQ
E-4924	Mitsubishi Electric Automation, Inc.
E-4933	Siemens Industry Inc.
E-4942	Bosch Rexroth Corporation
E-4952	Hommel - Etamic America Corp.
E-5048	Mahr Federal Inc.
E-5115	Brown & Sharpe
E-5115	Hexagon Metrology, Inc.
E-5126	Mitutoyo Corporation
E-5435	Faro Technologies, Inc.
E-5457	Wittenstein
E-5510	Carl Zeiss IMT Corporation
E-5521	Marposs Corporation
E-5610	Timken - Positioning Control
E-5747	Baldor Electric Company
E-5806	Saint-Gobain Ceramics
N-6144	Gudel Inc.
N-6300	Smalley Steel Ring Company
N-6322	Atlanta Drive Systems, Inc.
N-6414	Solar Atmospheres
N-6414	Solar Manufacturing
N-6437	American Stress Technologies, Inc.
N-6454	Andantex USA Inc.
N-6454	Redex-Andantex
N-6536	DTR Corporation
N-6548	AMTDA
N-6571	Renold Gears
N-6600	Yaskawa Electric America, Inc.
N-6625	Setco
N-6737	Höfler Maschinenbau GmbH
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N-6918	EMAG Maschinenfabrik Gmbh
N-6918	Koepfer America, L.L.C.
N-6918	Monnier + Zahner AG
N-6918	Richardon GmbH
N-6924	Bourn & Koch Inc.
N-6924	Federal Broach
N-6924	SAMP S.p.A.
N-6924	Sicmat S.p.A.
N-6924	Star SU LLC
N-6930	Klingelnberg GmbH
N-6930	Liebherr Gear Technology, Inc.
N-6938	J. Schneeberger Corporation
N-7000	Gleason Corporation
N-7000	The Gleason Works
N-7018	Reishauer Corporation
N-7027	American Broach & Machine Company
N-7027	American Gear Tools - Division of American Broach (DBA)
N-7027	QC American LLC - Division of the Qinchuan Machinery Develpoment Co.
N-7030	Gould & Eberhardt Gear Machinery
N-7030	Hoglund Technology
N-7030	R.P. Machine Enterprises, Inc.
N-7036	Kapp GmbH
N-7036	NILES Werkzeugmaschinen GmbH
N-7046	Cosen Saws, USA
N-7112	Broach Masters/Universal Gear
N-7115	Accu-Cut Diamond Tool Co., Inc.
N-7124	Elmass Broaching Technologies, L.L.C.
N-7127	*Gear Solutions* Magazine
N-7170	Mijno Precision Gearing
N-7220	Frömag
N-7220	Mitts & Merrill L.P.
N-7229	Broaching Machine Specialties Co.
N-7240	Dr. Kaiser
N-7240	S.L. Munson & Company
N-7329	Saacke North America, LLC
N-7400	Sunnen Products Company
N-7414	ANCA Inc.
N-7425	I-TECH International Corp.
N-7425	Ort Italia
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Tribology Aspects in Angular Transmission Systems

Part II

Straight Bevel Gears

Dr. Hermann Stadtfeld

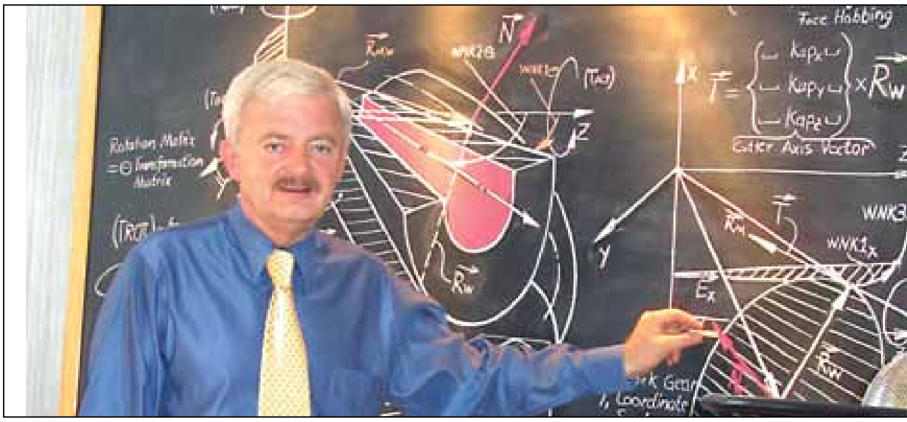
(This is the second of an eight-part series on the tribology aspects of angular gear drives. Each article will be presented first and exclusively by Gear Technology*; the entire series will be included in Dr. Stadtfeld's upcoming book on the subject, which is scheduled for release in 2011.)*

Design. If two axes are positioned in space—and the task is to transmit motion and torque between them using some kind of gears—then the following cases are commonly known:

- Axes are parallel → cylindrical gears (line contact)
- Axes intersect under an angle → bevel gears (line contact)
- Axes cross under an angle → crossed helical gears (point contact)
- Axes cross under an angle (mostly 90°) → worm gear drives (line contact)
- Axes cross under any angle → hypoid gears (line contact)

The axes of straight bevel gears, in most cases, intersect under an angle of 90°. This so-called shaft angle can be larger or smaller than 90°; however, the axes always intersect, which means they have at their crossing point no offset between them (*Author's note: see also previous chapter, "General Explanation*

continued



Dr. Hermann Stadtfeld *received a bachelor's degree in 1978 and in 1982 a master's degree in mechanical engineering at the Technical University in Aachen, Germany. He then worked as a scientist at the Machine Tool Laboratory of the Technical University of Aachen. In 1987, he received his Ph.D. and accepted the position as head of engineering and R&D of the Bevel Gear Machine Tool Division of Oerlikon Buehrle AG in Zurich, Switzerland. In 1992, Dr. Stadtfeld accepted a position as visiting professor at the Rochester Institute of Technology. From 1994 until 2002, he worked for The Gleason Works in Rochester, New York—first as director of R&D and then as vice president of R&D. After an absence from Gleason between 2002 to 2005, when Dr. Stadtfeld established a gear research company in Germany and taught gear technology as a professor at the University of Ilmenau, he returned to the Gleason Corporation, where he holds today the position of vice president-bevel gear technology and R&D. Dr. Stadtfeld has published more than 200 technical papers and eight books on bevel gear technology. He holds more than 40 international patents on gear design and gear process, as well as tools and machines.*

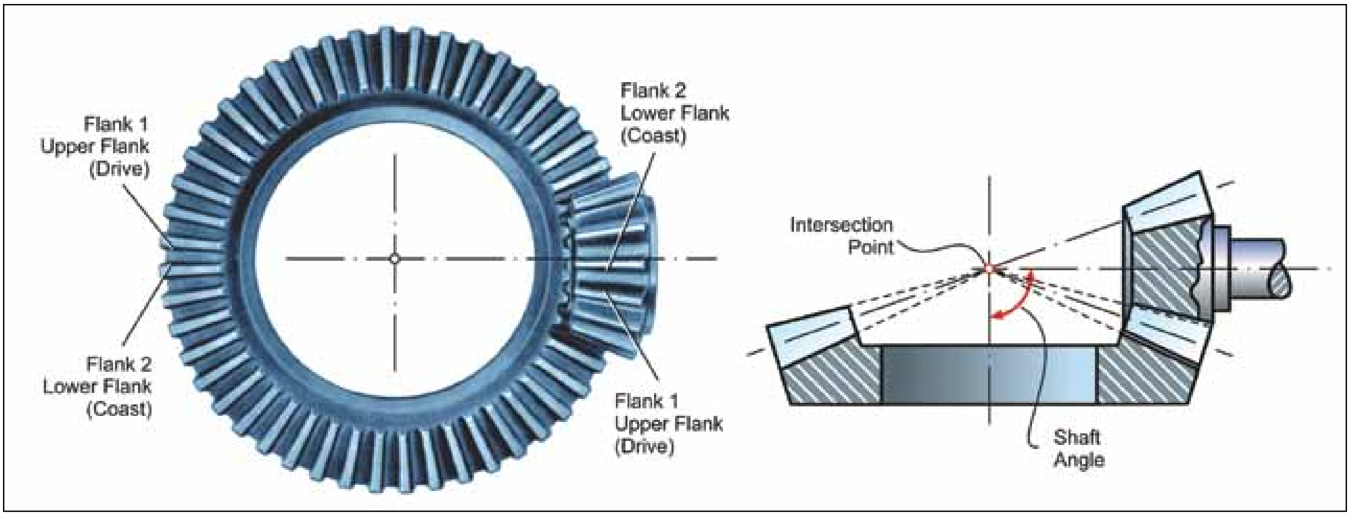


Figure 1—Straight bevel gear geometry.

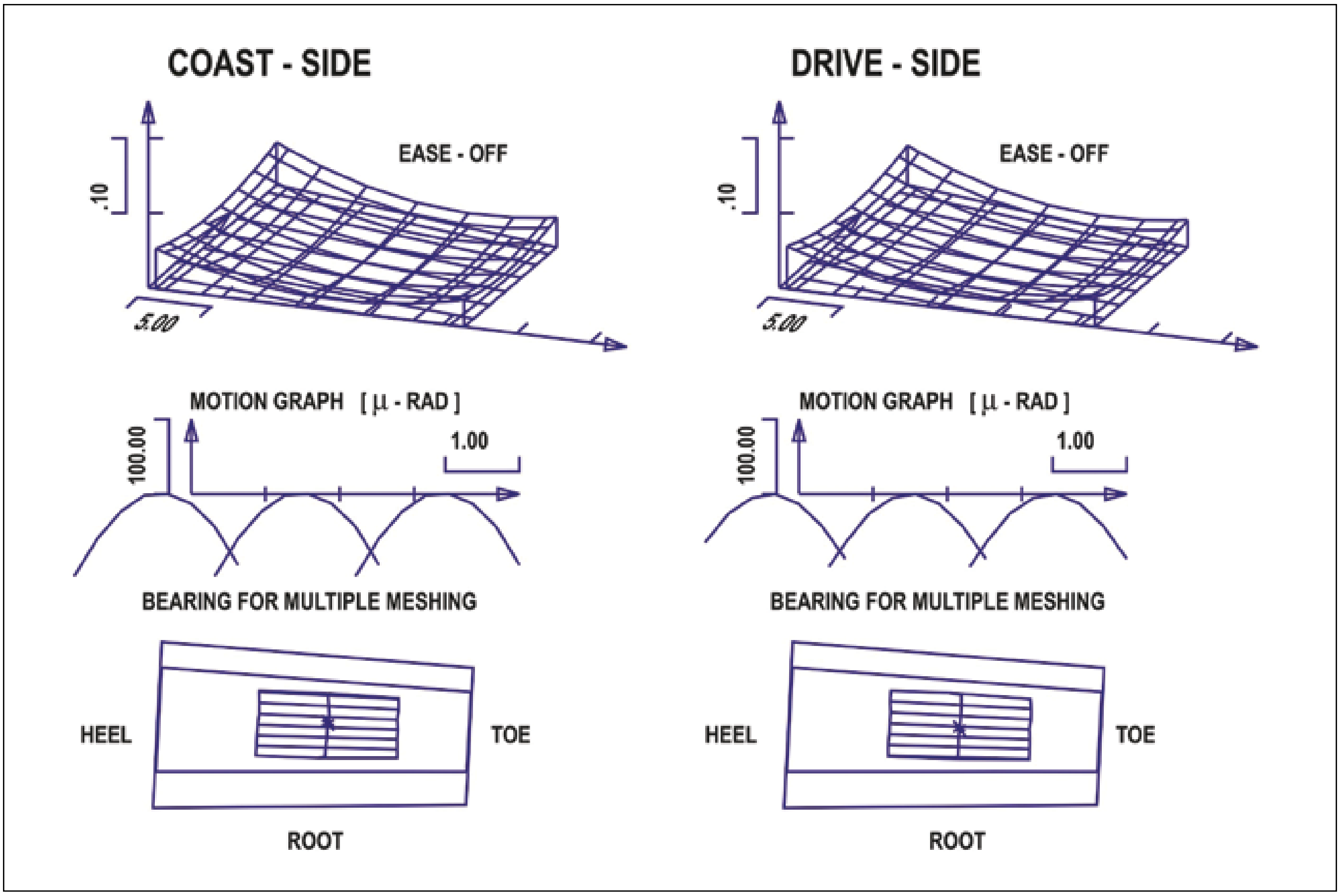


Figure 2—Tooth contact analysis of a straight bevel gear set.

of Theoretical Bevel Gear Analysis" on hypoid gears). The pitch surfaces are cones that are calculated with the following formula:

$$z_1/z_2 = \sin\gamma_1/\sin\gamma_2$$
$$\Sigma = \gamma_2 = 90° - \gamma_1$$

$$\text{in case of } \Sigma = 90° \rightarrow$$
$$\gamma_1 = \arctan(z_1/z_2) \rightarrow$$
$$\gamma_2 = 90° - \gamma_1$$

where:

z_1 number of pinion teeth
z_2 number of gear teeth
γ_1 pinion pitch angle
Σ shaft angle
γ_2 gear pitch angle

Straight bevel gears are commonly designed and manufactured with tapered teeth, where the tooth cross section changes its size proportionally to the distance of the crossing point between the pinion and gear axes. The profile function of straight bevel gears is a spherical involute, which is the direct analog to the tooth profiles of cylindrical gears.

