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A MEDIA SOLUTIONS PUBLICATION

OCTOBER 2003

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GEARSolutions

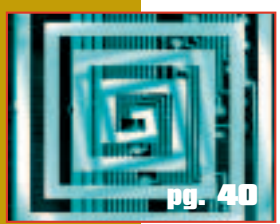
Your Resource for Machines, Services and Tooling for the Gear Industry

OCTOBER 2003

A MEDIA SOLUTIONS PUBLICATION

departments

features



Special thanks to Nachi Machining for contributions to our cover artwork. Layout design by Andy Spain for *Gear Solutions* magazine.

special advertising sections

From the Publisher

Deadlines, commitments, obligations, promises… all familiar words to gear manufacturers and magazine publishers alike. But you've got to get out of the office and mingle with your colleagues every once in awhile, else you'll lose sight of the big picture. And that's just the opportunity that Gear Expo provides: the chance to see old friends, make new ones, and check out all the exciting advancements being made in this endlessly fascinating industry.

In the same way, we've worked to gather news of cutting-edge equipment, software, concepts, and processes in the October issue of *Gear Solutions* that should help you in your never-ending quest to excel. In this issue of the magazine you'll find articles on Reishauer's RZ 400 grinding machine, which takes a major step forward in producing excellent gears of any lot size, and on the sense behind considering whirling and heat induction into your worm-gear manufacturing process. You will also read about the years of hard work and research that Universal Technical Systems has put into developing the most comprehensive gear-design software available on the market today. And for those of you who are true MAAG believers, you'll especially enjoy the article on the many benefits of upgrading your workhorse equipment with new tooling and electrical packages. Again, we present this material in the hopes that it will help you be more productive and efficient in your work—and to save a couple of dollars along the way.

In line with this philosophy is our company profile of New England Gear-the premier source for rebuilt and reoutfitted Fellows machines and parts in the United States. Jeff Barnes, the company's president and founder, has a world of experience to offer, and his knowledge can be accessed at the touch of a couple of numbers on your telephone keypad. We're also pleased to share our conversation with Norbert Weiss, of Frenco, who discusses the company's history, strengths, and future plans.

As always, Terry McDonald has found a way to get right to the heart of why safety really does matter in the workplace-especially in light of the rising cost of workman's compensation and medical insurance. Beyond that, personal-injury lawsuits have almost become commonplace, so the jobs of safety professionals have become that much more important to their employer's bottom line. Read Terry's words and remember that, quite often, it really is the little things that matter the most.

So we hope that you'll enjoy reading this issue of *Gear Solutions* magazine, and also that you'll visit our companion Web site at [www.gearsolutionsonline.com], where you will find machine listings and archives of all the articles and profiles we've published in our first year of production. We also hope you'll consider joining our "storefront community," which will get your name into the hands of the very people who need to see it.

Also, please stop by our Gear Expo booth #833—we look forward to seeing you!

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industryNEWS

New Products, Trends and Developments in the Gear Industry

Bourn & Koch Introduces 100H Series II Hobbing Machine

The 100H Series II Hobbing Machine incorporates the design and features of the Bourn & Koch 200H/400H Series II Hobbing Machines. Standard features include six CNC controlled axis; radial in-feed, axial feed, hob shift, hob spindle, work spindle, and hob swivel. New features include 6" of hob shift, standard Num 1050 CNC controller with Num digital drives with absolute encoders, conversational software, 2000 rpm hob spindle with five continuous Hp & 10 maximum peak Hp, full machine enclosure with stainless steel sloped guarding for wet or dry cutting capabilities, no hydraulics and easy placement tail center assembly with adjustable clamping force up to 500 lbs 3" stroke live center.

▲ 100H Series II Hobbing Machine from Bourn & Koch

The 100H accommodates parts with a maximum swing diameter of 10" and a cutting diameter of 4.5". Typical quality results of AGMA Class 10 with a double cut cycle and AGMA Class 9 with a single cut cycle can be expected. The 100H weighs 7,100 lbs with a cube size of 78" X 64" X 72" high.