Figure 1 shows an illustration of a straight bevel gear set and a cross-sectional drawing. Straight bevel gears have no preferred driving direction. Because of the orientation of the flanks during manufacture, the designations "upper" and "lower" flank are used. Per definition, the calculation programs treat the straight bevel pinion like a left-hand member and the straight bevel gear like a right-hand member. Consequently there is a drive side and a cost side designation, which is for proper definition rather than for implying better suitability of torque and motion transmission.

Analysis. The precise mathematical function of the spherical involute will result in line contact between the two mating flanks (rolling without any load). In the case of a torque transmission, the contact lines become contact zones (stripes) with a surface-stress distribution that shows peak values at the two ends of each observed contact line, where the contact line is limited by the inner and outer end of the tooth (toe and heel). In order to prevent this edge contact, a crowning along the face width of the teeth (length crowning) and in profile direction (profile crowning) are introduced into the pinion flanks, the gear flanks or both. A theoretical tooth contact analysis (TCA) previous to gear manufacturing can be performed in order to observe the effect of the crowning in connection with the basic characteristics of the particular gear set. This also affords the possibility of returning to the basic dimensions in order to optimize them if the analysis reveals any deficiencies. Figure 2 shows the result of a TCA of a typical straight bevel gear set.

The two columns in Figure 2 represent the analysis results of the two mating flank combinations (*see also "General Explanation of Theoretical Bevel Gear Analysis"*). However, the designation "drive" and "coast" are strictly a definition rather than a recommendation. The top graphics show the ease-off topographies. The surface above the presentation grid shows the consolidation of the pinion and gear crowning. The ease-offs in Figure 2 have a combination of length and profile crowning, thus establishing a clearance along the boundary of the teeth.

Below each ease-off, the motion transmission graphs of the particular mating flank pair are shown. The motion transmission graphs show the angular variation of the driven gear in the case of a pinion that rotates with a constant angular velocity. The graphs are drawn for the rotation and mesh of three consecutive pairs of teeth. While the ease-off requires a sufficient amount of crowning—in order to prevent edge contact and allow for load-affected deflections—the crowning in turn causes proportional amounts of angular motion variation of about 90 micro radians in this example.

At the bottom of Figure 2, the tooth contact pattern is plotted inside of the gear tooth projection. These contact patterns are calculated for zero-load and a virtual marking compound film of 6 µm thickness. This basically duplicates the tooth contact; one can observe the rolling of the real version of the analyzed gear set under light load on a roll tester, while the gear member is coated with a marking

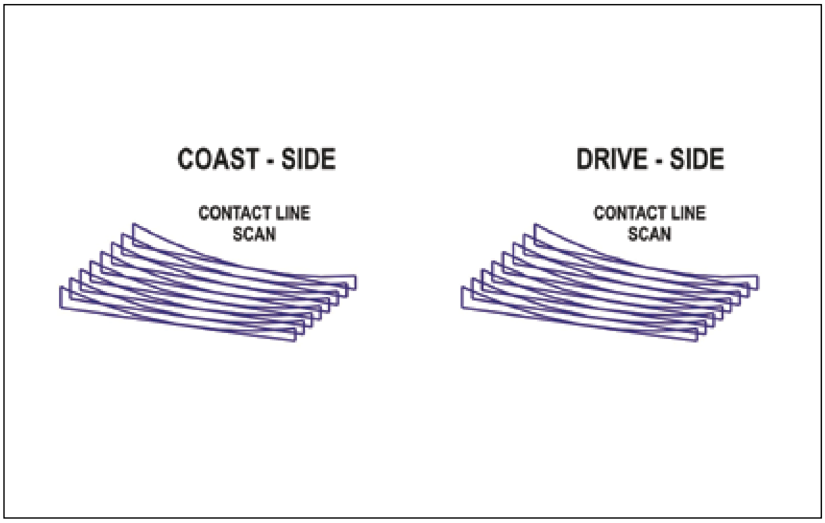


Figure 3—Contact line scan of a straight bevel gear set.

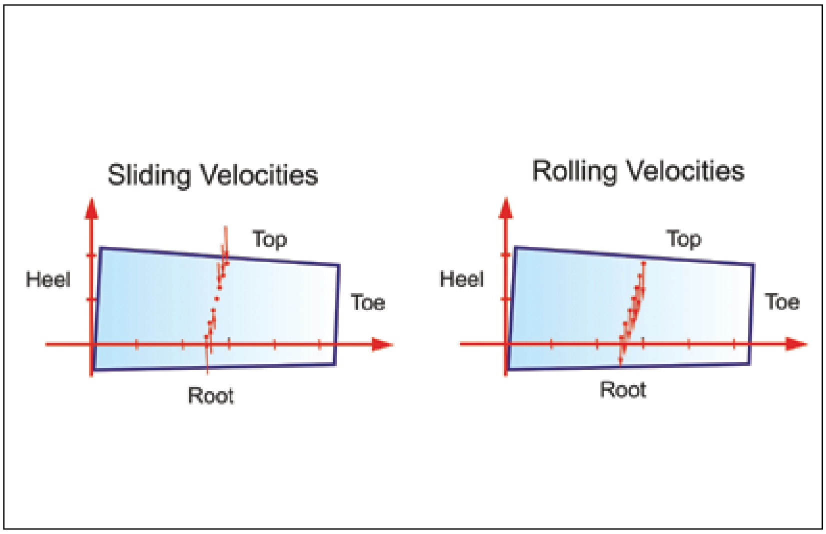


Figure 4—Rolling and sliding velocities of a straight bevel gear set along the path of contact.

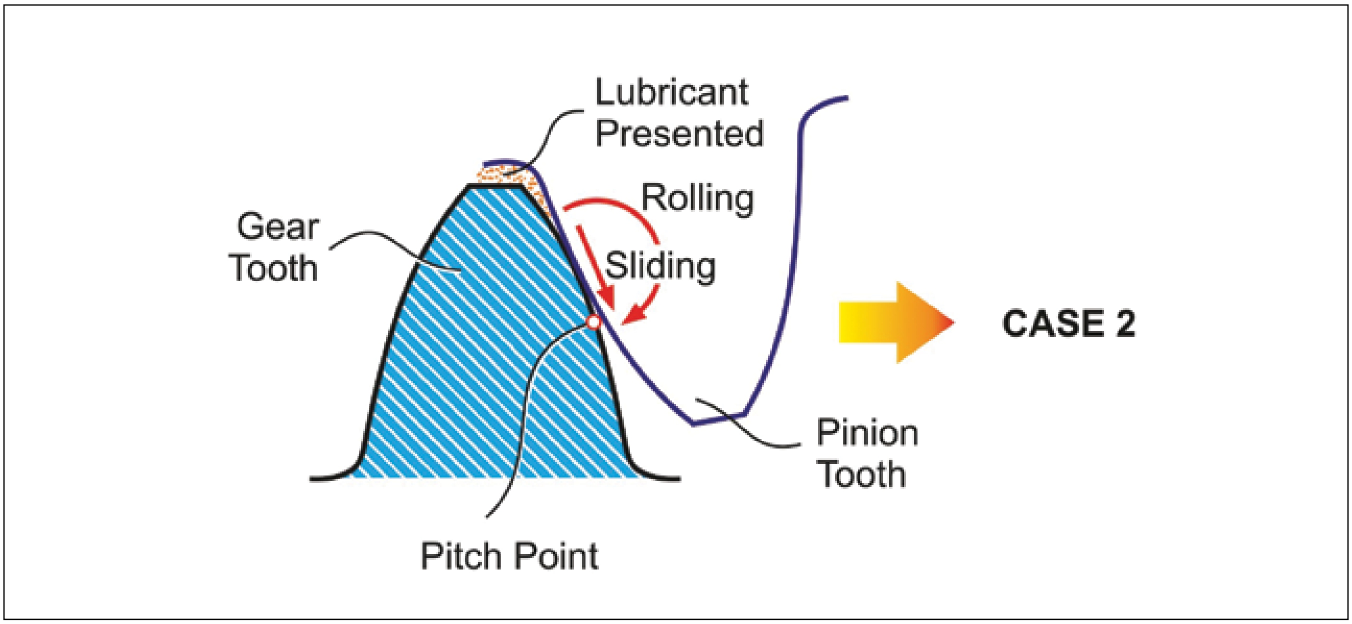


Figure 5—Profile sliding and rolling in straight bevel gears.

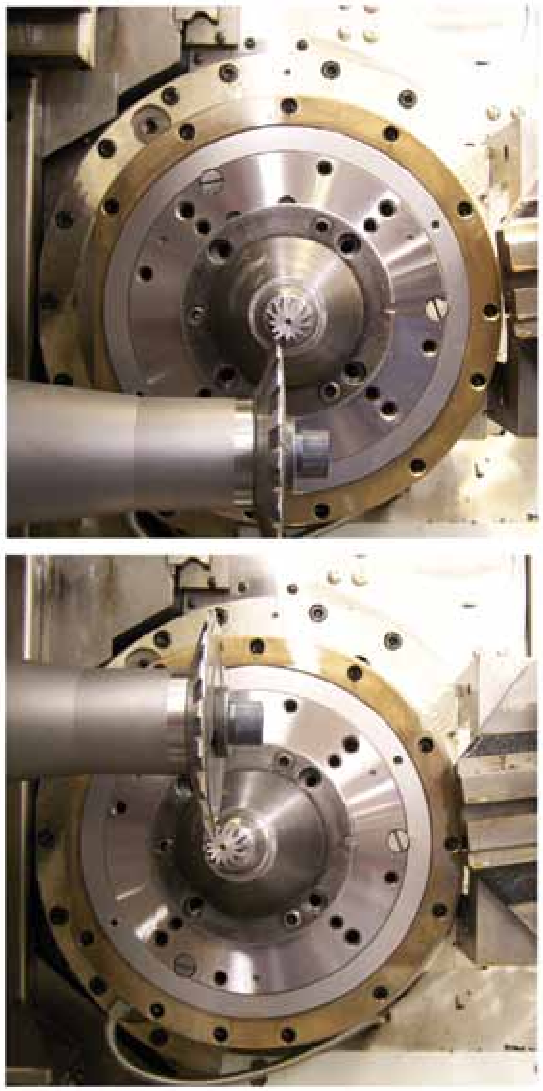


Figure 6—Straight bevel gear cutting with disc cutter (top: lower flank, bottom: upper flank).

compound layer of about 6 μm thickness. The contact lines extend in tooth length direction as straight lines—each of which point to the crossing apex point of face-pitch and root-cone. The path of contact is oriented in profile direction and crosses the contact lines under about 90°.

The crowning reflected in the ease-off results in a located contact zone inside the boundaries of the gear tooth. A smaller tooth contact area generally results from large ease-off and motion graph magnitudes, and vice versa.

Figure 3 shows eight discrete, potential contact lines with their crowning amount along their length (contact line scan). The length orientation of the contact lines, caused by the zero-degree spiral angle, results in a contact line scan with horizontally oriented gap traces. If the gearset operates in the drive direction, then the contact zone (instant contact line) moves from the top of the gear flank to the root. There is no other utilization of the face width than a contact spread under increasing load.

The graph in Figure 4 illustrates the rolling- and sliding-velocity vectors; each vector is projected to the tangential plane at the point-of-origin of the vector. The velocity vectors are drawn inside the gear tooth boundaries (axial projection of one ring gear tooth). The points-of-origin of both the rolling- and sliding-velocity vectors are grouped along the path of contact, which is found as the connection of the minima of the individual lines in the contact line scan graphic (Fig. 3). Figure 4 shows the sliding-velocity vectors with arrow tip, and rolling-velocity vectors as plain lines. Contrary to spiral bevel and hypoid gears, the directions of both—sliding and rolling velocities—are oriented in profile direction. The rolling velocities in all points are directed to the root, while the sliding velocities point to the top above the pitch line and to the root below the pitch line. At the pitch line, the rolling velocity is zero, just like in the case of cylindrical gears.

Straight bevel gears have properties very similar to spur gears. The path of contact moves from top to root (in the center of the face width) and the contact lines are oriented in face width direction (Fig. 2). Sliding- and rolling-velocity vectors are pointing in profile direction (Fig. 4), which will shift the contact lines in Figure 4 exclusively in profile direction. This means the crowning of the contact lines has no significant influence on the lubrication case ("*General Explanation of Theoretical Bevel Gear Analysis*"), but only the involute interaction will define the lubrication case and the hydrodynamic condition.

If the lubricant were presented, for example, on the top of the gear tooth as in Figure 5, the sliding- and rolling-velocity directions would result in Lubrication Case 2 as previously discussed in "General Explanation of Theoretical Bevel Gear Analysis." As the rolling progresses below the pitch point, the sliding velocity will change its direction and the lubrication case becomes Case 3, which is very unfavorable and reason to assure lubrication is presented on both sides of the contact zone.

Manufacturing. The manufacturing processes of straight bevel gears are planing with two tool generators, milling with two interlocking disk cutters or milling with a single-disk cutter (Gleason Coniflex). The planing and interlocking disk cutter processes are outdated and typically performed on older, not current mechanical machine tools. The single-disk-cutter milling process was developed for modern free-form machines. It enables the use of carbide cutting tools in a high-speed, dry-cutting process.

The blades of the circular cutter disk envelope an axial plane (or slight cone) on the right side of the disk in Figure 6. This plane is oriented in space and simulates one side of a generating rack, analog to a cylindrical, gear-generating rack. Due to the diameter of the cutter disk, the root line of the straight bevel gear

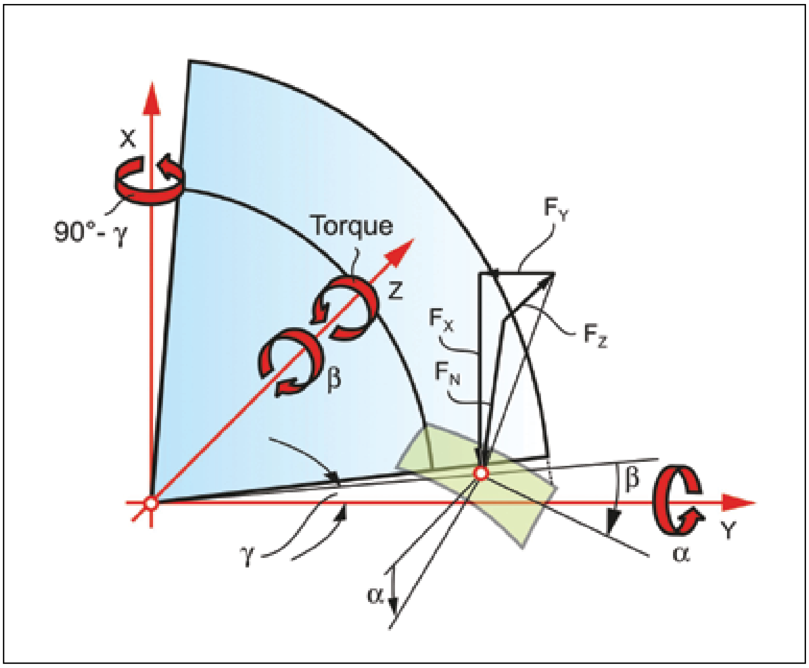


Figure 7—Force diagram for calculation of bearing loads.

cut shown in Figure 6 is curved, rather than straight. The curve in the root is a side effect of this particular process, and has never proven to be of any disadvantage regarding the gear set kinematics or strength. The left photo in Figure 6 shows the cutting of the lower flanks. The opposite flanks of the same slots are cut with the same tool in the upper position, as shown in the right photo in Figure 6.

Hard finishing after heat treatment is possible by grinding with a permanent, CBN-coated grinding wheel, which basically resembles the geometry of the cutter disk. The geometry and kinematics of the grinding process are identical to the cutting in Figure 6.

Application. Most straight bevel gears used in power transmission are manufactured from carburized steel and undergo a case hardening to a surface hardness of 60 Rockwell C (HRC) and a core hardness of 36 HRC. Because of the higher pinion revolutions, it is advisable to provide the pinion a higher hardness than the ring gear (e.g., pinion 62 HRC, gear 59 HRC).

Regarding surface durability, straight bevel gears are also very similar to spur gears. At the pitch line, the sliding velocity is zero and the rolling velocity, under certain loads, cannot maintain a surface-separating lubrication film. The result is pitting along the pitch line that can destroy the tooth surfaces and even lead to tooth flank fracture. However, it is possible that the pitting can be stabilized if the damage-causing condition is not often represented in the duty cycle.

The axial forces of straight bevel gears can be calculated by applying a normal force vector at the position of the mean point at each member (*see also "General Explanation of Theoretical Bevel Gear Analysis*"). The force vector normal to the transmitting flank is separated in its X, Y and Z components (Fig. 7).

The relationship in Figure 7 leads to the following formulas, which can be used to calculate bearing force components in a Cartesian coordinate system and assign them to the bearing load calculation in a CAD system:

$$F_x = -T / (A_m \bullet \sin\gamma)$$
$$F_y = -T \bullet (\cos\gamma \bullet \sin\alpha) / (A_m \bullet \sin\gamma \bullet \cos\alpha)$$
$$F_z = T \bullet (\sin\gamma \bullet \sin\alpha) / (A_m \bullet \sin\gamma \bullet \cos\alpha)$$

where:
- T torque of observed member
- A_m mean cone distance
- γ pitch angle
- α pressure angle
- F_x, F_y, F_z bearing load force components

The bearing force calculation formulas are based on the assumption that one pair of teeth transmits the torque, with one normal-force vector in the mean point of the flank pair. The results are good approximations, which reflect the real bearing loads for multiple-tooth meshing within an acceptable tolerance. A precise calculation is, for example, possible with the Gleason bevel and hypoid gear software.

Straight bevel gears have lesser axial forces than spiral bevel gears. The axial force component—due to the spiral angle—is zero. Zero-spiral angle minimizes the face-contact ratio to zero, but results in maximal tooth root thickness.

The tooth thickness counts squared in a simplified root-bending-stress calculation using a deflection beam analogy. The thickness reduces by cos (spiral angle). The face-contact ratio increases, simplified by tan (spiral angle). Those formulas applied to a numerical example will always show an advantage of the spiral angle in root-bending strength. However, the crowning of real bevel gears will always cause one pair of teeth to transmit an over-proportionally high share of the load, while the one or two additionally involved tooth pairs will only share a small percentage of the load. Finite element calculations can be useful in finding the optimal spiral angle for maximal root strength. As a rule, bevel gears that are not ground or lapped after heat treatment show the highest root strength with the lowest spiral angles. This explains why—in those cases—the straight bevel gear remains the bevel gear of choice.

Straight bevel gears can operate with regular transmission oil or, in the case of low RPMs, with a grease filling. In case of circumferential speeds above 10 m/min., a sump lubrication with regular transmission oil is recommended. The oil level has to cover the face width of the teeth lowest in the sump. Excessive oil causes foaming, cavitations and unnecessary energy loss. There is no requirement for any lubrication additive. Because the two kinds of flanks in a straight bevel gear (upper and lower) are mirror images of each other, there is no preferred operating direction, which is advantageous for many industrial applications.

(*Ed.'s Note: Next issue—"Zerol Bevel Gears."*)

Corrections

The previous article in this series, "General Explanations on Theoretical Bevel Gear Analysis," which appeared in the August 2010 issue of *Gear Technology*, contained two errors. The corrected or clarified text is highlighted below.
The complete corrected version of the article is available at *http://www.geartechnology.com/issues/0810*

Corrections

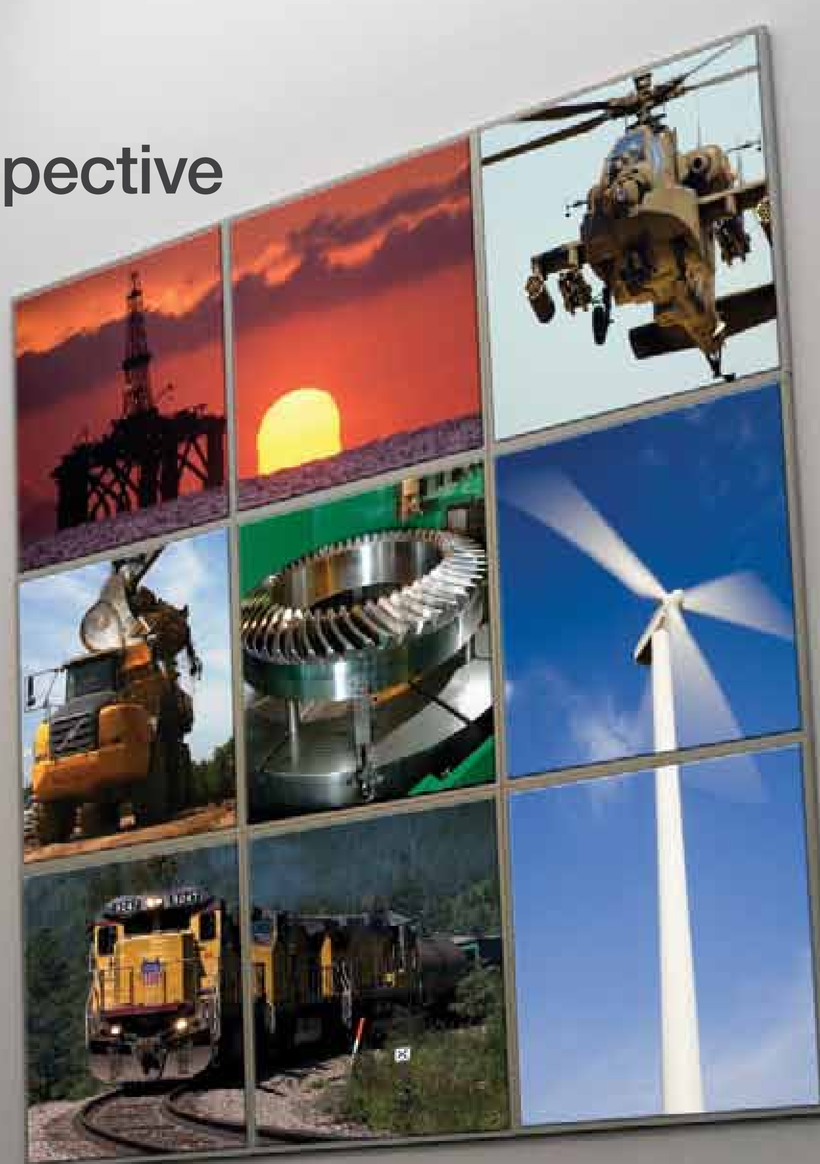
Page 49, left middle paragraph:
6 µm instead of 6 mm. (The error appears twice in this paragraph.)

Page 52, Formula 7:
Eliminate absolute value of Fn

$$|Fn| = Fx / (\cos\beta \bullet \cos\alpha)$$
$$= -T / (A_m \bullet \sin\gamma \bullet \cos\beta \bullet \cos\alpha) \quad (7)$$

The Gear:

An Industry Perspective



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Engagement of Metal Debris into Gear Mesh

Robert F. Handschuh and Timothy L. Krantz

(Proceedings of MPT2009-Sendai JSME International Conference on Motion and Power Transmissions, May 13–15, 2009, Matsushima Isles Resort, Japan.)

Management Summary

A series of bench-top experiments was conducted to determine the effects of metallic debris being dragged through meshing gear teeth. A test rig that is typically used to conduct contact fatigue experiments was used for these tests. Several sizes of drill material, shim stock and pieces of gear teeth were introduced and then driven through the meshing region. The level of torque required to drive the "chip" through the gear mesh was measured. From the data gathered, chip size sufficient to jam the mechanism can be determined.