For more information, contact Bourn & Koch at (815) 965-4013,

▲ The Boeing F/A-18E/F Super Hornet

Boeing F/A-18E/F Super Hornet Completes First AESA Flight

In a press release dated August 13, 2003, it was announced that the Boeing F/A-18E/F Super Hornet program moved closer to equipping the fleet with the latest in radar technology on July 30 at Naval Air Systems Command China Lake, California, when a test aircraft carrying the APG-79 Active Electronically Scanned Array radar system completed several test flights with the radar operating.

"We are continually increasing the capabilities that puts the 'super' in Super Hornet," says Naval Air Systems Command F/A-18 Program Manager Capt. B.D. Gaddis. "This is a major step toward making the F/A-18 all that we've planned it to be."

The AESA radar system replaces existing mechanically scanned antennas with a radar beam that can be steered at close to the speed of light. This rapid beam scan feature improves performance dramatically, and because the array is solid state, mechanical breakdowns will be virtually eliminated.

"The AESA radar system is part of a spiral development designed into the Super Hornet playing an important role in its promised leading-edge technology," says Tony Parasida, vice president, F/A-18 program, for Boeing. "The Super Hornet was designed with room for growth—room to incorporate new technologies now and to enhance the aircraft's network centric capability."

AESA works with several existing elements of the Super Hornet weapon system, such as the stores management system, the gun director, and AIM-120 and AIM-9 missiles, to enhance the lethality, survivability, and affordability of the F/A-18E/F. The radar system will increase situational awareness of the battlespace and reduce observability of the aircraft, as well as provide significantly improved operational capability in a weapons platform that already provides superior air and ground attack maneuverability and accuracy. Boeing expects to deliver the AESA radar system, built under a subcontract by Raytheon Corporation of El Segundo, California, as part of the F/A-18E/F by 2005.

A unit of The Boeing Company, Integrated Defense Systems is one of the world's largest space and defense businesses. Headquartered in St. Louis, Boeing Integrated Defense Systems is a $25 billion business. It provides systems solutions to its global military, government, and commercial customers. It is a leading provider of intelligence, surveillance, and reconnaissance; the world's largest military aircraft manufacturer; the world's largest satellite manufacturer and a leading provider of space-based communications; the primary systems integrator for U.S. missile defense; NASA's largest contractor; and a global leader in launch services.

For more information contact Kathleen M. Cook, Naval Systems, at (314) 233-6818, or via e-mail at kathleen.m.cook@boeing.com. Visit the company's Web site at [www.boeing.com].

or via e-mail at bournkoch@worldnet.att.net. Access their Web site at [www.bourn-koch.com], and also visit them at Gear Expo booth #1134.

Arrow Introduces New Technology for Design of High-Precision Spur and Helical Gearing

Arrow Gear Company, a global provider of high precision gearing, today announced the introduction of a computer modeling system for use in the design of spur and helical gears. Promising to be the next generation of production technique for precision gearing, Arrow's system provides a dramatic reduction in lead times, greatly enhances quality and lowers costs to the customer.

This system uses advanced computer technology to predict the performance of a gear before the part is machined. These techniques include Loaded Tooth Contact Analysis (TCA), which is used to determine how the gear will be affected in its actual use under load. In addition, Finite Element Analysis is used to study the physical stresses on the gear under load, thus allowing engineers to modify the design to provide maximum performance.

Notably, Arrow Gear is the first gear company in the world to offer these complete design capabilities in-house.

The benefits to Arrow's customers from this capability are far reaching. By minimizing the time spent on design and development of a new gear application, the customer saves a great deal of time and expense on upfront costs. In addition, the benefit of bringing a product to market sooner than previously allowed translates to a faster return on new product investment.

This system for spur and helical gears is the most recent expansion of Arrow's design and development capabilities, which follows a similar system used by the company for spiral and hypoid bevel gears. The development phase of bevel gears is highly involved, however, Arrow's system has proven to greatly reduce expense to the customer. By eliminating the conventional trial and error process of developing bevel gears, Arrow has been able, in some cases, to reduce development time from six months to less than three weeks. Customers that have taken advantage of Arrow's advanced bevel design capabilities have conservatively saved $250,000 per gear set in design and development costs.