Introduction

In some space mechanisms, the loading can be so high that there is some possibility that a gear chip might be liberated while in operation of the mechanism (Refs. 1–5). Also, due to the closely packed nature of some space mechanisms—and the fact that a space grease is used for lubrication—chips that are released can then be introduced to other gear meshes within this mechanism. In this instance, it is desirable to know the consequences of a gear chip entering in between meshing gear teeth. To help provide some understanding, a series of bench-top experiments was conducted to engage chips of simulated- and gear-material fragments into a meshing gear pair. One purpose of the experiments was to determine the relationship of chip size to the torque required to rotate the gear set through the mesh cycle. The second purpose was to determine the condition of the gear chip material after engagement by the meshing gears—primarily to determine if the chip would break into pieces and to observe the motion of the chip as the engagement was completed. This article also

Figure 1—Bench set-up for gear chip engagement testing using the NASA Glenn fatigue rig.

presents preliminary testing done with metal "debris"—other than chips from gears—namely, steel shim stock and drill bits of various sizes and diameters.

Test Equipment

The gear testing was done using a (Cleveland-based) Glenn Research Center spur gear fatigue test rig. This rig uses two identical spur gears engaged with one another. The shaft mounting is an overhung arrangement for the test gears, and the nearby bearings are roller bearings. The overhung distance from the bearing supports is approximately 32 mm (1.25 in.). Because the test machine was designed for experiments of gear fatigue, the shaft and bearing supports are relatively large and stiff. Figure 1 shows the test gearbox with a pair of test gears mounted.

Test Gears, Debris and Procedure

The gears used for this study were case-carburized and ground, and were manufactured from the steel alloy AISI 9310. The gears' design information is shown in Table 1. The gears were shot peened after hardening and before final grinding. The gears were representative of gears utilized in a space mechanism that was being simulated.

The gear design specifications and the actual mounted center distance determine the root clearance and backlash of a gear pair. The backlash and root clearances were determined for the first pair of test gears mounted on the test fixture. The backlash was measured as 0.15 mm (0.006 in.), using a standard measurement set-up (Fig. 2). The root clearance was measured as 0.94 mm (0.037 in.). The root clearance was determined by running a piece of soft material (solder) through the mesh and measuring the deformed material with a caliper.

Three types of "debris" were placed into the meshing gear teeth for testing—steel shim stock, drill bit shanks and pieces—or "chips"—from gear teeth. The shim stock materials used were steel and stainless steel. The shim thickness ranged from 0.13 to 1.88 mm (0.005 to 0.074 in.). The shims were cut to a length of approximately 2.5 to 3.8 mm (0.100 to 0.150 in.), representing approximately half of the tooth height. The shim lengths were wider than the faces of the gears and were placed to engage the full face width of the gear teeth (Fig. 3). The drill bit shanks used for these experiments had shank diameters ranging from 1.07 to 1.96 mm (0.042 to 0.077 in.).

The gear chip pieces used in this work were liberated from a spare test gear (case-carburized and ground AISI 9310 steel). Ten gear chips were used for testing. Eight of the

continued

Table 1—Basic Gear Dimensions	
Number of Teeth	42
Module, (Diametral pitch); mm (1/in.)	2.12 (12)
Circular pitch, mm (in.)	6.65 (0.2616)
Whole depth, mm (in.)	4.98 (0.196)
Addendum, mm (in.)	2.11 (0.083)
Chondal tooth thickness, mm (in.)	3.25 (0.1279)
Helix angle, (deg)	0
Pressure angle, (deg)	25
Pitch diameter, mm (in.)	88.9 (3.50)
Outside diameter, mm (in.)	93.14 (3.667)
Root fillet, mm (in.)	1.02 (0.04)
Measurement over pins, mm (in.)	93.87 (3.6985)
Pin diameter, mm (in.)	3.66 (0.144)
Backlash, mm (in.)	0.15 (0.006)
Tip relief, mm (in.)	0.015 (0.0006)

Figure 2—Set-up for backlash measurement using dial indicator.

Figure 3—Example of shim and placement used for engagement testing.

Table 2—Mass of the Test Gear Chips	
Chip Identification Number	Mass, (grams)
1	0.090
2	0.100
3	0.106
4	0.116
5	0.139
6	0.254
7	0.342
8	0.045
9	0.098
10	0.032

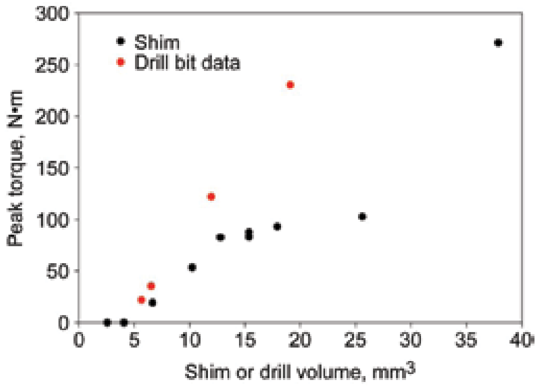

Figure 4—Relationship of volume of engaged objects to the peak torque required to rotate the gears for the NASA GRC spur gear rig using 12-pitch case-carburized steel gears.

Figure 5—Example of deformed shim stock after engagement of meshing gear teeth.

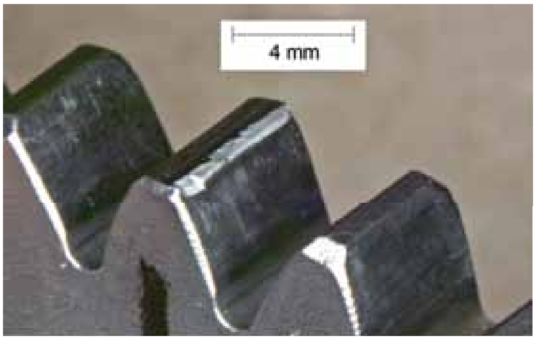

Figure 6—Example of damaged tooth tip after engagement of 1.96 mm (0.077 in.) diameter drill bit shank.

ten chips were created by scoring a mark on the gear tooth, using a small rotating cutting wheel and then striking the score line with a cold chisel. This created chips with irregular shapes, and the chips were of varying sizes (mass). Two of the gear chips were made by cutting the gear tooth using a metals lab cutting wheel. These two chips have a more-regular shape and (as compared to chips made by striking) relatively smooth edges.

To quantify the sizes of the chips, the mass of each chip was determined (Table 2). The figures that follow show at least one image with a scale marker for each chip used for testing.

Testing using the shims and drill bits was done with no lubrication on the gear teeth. For tests done with gear chips, a generous amount of a Teflon-based, space-qualified grease was applied with a brush to the teeth prior to testing. During testing, one of the gear shafts (the driven gear) was free to rotate—i.e., there was no resistive torque applied. The driving gear was rotated with a torque wrench by hand in a very deliberate manner. The peak torque reading recorded by the torque wrench was recorded as the engaged debris was rolled through the mesh.

Test Results

The results for the shim stock and drill bit testing will be discussed first.

To relate the peak torque required to roll the object through the gear mesh to the size of the object, the volume of the object was calculated—assuming the full face width of the gear was engaged and using a nominal height of 3.18 mm (0.125 in.) for the shim objects. The resulting relationship of peak torque to the object volume is provided in Figure 4. For the smallest shims tested, only a very small, nominal drag torque of the rig set-up was required to rotate the shim through mesh. The drill bit shanks required a significantly greater peak torque for an equivalent volume of shim stock material. This can be explained by the higher hardness of the drill bit shank, relative to shim stock—thereby requiring larger peak torque before any plastic deformation (or shaft deflection) of the bit shank or gear teeth takes place.

For the drill bit test data, a straight line can be passed through the data. In the data for the much softer shim stock, there initially appears to be a linear relation—up to a certain volume. Then a region of this data is nearly non-varying—and only increasing torque slightly as the volume was increased. Finally, for this data, a rather large increase in torque was recorded as the shim volume was in excess of 35 mm^3.

A plausible explanation for this can be stated as follows:

Initially, the shim stock plastically compresses and an increase in volume causes a proportional change in torque. As the volume is increased, enough of the tooth tip root clearance is still available to plastically compress the shim material, resulting in little increase in torque. Finally, as the volume of the tooth-tip-to-root-clearance is used up, the torque required to "extrude" the shim increases substantially.

In the case of the shim stock material, the main effect was elastic deformation of the support structure (shaft and bearings) and plastic deformation of the shim stock. Essentially, the shim stock was extruded. The shim stock took the shape of the root-fillet region of the driven gear, with intrusion by the tip of the driving gear (Fig. 5). The peak torque was roughly a linear function of the engaged shim volume. By visual examination, it was judged that the gear teeth were not damaged by engagement of the shim stock. For the case of the drill bit shanks, the main effect was elastic deformation of the supporting structure and some plastic deformation of the teeth. The drill bit shanks permanently deformed and damaged the tooth tip that made contact with the bit shank during the meshing process (Fig. 6).

Next, the results of testing with the gear chips are presented.

The peak torque required to rotate the gears was, to a good approximation, a linear function of the mass of the engaged chip (Fig. 7). For chip #2 of Table 2, the peak torque exceeded the measuring capacity of the torque wrench, and, since the peak torque was not known precisely, the data point was not included in the plot of Figure 7. A larger-capacity torque wrench was used for subsequent testing.

It was noted that immediately after testing, the disengaged chips were hot—indicative of the tremendous friction forces and plastic deforming work being done during the meshing process. Some of the smaller chips tended to remain in the root of the gear after the engagement. Larger chips were forced out of the mesh and were found on the table top, just below the gear mesh. The gear on the left had been rotated clockwise with the torque wrench (the input-torque direction), so the motion tended to throw and/or allow the chip to drop to the tabletop. For the two largest chips (#6 and #7 of Table 2), the engaged gear teeth were deformed and sufficiently damaged that the gears could no longer be rotated with hand torque past the damaged tooth. An image of such damage is provided in Figure 8.

Images of the chips—both before and after

continued

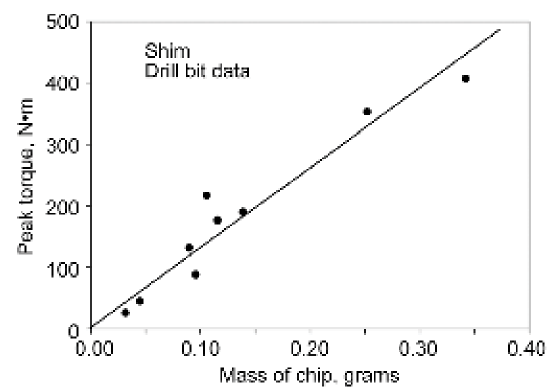

Figure 7—Peak torque recorded during chip engagement testing on GRC bench test set-up as a function of the mass of the engaged chip. The line is a linear regression of the data.

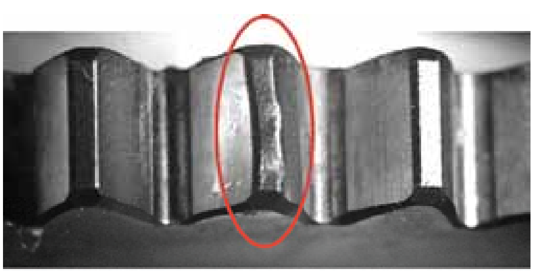

Figure 8—Severely deformed gear tooth as a result of engagement with largest chip tested, chip #7 having a mass of 0.342 grams. The gears can no longer be rotated to engage and pass through this tooth after using hand torque.

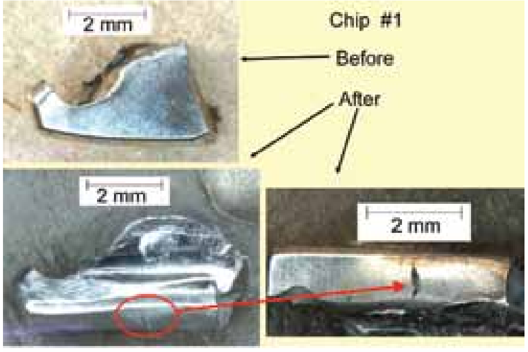

Figure 9—Chip #1, mass of chip 0.090 grams.

Figure 10—Chip #2, mass of chip 0.100 grams.

Figure 11—Chip #3, mass of chip 0.106 grams.

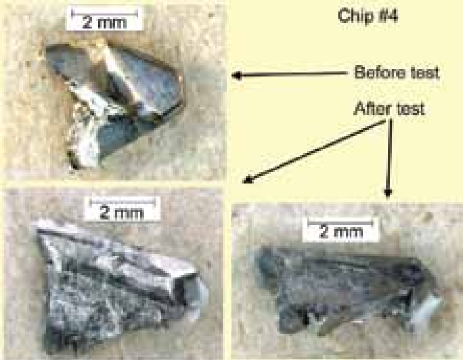

Figure 12—Chip #4, mass of chip 0.116 grams.

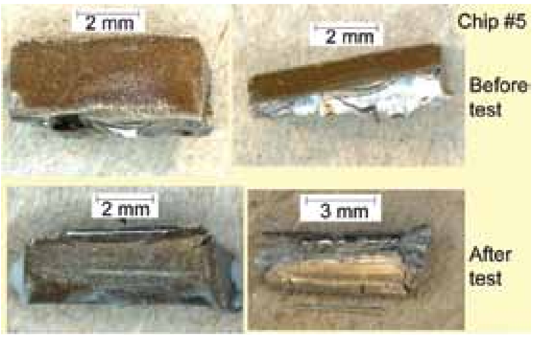

Figure 13—Chip #5, mass of chip 0.139 grams.

engagement testing—are provided in Figures 9–18. The images show that the main effect on the chips was deformation of the chips to conform to the available tooth root spaces. In general, the chips remained intact. For the case of chips #5 and #8, small pieces were liberated from the main piece, as can be seen in the figures. Chip #10 especially shows that the case-carburized material, even though generally described as brittle, can be significantly deformed and exhibit some toughness. Although the chip experienced some "tearing," the chip did not "shatter" or otherwise exhibit extreme brittleness.

Finally, all the data generated is shown in Figure 19. The drill bit and shim stock mass data was found using the data from Figure 4. The drill bit data was very comparable to the tooth chip data following the same trend. The shim stock data had a lower torque level over all the data taken. This must be an artifact of the nominal material hardness. The scatter in the tooth chip data is possibly due to non-symmetric shapes in comparison to the symmetry of the drill bit data.

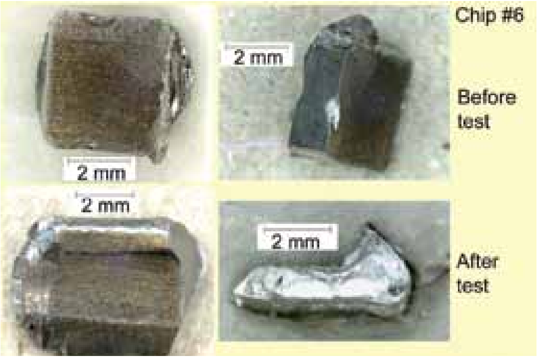

Figure 14—Chip #6, mass of chip 0.252 grams.

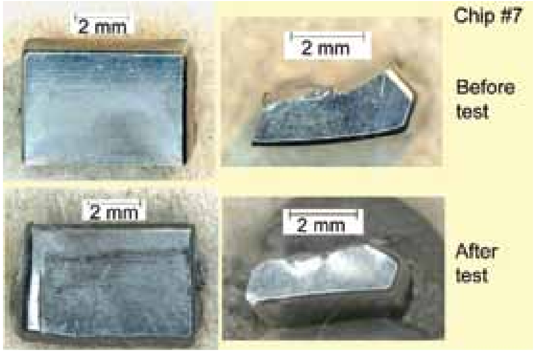

Figure 15—Chip #7, mass of chip 0.342 grams.

Conclusions

A series of bench-top experiments was conducted to provide an understanding of the engagement of metal debris into a gear mesh. The gears used for testing were case-carburized, 12-pitch spur gears made from the steel alloy AISI 9310. The metal debris that was engaged into the pair of meshing test gears was shim stock, drill bit shanks and chips of gears liberated from a test gear.

It was found that the peak torque required to rotate the gears with the object engaged was proportional to the size (mass) of the engaged object. Put another way, engaging objects of higher hardness required a significantly greater peak torque relative to an equivalent-sized object of lesser hardness.

For the largest chip sizes tested, sufficient deformation occurred to the gear teeth to prevent smooth motions of the gear when the damaged tooth is engaged.

During this study, no new chips or obvious tooth fracture occurred.

Even though case-carburized steel hardened in the manner of the aerospace gears is generally described as "brittle," the chips exhibited significant deformation and a degree

continued

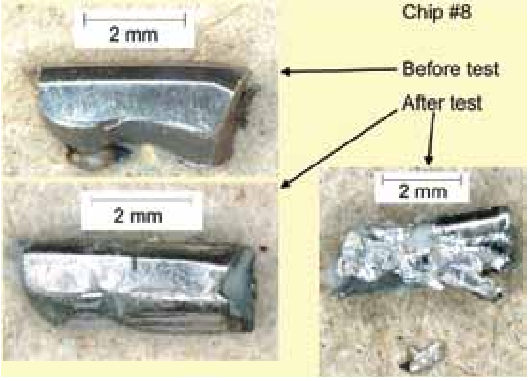

Figure 16—Chip #8, mass of chip 0.045 grams.

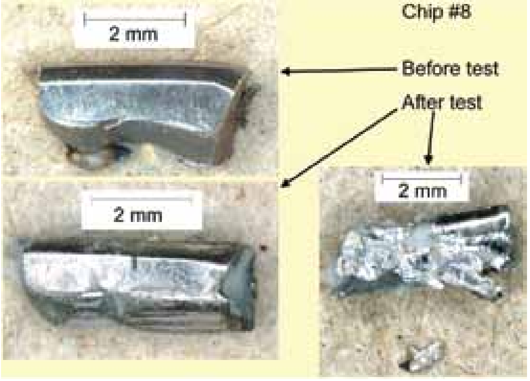

Figure 17—Chip #9, mass of chip 0.096 grams.

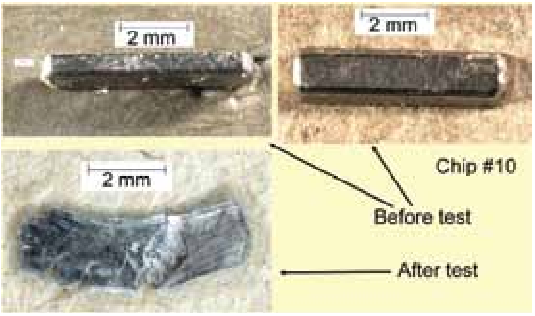

Figure 18—Chip #10, mass of chip 0.032 grams.

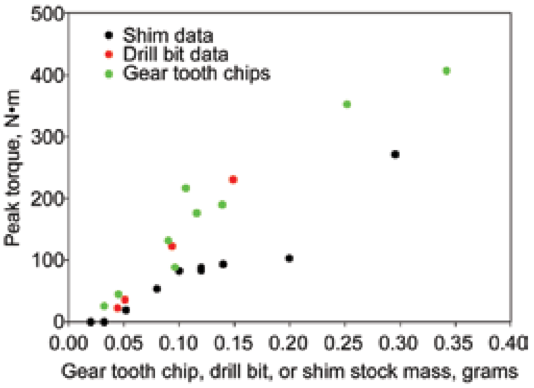

Figure 19—Debris mass versus peak torque required to rotate the gear mesh.

of toughness. Chips did not "shatter" or otherwise exhibit extreme brittle behavior.

Although large chips caused significant damage to the test gear teeth, the data generated in this study could be used for benchmarking the minimum torque needed to drive a gear chip of a certain mass for the tested system.

Therefore, the torque required to drive a gear chip through mesh would be expected to be system-dependent.

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2. Proctor, M., F. Oswald and T. Krantz. "Shuttle Rudder/Speed Brake Power Drive Unit (PDU) Gear Scuffing Tests with Flight Gears," NASA/TM—2005-214092, December 2005.
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Dr. Robert F. Handschuh *possesses more than 25 years of experience with NASA and the Dept. of Defense in rotorcraft drive system analysis and experimental methods. He has served as the Drive Systems Team leader for the Tribology & Mechanical Components Branch at NASA Glenn Research Center for over 15 years. The Drives Team Leader is responsible for the technical work conducted by the Drives Team within the Mechanical Components Branch. This includes managing, advocating and directing work in this area for rotorcraft and advanced geared turbofan engine technology. Other recent activities include drive system configuration assessment for the multi-fan drive system for the Blended Wing Body aircraft, propulsion lead for the NASA Heavy Lift Rotorcraft Program and mechanical system investigation as part of the Space Shuttle Return to Flight efforts. He is currently leading research in high-speed gearing, including windage and loss-of-lubrication technology. Handschuh has developed analytical processes for conducting thermal analysis of spiral bevel gears from a fundamental, geometrical model development for gear geometry in analyzing the transient, thermal environment using a time-and-position, varying finite element modeling technique. He has successfully developed many experimental research test facilities, including: high-temperature, ceramic-seal erosion, blade-shroud seal rub test, planetary gear train test facility, spiral bevel and face gear test facility, high-speed helical gear train facility, single tooth bending fatigue test facility and high-speed windage. He is the author of many papers within the scope of his expertise.*

Tim Krantz *has worked since 1987 as a research engineer at the NASA Glenn Research Center—first as an employee of the U.S. Army and presently as an employee of NASA. He has researched many topics to improve power transmission components and systems, with an emphasis on helicopter gearbox technologies. He has also helped investigate several issues for the NASA Engineering Safety Center, including the space shuttle rudder speed brake actuator, space shuttle body flap actuator and the International Space Station solar alpha rotary joint mechanism. He is the current vice-chair of the ASME Power Transmission and Gearing Committee.*

The Ultra Light Urban Vehicle project at Bradley University has evolved over four years (courtesy of Winzeler Gear).

The Efficiency Experts

BRADLEY UNIVERSITY AND WINZELER GEAR COLLABORATE ON URBAN VEHICLE PROJECT

Matthew Jaster, Associate Editor

The idea sprang from the mind of Dr. Martin Morris, professor of mechanical engineering at Bradley University, a few years back. "I'm sure it was not an original idea, but it became obvious to me that most of the energy required to transport my wife to the grocery store was used to move more than a ton of automobile across town and back," Morris says. "The weight of the important cargo was a small fraction of the weight of the total vehicle. Every time she would hit the brakes, all the kinetic energy of the car dissipated into the atmosphere through the brake pads. Think of all the people doing similar tasks. What a complete waste of energy."

These thoughts led Morris to a discussion with Jesse Maberry, a Bradley alumnus, on a proposal for a three-wheeled vehicle licensed as a motorcycle that carried two people and baggage, weighed about 350 lbs., with regenerative braking and a maximum top speed of 45 mph.

"Maberry liked the idea so much that he suggested we develop a mechanical engineering senior project to design, build and test such a vehicle at Bradley," Morris says. "He helped with the funding, and for about four years now the Ultra Light Urban Vehicle (ULUV) project has been evolving."

In its latest form, the ULUV weighs about 430 lbs., has regenerative braking, a top speed of 45 mph and a range of about 40 miles in stop-and-go traffic. "The cost of travel is about 0.6 cents per mile," Morris says. "Next year, we're targeting weight reduction and increasing the range, which should further reduce the cost per mile."

A Perfect Fit for Plastic

John Winzeler, president of Winzeler Gear in Harwood Heights, Illinois, has been a supporter of the mechanical engineering program at Bradley for many years. "He has helped us by supporting our Formula SAE program and has been an annual client for our senior design course

continued

Students at Bradley University worked with Winzeler Gear on the gear train for the Ultra Light Urban Vehicle.

sequence by providing challenging projects for our student teams," Morris says. "Our teams have delivered custom equipment and software developed for the testing of plastic gears. Winzeler has also funded research assistantships to support graduate student research to study the failure of plastic gears."

Plastic gears can be lightweight, durable, quiet and affordable. Morris thought a prototype urban vehicle would be an outstanding test bed for a lightweight transmission system designed with plastic gears. Using this transmission system, the team could run the drive motor at higher speeds without generating excessive noise. "The higher speeds contributed to improved performance of our energy management system," Morris says.

He proposed the idea to Winzeler and gear engineer Mike Cassata, both alumni of Bradley University.

"Two years ago, we were working with TTC Transmission Technologies on a transmission for a 25 hp electric motorcycle," Winzeler says. "We were brought in to look at that design and convert it from metal to plastic. We actually had done the stress calculations and believed there was a high probability of success. Once we started the prototype transmission, unfortunately, the motorcycle company went under during the recession."

The knowledge collected for this project, however, convinced Winzeler and his staff to look further into the ULUV concept. Cassata began running design calculations and determined that it could be a plastic transmission. "We designed the transmission, Dupont provided the material and Forest City Gear hobbed the sun and planet gears and shaped the ring gear. The students took a tour of Forest City Gear's Rockford plant so they could see how the gears were machined." Cassata says.

"They were very supportive of the idea," Morris adds. "Cassata worked with our students to design the gear train using Delrin plastic. The student team benefited from a real exercise in designing a gear train using plastic gears."

There were several challenges for the engineering team tasked with designing the transmission. "The first thing was to come up with the general design. We were talking about having a single spur gear reduction, but found out we couldn't get the needed reduction in the size restraints they had. This car had to weigh a certain amount according to the project definition," Cassata says. "We found out that with the reduction they needed, we needed to go with a planetary drive."

Once the team determined the drive system and the amount of space they had to work with, the next step was designing a planetary drive that had the correct reduction and thickness to withstand the forces. "It was then a matter of calculating the stresses," Cassata says. "We have a program written by our senior engineer to calculate the stresses on the teeth. We were able to meet the stresses based on the worst case scenario of the motor. After that, we had conversations with Bradley students about lubrication, temperature, how are you going to fix it to the motor, and other details concerning the vehicle."

"At the end of the day," Winzeler says. "Our main goal was to make sure the teeth don't break or the car refuses to go forward."

The planetary drive consists of a brass sun and Delrin planets and ring gear. The drive has a reduction of approximately 4.57:1 using the sun as an input and the planet carrier as the output. Gear face widths were set to 25.4 mm for all gears. A standard three-module, full-fillet hob was used for the sun and planets and a full radius shaper was used for the ring. The outside diameter of the ring gear was 200 mm. The system is sealed within an aluminum housing and uses automatic transmission fluid for the lubricant.

"The speed reduction of the system allows us to run our electric motor at the higher speeds that are required for better performance of our energy management system," Morris says. "We were originally planning to use a belt system, but we calculated a very high belt speed and excessive noise. The system was designed to transmit about 20 hp."

The Bradley engineering team consisted of eight students, four working on energy management and four working on the vehicle itself. "The students did all the other machining at Bradley University," Cassata says. "This was part of the parameters of the project and allowed the engineers direct feedback on the design."

With Young's quick response at Forest City Gear to supply the gear hobbing machines, the students were able to observe and participate in the fabrication of the gears as well. "Fred has a big heart, this can't be overstated," Winzeler says. "He quickly agreed to get involved in the project and supply the materials despite FCG's very busy schedule."

Winning Results

For projects that bring manufacturing companies together with educational institutions, the benefits are endless. Winzeler Gear makes money selling gears, but the company supports its customers with R&D assistance or even product design. "We're gray box designers," Winzeler says. "A customer comes to us and says 'we have this much space, this much work to do, how do you suggest we accomplish this?' We never turn down a project that can help the company grow in other areas. This is what makes something like the ULUV project so valuable."

Bradley engineering students worked with Winzeler on sizing the gears on the Ultra Light Urban Vehicle project.

Thanks to the plastic transmission design, Winzeler Gear now has a prototype that they can do in four weeks and build a business case for. "Now we have to invest the money to make it a production item. I recently went to SAE in Detroit and listened to some of the latest transmissions developments and technologies on the market," Winzeler says. "This project has allowed us to develop a deeper knowledge of power transmission in small vehicles. At the end of the day, this is what all the large transmission companies are talking about. Borg Warner and Getrag are discussing weight, friction reduction and sound quality. This all can be applied to larger horsepower vehicles. Our goal is to show our work to automotive transmission companies and discuss the options of plastic gear-

continued

The plastic transmission design gives Winzeler Gear a prototype for which they can build a business case.

ing in these applications."

By continually working with Bradley University on engineering projects, Winzeler Gear also has a great recruiting tool. "We're always looking for prospective employees and senior projects like this one can be a great resource for future engineers. Plus, we enjoy getting students involved in gearing and plastics. It also educates the college faculty on what's currently going on in the manufacturing industry."

Morris sees the relationship between Bradley and Winzeler Gear as a win-win for all participants. "We have collaborated on senior projects for the past ten years. I think the projects have delivered value to Winzeler Gear and I am certain the students have benefitted by working on their projects. We plan to continue refining our urban vehicle concept to look for weight savings, perhaps by modifying other parts of the power train to include plastic gears/components."

Morris hopes by demonstrating the life and load carrying capacity of the plastic gears for this type of application that it benefits Winzeler's business.

As for Winzeler's concerns about teeth breaking or an electric vehicle that fails to move forward, there was never any reason to panic.

"The gear system is quiet, and it resulted in a system of reasonable size and speed for the drivetrain. The vehicle is an improvement over the previous vehicle, and it will be licensed for street driving," Morris says.

Morris notes that the electric car design is an important component to the country's energy future, a future where President Obama hopes to see one million electric cars operating on U.S. roads by 2012. For now, he's simply satisfied with a compact vehicle that can take his wife to the grocery store and back without wasting energy.

"Our economy, our manufacturing base, our standard of living is linked to the availability of affordable energy in the United States. Everything we do involves the conversion of available energy. As a nation, we cannot afford to waste this," Morris says. "Furthermore, I believe that our consumption and dependence on foreign oil is a critical issue of our national security. Roughly 1/3 of our national energy consumption can be related to transportation. That's a lot of energy. The significance of this work is directly linked to energy, its cost, and the resulting effect on our economy."

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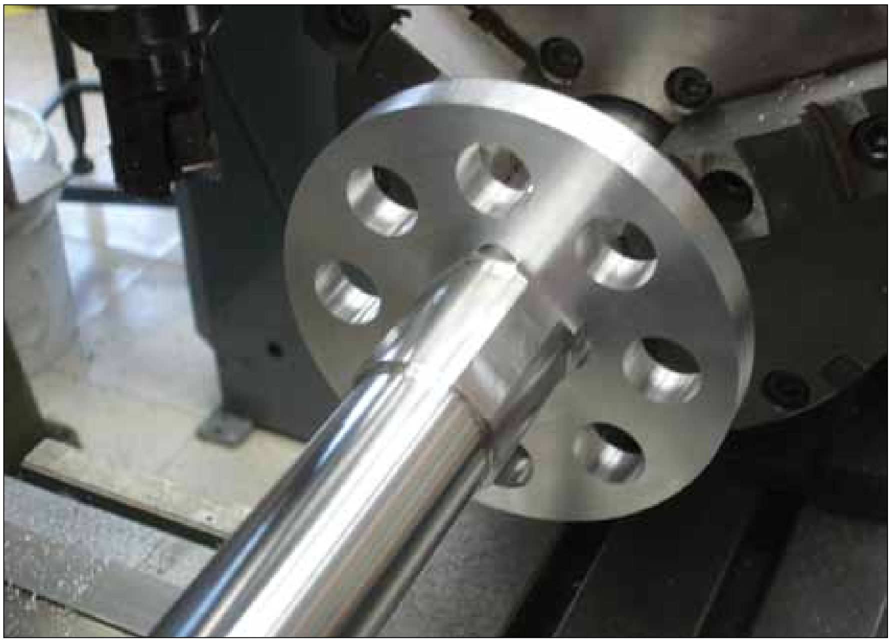

Bradley students were also involved in the machining of the housing and carrier shaft (pictured above).

The Electric Car: A Timeline

Robert Anderson invented the first crude electric carriage sometime between 1832 and 1839. American inventor Thomas Davenport and his Scottish counterpart Robert Davidson created electric road vehicles with non-rechargeable electric cells in 1842. An improved capacity storage battery came in the late 1800s as the electric concept began to flourish. In 1897, the first commercial application was established with a New York City taxi fleet built by the Electric Carriage and Wagon Company of Philadelphia. Woods Electric Phaeton, built in 1902, had a range of 18 miles, a top speed of 14 mph and a cost of $2,000.

In 1916, Woods invented a hybrid car that had both an internal combustion engine and an electric motor. By 1935, due to a long list of new inventions, the electric vehicle had all but disappeared. Once the 1960s and 1970s came along, electric vehicles began making a comeback with concerns over fuel emissions and the dependency of foreign crude oil. Sebring-Vanguard and the Elcar Corporation were two electric car leaders at this period of time.

Energy legislation, including the U.S. 1990 Clean Air Act Amendment and the U.S. 1992 Energy Policy Act, renewed electric vehicle developments in the 1990s. But by 2000, the vehicles weren't getting the attention of anyone but environmental activists. A documentary film released in 2006 titled Who Killed the Electric Car discussed a possible conspiracy involving the automakers and oil companies against energy efficient alternatives. In addition, the recent economic recession brought energy and sustainability back to mainstream media.

Today, energy advocates and consumers all but demand more energy efficient products from auto manufacturers. The Detroit Three and foreign automobile companies alike are providing more electric and hybrid options. As for urban transportation, rapid bus transport, bicycle superhighways and small energy efficient vehicles like the ULUV, might be the answer to solving energy problems in the future. The fact that Google is full of electric urban vehicle concepts is a sign that engineers all over the world are taking energy efficient vehicles very seriously. For more information, visit *www.hybridcars.com*.

October 4–6—International Conference on Gears 2010. Technical University of Munich, Garching, Germany. The German Society for Product and Process Design (VDI) will host this technical conference and small exhibition. Hundreds of technical papers will be presented by many of the world's leading authorities on gear engineering and manufacturing. For more information, visit *www.vdi-gears.eu*.

October 4–8—Basic Training for Gear Manufacturing. Richard J. Daley College, Building 300, 7500 S. Pulaski Rd., Chicago. Through classroom and hands-on training from AGMA, attendees learn to set up machines for maximum efficiency, inspect gears accurately and understand basic gearing. The course covers gearing and nomenclature, principles of inspection, gear manufacturing methods and hobbing and shaping. The course is intended for those with at least six months of experience in setup or machine operation, though most everyone can benefit. Past students have included executives, sales representatives and quality control managers. For more information, e-mail Jenny Blackford at blackford@agma.org or visit *www.agma.org/events-training/detail/basic-training-for-gear-manufacturing2/*.

October 13–14—WZL Gear Conference USA. The Westin, Westminster, CO. For more than 50 years, the annual WZL Gear Conference in Aachen, Germany has been the basis for exchange of technical information between the members of the WZL Research Circle. For only the third time, this conference is being brought to the USA. Hosted by Kapp Technologies, and including a tour of the Kapp facilities, the conference includes about a dozen presentations by WZL experts. Cost is $240 per person. To register, e-mail Pattea Carpenter at *patteac@kapp-usa.com*.

October 17–19—AGMA Fall Technical Meeting. Hyatt Regency Milwaukee, Milwaukee. Technical excellence in the gear industry is the focus of AGMA's Fall Technical Meeting. The FTM highlights the latest research in the industry from experts all over the world. This year the FTM is going green and will not be distributing paper copies at the meeting. Paid registrants will receive a link a week prior to the event through which they can access the full paper presentations. For more information, visit *www.agma.org/events-training/detail/2010-fall-technical-meeting/*.

October 20–21—Manufacturing Innovations-Aerospace/Defense. Gaylord Palms, Orlando, FL. Manufacturing Innovations-Aerospace/Defense is exclusively designed for aerospace and defense manufacturers and suppliers, addressing an expanding market with specific needs for innovation, precision, accelerated production and improved quality. The event will be co-located with the Aerospace Measurement, Inspection and Analysis Conference. For more information, visit *www.sme.org/aerospacedefense*.

October 26–29–Lean to Green Manufacturing Conference. Hyatt Regency Columbus, Columbus, OH. The Society of Manufacturing Engineers is committed to keeping industry practitioners current on best practices for lean and green manufacturing along with integrating and implementing these principles. The conference will help develop strategies and options for growing companies. Using lean manufacturing principles as the base, industry leaders will share their experience for improving environmental impacts, eliminating waste and maximizing green benefits. For more information, visit *www.sme.org*.

November 2–4—Fabtech. Georgia World Congress Center, Atlanta. Fabtech is the largest event in North America dedicated to showcasing a full spectrum of metal forming, fabricating, tube and pipe, welding and finishing equipment and technology. In 2010, the event returns for the first time in four years to the Southeast. More than 22,000 buyers and sellers from around the world will gather in Atlanta. For more information, visit *www.fabtechexpo.com*.

November 30–December 1—Innovative Automotive Transmissions and Drivetrains. Berlin, Germany. The International CTI Symposium and its specialist exhibition, Transmission Expo, is a European event for people seeking information on the latest technical developments in automotive transmissions and drivetrains. For more information, visit *www.getriebe-symposium.de*.


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DELTA RESEARCH BETS BIG ON THE FUTURE OF GEAR-MAKING TECHNOLOGY

by Mike Principato

When Bob Sakuta stepped into his father's shoes at Delta Research in 1987, he'd already learned one of the most important lessons of the contract machining business: Time waits for no one.

Bob's father, Alex, started Delta as the quintessential mom-and-pop machine shop in 1952, back in the day when the world was full of promise for entrepreneurs who knew how to crank the handles on a mill or a lathe on behalf of the booming post-World War II American automobile industry. Under Sakuta's leadership, Delta rose as a powertrain and transmission prototype developer and supplier to the Big Three. By the time young Bob took over the family business, the sun was already beginning to set on the salad days of that market, especially for automotive component suppliers that didn't have an edge in engineering know-how or manufacturing technology. Sakuta's solution? Build an edge in both.

Twenty-three years later, Delta Research supplies high-precision gears, transmissions, powertrains, shafts and assemblies for automotive and aerospace industries. Delta has completed a successful transition from a small, general job shop to a 100-employee, design/engineering/contract manufacturer producing some of the most challenging automotive and aerospace components in the world.

Making the Impossible Possible

"As machine shops go, Delta is state-of-the-art in gear manufacturing technology, particularly in ring gears, which are among the more difficult automotive

continued

powertrain gears to make," says Gregory Razook, quality engineer for Continental Automotive. A few years ago, Razook was sourcing a super-precise compound pinion gear for a transmission application that had to meet the super-quiet NVH (noise, vibration, harshness) standards required of a prototype hydrogen fuel cell vehicle under development at Continental.

"We'd already been using Delta to quality-screen another manufacturer's gears during the first-generation prototype program of this fuel cell vehicle," explains Razook, who says when the second-generation vehicle made the drawing board, Delta was in the right place at the right time and went from back-up to primary supplier of the new gear.

"Delta can produce extremely difficult, high-precision gears and parts in very low quantities with accuracy and consistency, and to a higher finish than other suppliers. They're unique in that they were able to design and produce that complex second-generation gear for Continental in prototype quantities," Razook says.

Bigger, Better, Faster, Newer

One of the keys to Delta's ability to help customers like Continental is Sakuta's commitment to continuously reinvest in the latest equipment. Recent acquisitions include the first Kapp 500 Flex CNC gear grinder installed in the United States; a Burri wheel dresser which allows Delta to quickly run generative gear grinding for small lots; and a Mitsui Seiki HU6A-5X trunnion system machining center, a true 5-axis CNC machine with a 36" cube work envelope. All in all, Delta boasts tens of millions of dollars' worth of machine tools to cut, grind, hob, broach, shape, super-finish, EDM and inspect complex parts, all programmed and operated by craftsmen who average 20 years of experience.

After spending five minutes with Sakuta, it's easy to detect the kind of confident, competitive drive that compels an already successful business owner to keep reaching for another brass ring. The genial Sakuta loves his work. He demands the best tools to help his company stay competitive in the industry.

Tony Werschky, who oversees marketing and sales for Delta, recalls a piece of company lore that perfectly captures Sakuta's business philosophy and ambition and helps explain how Delta's manufacturing facilities resemble working showrooms of the most advanced machining technology in the world.

"As the story goes, Bob was cleaning out his desk one day a while back and came across a dog-eared "Ten Year List" that he'd handwritten back in the '80s with his late brother, Dennis Sakuta. The sheet was a listing of all of the machinery that they believed Delta would need to succeed over the coming decade," Werschky says. "And although some of those machines have already been replaced with new machines, every single machine on that list had been purchased, right on schedule."

What's Next?

Delta gained momentum over the past few years, even as other aerospace and automotive component suppliers struggled to survive. In 2004 Sakuta acquired Tifco Gage & Gear, a well-known niche manufacturer of master gears, spline gages and other precision gaging equipment. Formerly, Tifco was based in Wixom, MI but is now based in Livonia, Michigan, and is now named Delta Gear.

"We're interested in long-term relationships with our customers, and with Delta Gear and Delta Research working as one, we've created a well-rounded organization that can handle challenging gear production, complex precision machining and gearbox assemblies from start to finish," Sakuta says.

That's exactly what customers like Razook, from Continental Automotive, want to hear. Fuel-cell-powered vehicle development is challenging enough without wondering about sub-suppliers' performance. "Delta's a problem-solver for us," Razook says. "There are lots of complex issues surrounding the development of our products. With Delta, we don't have to worry about the quality of our gears—we know they're the experts."

Broaching Machine Specialties

TO REPRESENT ARTHUR KLINK COMPANY

Broaching Machine Specialties (BMS) of Novi, MI, has entered into a joint operating agreement with the Arthur Klink Company of Pforzheim, Germany. BMS will act as the North American Sales and Service Center for Arthur Klink broaching and grinding systems. BMS also will provide CNC broach sharpening and reconditioning services for all types of broach cutting tools.

The Arthur Klink Company is a manufacturer of helical broaching machines, helical broach tools, hard gear broaching machines, carbide broach tools, CNC broach sharpeners and profile grinding machines. The company also provides large-diameter internal broaching tools up to 20" in diameter and 144" length; combination milling and broaching machines for manufacturing steering racks; and rack tooth milling and grinding machines.

BMS continues to service the international market with its own full line of new and remanufactured turnkey broaching systems, used broaching machines, broaching machine parts, in-field repair and production broaching services.

BMS and Arthur Klink will be at IMTS in booth N-7229, or you can visit *www.broachingmachine.com* for more information.

Mitsubishi

TO BUILD GEAR MACHINES IN CHINA

Mitsubishi Heavy Industries, Ltd. (MHI) is planning to launch production of gear cutting machines in China at a facility that will simultaneously serve as a production base for other company business. MHI has determined to build a new plant on the premises of Changshu Ryoju Machinery Co., Ltd. (CRM) in Changshu, Jiangsu Province, an existing local production base for the company's rubber tire machinery. The new facility will serve both for production of gear manufacturing equipment and for expanded production of rubber tire machinery.

Adoption of this "shared factory" scheme is intended to enable the company's gear machinery business to launch local production swiftly and cost-effectively. Production of gear cutting machines at the new plant is slated to commence in March 2011. The initiative will mark the implementation of MHI's first shared factory scheme for launching overseas production.

MHI decided to launch production of the gear cutting machines in expectation of large demand from Chinese automobile manufacturers, whose output has been expanding rapidly. MHI will initially manufacture its best-selling GE15A dry cut gear hobbing machine at the new plant. By securing the same technological features and high quality as in corresponding machines being produced in Japan, the company intends to expand sales to manufacturers of high-precision, small-size gears for automobiles, motorcycles, decelerators, etc. The company looks to produce 40 units during the first year, and 100 units by the fourth year.

In addition to being equipped with various gear cutting machine manufacturing equipment, including assembly and measurement-related facilities, the new plant will also have a showroom to exhibit machines as well as to accommodate test-cutting requests from potential customers.

Plans call for construction to be completed by February 2011.

Albins Off Road Gear

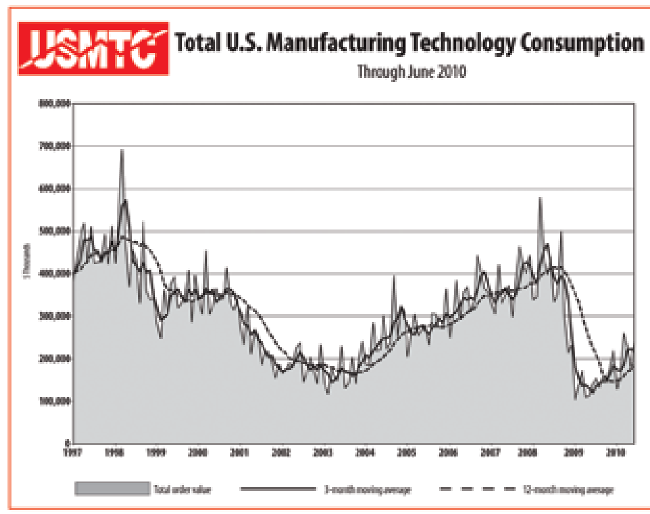
EXPANDS CAPACITY

Albins Off Road Gear of Ballarat in Victoria, Australia has recently purchased a Samputensili S375G profile gear grinding machine. This is the latest acquisition for this company whose other recent acquisitions include two Seiwa CNC gear cutters; eight CNC lathes, including a Mazak Integrex; numerous CNC Milling machining centers, including 5-axis and pallet-load machines as well as a CNC Klingelnberg Palloid spiral bevel machine; CNC internal and external cylindrical grinders; CNC gear inspection and a 5-axis CMM.

The new Samputensili machine can work with workpieces up to 375 mm diameter and 1000 mm length. Helix angles of 0–90 degrees are achievable with this machine, which exceeds most other common gear grinders by up to 45 degrees.

With the ability to use a grinding wheel as small as 80 mm in diameter, this grinder offers the ability to do fine grinding of shoulders next to gears. This machine also has the capability to grind almost any defined shape at a helix angle.

June Manufacturing Technology Consumption Up 35.8%



June U.S. manufacturing technology consumption totaled $241.47 million, according to AMT—The Association For Manufacturing Technology and AMTDA, the American Machine Tool Distributors' Association. This total, as reported by companies participating in the USMTC program, was up 35.8 percent from May and up 71.1 percent from the total of $141.12 million reported for June 2009. With a year-to-date total of $1,207.60 million, 2010 is up 56.1 percent compared with 2009.

These numbers and all data in this report are based on the totals of actual data reported by companies participating in the USMTC program.

"Typically, manufacturing technology order rates slow down in the months leading up to the International Manufacturing Technology Show—IMTS (Sept. 13–18, McCormick Place, Chicago, IL), the largest production technology show in the Americas," said Douglas K. Woods, AMT president. "However, increased foreign direct investment and a doubling of orders in aerospace and construction equipment through the first half 2010 resulted in an acceleration of USMTC orders rather than the typical slow down."

The United States Manufacturing Technology

Consumption (USMTC) report, jointly compiled by the two trade associations representing the production and distribution of manufacturing technology, provides regional and national U.S. consumption data of domestic and imported machine tools and related equipment. Analysis of manufacturing technology consumption provides a reliable leading economic indicator as manufacturing industries invest in capital metalworking equipment to increase capacity and improve productivity.

Second Quarter 2010 Workholding Shipments Up 7.7%

At $53.8 million for second quarter 2010, shipments of workholding equipment were up 46.3 percent from second quarter 2009, according to the Advanced Workholding Technology (AWT) Group of AMT—The Association For Manufacturing Technology.

Workholding equipment shipments within the U.S. by the 37 companies participating in the AWT statistical report totaled $45.7 million while exports amounted to $8.1 million.

The report from the AWT shows that domestic workholding equipment shipments increased 7.4 percent and U.S. exports increased 9.4 percent from first quarter 2010. The Midwest increased 9.2 percent from first quarter 2010 and remained the largest domestic destination with 40.5 percent of total domestic shipments. Growth in the Central region was 4.8 percent, moving it above the Northeast for the second largest share of domestic shipments, with 18.4 percent domestic share. Shipments to the Northeast rose by 2.7 percent, moving down to the third largest domestic market with 16.4 percent of domestic shipments in the second quarter. The South had 13.8 percent of second quarter 2010 domestic shipments, with an increase of 7.9 percent from the previous quarter. The West remained the smallest domestic market again with a 6.5 percent increase from first quarter leaving it with 11.0 percent share. Additionally, second quarter 2010 employment levels were up 1.0 percent from first quarter 2010 but only increased by 0.1 percent when compared to

continued

the second quarter of 2009.

The Advanced Workholding Technology Group is comprised of AMT members that produce chucks, jaws, collets, vises, fixtures, and other workholding equipment. The AWT operates as a forum to serve the interests of U.S. manufacturers of workholding equipment. The overriding goal of the AWT is to develop ways to better serve the workholding customer, and to implement programs to help the workholding community in this endeavor. While AWT members must be members of AMT, any OEM workholding manufacturer or U.S.-based company that is a sole distributor of a foreign-built workholding product line may participate in the AWT statistical program.

SME

GIVES $382,250 IN SCHOLARSHIPS AND AWARDS FOR STUDENTS AND EDUCATORS

For 2010, the SME Education Foundation awarded $382,250 in scholarships and awards ranging from $1,000 to $70,000 to 140 students and educators at 87 colleges and universities in 24 states and two provinces in Canada. The foundation encourages financial support of manufacturing education programs in the United States where there is a desperate need for highly-skilled technical workers.

"This funding reflects our determination to advance manufacturing education however possible," says Bart A. Aslin, foundation director, SME Education Foundation. "These young people have proven themselves to be engaged and intent in their studies and deserve this financial encouragement. And to our legion of donors who continually provide their support, we thank them for their generosity."

The SME Education Foundation, celebrating its 30th anniversary this year, has invested more than $4.5 million in youth programs, helping more than 10,000 young people explore careers in science, technology, engineering and mathematics; granted more than $4.2 million in scholarships to students studying manufacturing-related programs and invested $17.3 million in grants to 35 colleges and universities to develop industry-driven curricula.

Mazak

CONSTRUCTING SOUTHWEST TECH CENTER, HQ

Houston is the site of Mazak Corporation's future Southwest Technology Center and Regional Headquarters. The facility will offer support to manufacturers in all industries, with a special focus on those serving the energy sector.

Construction was planned to begin in July on the 30,000-square-foot technology center being erected on 4.5 acres at the intersection of Beltway 8 and Green Crossing Boulevard. The facility will be Mazak's third and largest expansion of its existing Southwest Technology Center, which was originally founded in 1978.

"Throughout the economy of the past two years, Mazak has consistently been a vocal advocate of continued investment in American manufacturing," says Brian Papke, president of Mazak. "It's something we encourage our customers to do and something we do ourselves. We've seen a lot of companies scale back their investment levels over the past several years. We fully understand there may be economic reasons to do so, but we believe that it is an important time to invest in order to be competitive in the future.

"Additionally, we recognize the growing importance of creating machine tools that are not only more productive, but that are also energy efficient and environmentally sound. This new facility will be a place where we can work together with our customers to address and develop improvements in all of these critical areas."

The size of the Southwest Technology Center being built will allow for cutting demonstrations, service and applications support for some of Mazak's largest machining centers. It will serve as a regional service hub, staffed with 20 field service engineers and five phone support engineers.

A 100-seat learning and conference area will be housed at the facility for meetings, regional seminars and training events presented by both Mazak and its suppliers in the industry. Mazak anticipates a grand opening in June 2011 where a range of products will demonstrate various applications.

State of U.S. Manufacturing

DISCUSSED IN WHITE PAPER

The Hollings Manufacturing Extension Partnership (MEP) Advisory Board analyzes the state of U.S. manufacturing and the characteristics of good manufacturers and plots a course to improve the competitiveness of the industry in a recently released white paper.

The MEP is managed by the National Institute of Standards and Technology (NIST). The Manufacturing Extension Partnership Advisory Board (MEPAB) is an external advisory body created to provide guidance and advice on the MEP program from the perspective of industrial extension customers and providers who have a vision of industrial extension with a national scope.

The MEPAB report finds that there are reasons for concern about the industry's future, but there are also reasons for optimism. It presents the view that resolving the competitive disadvantages U.S. manufacturers face is complicated, and innovation alone is not enough to create successful companies. According to the 44-page report, innovation must result in new products, production processes, management practices, as well as green manufacturing and an executive concern for the workforce, which includes developing in-house talent.

Another suggestion the report makes is that manufacturers, government and academia should be involved in developing national manufacturing policies and providing supporting implementation infrastructure. In regards to national policy, the board says developing metrics to measure the return on investments in R&D and federal labs should be priorities. The report recommends rewarding institutions that actively seek out opportunities for translating and transferring the products of their research into commercial technologies.

The entire report is available free to download at *www.nist.gov/mep/upload/MEP_advisory_report_4_24l.pdf.*

Gary Lehman

APPOINTED TO BOARD OF TRUSTEES AT PURDUE UNIVERSITY

Indiana Governor Mitch Daniels on August 13 named Gary J. Lehman to the Purdue University Board of Trustees.

Lehman has served since 2003 as president and CEO of Fairfield Manufacturing Inc., the largest independent gear manufacturer in North America. He received his bachelor's degree in industrial management from the Krannert School of Management in 1974 and earned an MBA from Case Western Reserve University.

He co-founded The Cannelton Group, a consulting firm specializing in strategic and operational assistance to manufacturing companies. He also has served as president of Philips Lighting Electronics North America and has held senior positions with Federal Mogul, TRW, Deere and Co., and Allen Bradley.

"It's an honor to be asked to serve this great university in this manner," Lehman says. "My parents, my wife and two of our children are all Purdue grads, and this university has been a large part of my entire life. Purdue has a great history, and it's humbling to be part of helping to assure it retains its outstanding reputation."

Forest City Gear

HIRES AND PROMOTES SIX EMPLOYEES

Joe Luy

Forest City Gear (FCG) announced the hiring of four new employees and the promotion of two longtime employees. "We've been growing steadily in the last two years, despite the economic conditions, and this news reflects that situation," comments company president Wendy Young, who runs the business alongside her husband, CEO Fred Young.

Effective immediately, the following new individuals have been hired: Joe Luy, quality manager; Bruce Haxton, gear processing engineer; Paul Lindquist, process engineer; and Jim Cagle, cost estimator.

Luy will supervise the company's quality lab, acknowledged as one of the finest metrology centers in the gear industry. Over a third of Forest City Gear's current cus-

continued

Correction

In the August issue's technical article, "Crowning Techniques in Aerospace Actuation Gearing" by Anngwo Wang and Lotfi El-Bayoumy, Mr. El-Bayoumy's name was misspelled. *Gear Technology* regrets the error.

—*The Editors*

N E W S


Bruce Haxton

tomers are other gear companies around the world, who bring FCG work they cannot do themselves, either on tolerance or consistency. Luy will also manage the company's ISO and ITAR registered programs, the latter having been secured this past March.

Haxton will be responsible for the transitions from design to manufacturing protocols at FCG. He brings an impressive background in gearmaking to the task.


Paul Lindquist

Lindquist oversees the utilization of the company's 80+ machine tools to streamline production workflow through the shop.

Cagle will help keep pace with the hundreds of RFQ's received each week at FCG, a daunting task, to say the least.


Jim Cagle

Also, two longtime employees have been promoted. Krista King was promoted to order processing, She will work with numerous vendors and the strict guidelines of the many government, aerospace and defense contractors served by FCG. Her primary role will be processing purchase orders for the company.


Krista King

Andrea Bagwell was promoted to Estimating/Quoting Assistant. She will be responsible for the preparation of quotes, serving the now larger department of inside sales engineers and others, including Fred Young, who continues in his longtime role of reviewing and estimating particularly challenging gear jobs at the company.


Andrea Bagwell

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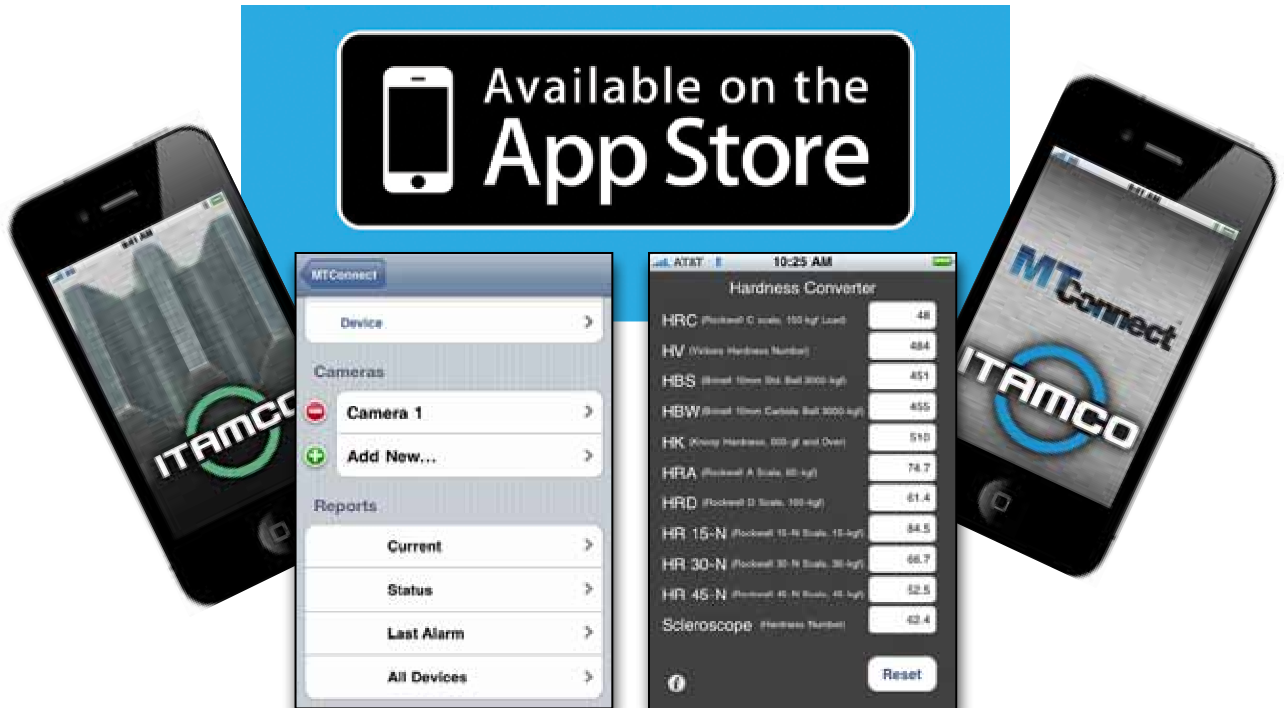

If you haven't played around with an iPhone, iPod Touch or iPad, you're missing out. These small machines can hold your entire music, film, photograph and book collections on a single handheld device. They can also direct you to a local restaurant, purchase movie tickets before a show or give you a step-by-step guide to creating the perfect cocktail (In ten years tops, it will probably be able to actually make one for you).

But it's not all fun and games for Apple's line of technological wonders. The business world has caught on as well, creating financial resources, web meetings, analytic reports, sales quotes and even time management applications that executives can take with them on the go. It was just a matter of time before manufacturing followed suit.

As a contract manufacturer, Indiana Technology and Manufacturing Companies (ITAMCO) supplies to industries such as renewable energy, off-highway, mining and oil. The company maintains a strong technology base by keeping up with global trends, including those found outside the manufacturing sector. With a rising number of iPhones and iPads on the production floor, engineers at ITAMCO began toying with the idea of creating manufacturing apps to assist their workforce.

"At the beginning of the year, we started developing manufacturing applications specifically for the iPhone," says Joel Neidig, systems engineer at ITAMCO. "It's an easy tool for distribution and a great marketing tool as well. We realized there weren't many manufacturing applications available that utilized this type of portable technology."

A Hardness Conversion application seemed the appropriate place to start, according to Neidig. "We purchase a variety of alloy steel forgings for our products, and see a lot of drawings with different hardness scales on them that require conversion on a daily basis. The app was designed so our team members can have quick access to accurate conversion data. It helps everyone from purchasers to receiving inspectors and estimators."

In addition to Hardness Conversion, the company has created GearWare, an app that converts different gear pitch sizes, and Feed Rate Calculator, an application that simply calculates feed rates and speeds for the machinist. All three manufacturing applications are currently available at the iTunes website (*www.apple.com/itunes/*).

The company plans to release more applications in the future, including a portable version of MTConnect, a standard allowing machines to pass data more effectively across the shop floor.

"We've developed an MTConnect iPhone application that can be used to connect to multiple agents so that users can view real-time data generated from their machine tools and controls," Neidig says. "MTConnect will allow a plant manager to check maintenance or quality control issues directly from their own handheld devices."

And the best part of these handy software applications? They are absolutely, 100 percent free of charge. "Most people won't even spend 99 cents on an application unless it's really worth it," Neidig jokes. "We decided to make our apps free of charge and give something back to the manufacturing industry."

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