"It's important to understand that bevel gear development is much more involved than spur and helicals, and by nature, spur and helical development is not as costly. However, we anticipate that our new design capabilities will translate into a significant impact on cost savings and improved quality for our customers' spur and helical gear needs," stated Joseph Arvin, Arrow Gear President.

For more information about Arrow's design capabilities for high precision gearing, please visit [www.arrowgear.com].

New Ultra-Precise Gear Measuring Machine

Ogasawara Precision Laboratory Ltd., of Japan, has announced the development of a new ultra-precise gear measuring machine. As a leader in manufacturing highly precise fine-pitch gear tools and metrology products, Ogasawara has raised the level of quality in the industry. The ability to manufacture such high-quality products is the result of more than 60 years of experience in perfecting manufacturing and inspection methodology.

In such industries as industrial robotics, the demand for precision fine-pitch gears with reduced backlash calls for extreme accuracy in gear-tooth

profiles. Developing a gear measuring instrument that can certify the static accuracy of gears (tooth profile deviation, lead variation, pitch deviation, run-out) within 0.1~0.3 µm has proven the level of Ogasawara's technology.

Ogasawara Precision will present a report on the development of this ultra-precise gear measuring instrument at the American Society for Precision Engineering (ASPE) annual meeting to be held October 26-31, 2003, in Portland, Oregon.

For more information contact Russell, Holbrook & Henderson, Inc.—the U.S. Division of Ogasawara Precision Laboratory Ltd.—at (201) 796-5445, or via e-mail at sales@tru-volute.com. Visit online at [www.tru-volute.com].

Trochoidal Gears from Trogetec

Trogetec, Inc. (Trochoidal Gear Technologies), of Riverton, Wyoming, offers epitrochoidal stock spur gears in miniature to large sizes. Innovative and cost-effective, two-tooth spur gears operate in an internal gearmesh engagement with two to three cylindrical teeth of four-roller (four-pin) followers of 2:1 ratio gear reducers of either the planocentric cyclo or the parallel shaft design types. Single-station cardioid indexers for excellent full-turn output motion are ideal for applications in packaging, automation, and other uses requiring compactness,

Machine Tool Builders to Provide Ingersoll Support

Since the recent closure of the Ingersoll Milling Machine Company, Machine Tool Builders has been aggressively pursuing the company's former employees and resources. As a result, the company has secured a number of key individuals in numerous locations around the country in order to assist former Ingersoll customers.

The launch of the Special Machine Division of Machine Tool Builders for servicing Ingersoll machines is currently ongoing and will take several months to complete. This new organization will eventually employ many of the former Ingersoll engineers, technicians, and service personnel. During the formation period, the company is accepting service, retrofit, and repair requests from customers with projects that were ongoing, scheduled, or quoted.

All questions can now be placed through Machine Tool Builders by contacting Steve Birchall at the number listed below. With 28 years at Ingersoll, he was formerly head of the technical support group, and is intimately familiar with many of the projects, both current and past. David Livingston has also joined. With 28 years at Ingersoll, he is the regional service representative in the Detroit area. In addition, Scott Weiss has 15 years of experience, and is located in the Seattle area to continue servicing the West Coast and The Boeing Company. Todd Whiteman, former controls group manager, spent 15 years with Ingersoll, and has joined along with Robin Newgard, the former systems engineering supervisor, who spent 25 years at Ingersoll. Randy Trank is an electrical hardware engineer with 17 years at Ingersoll, and Don Ross, who specializes in mechanical and spindle unit repair, spent 24 years at that company.

For more information, contact Steve Birchall at (815) 636-7502, or via e-mail at sbirchall@machinetoolbuilders.com. The company's Web site is [www.machinetoolbuilders.com].

smooth and quiet operation, high-load and high operating-speed capabilities, and long, maintenance-free service life. The gears are available in various metals and engineering thermoplastics. Fabrication to tooling tolerances of +/-0.0003" (0.0127 mm) or less is optional for the gears and followers.

Trogetec also handles eccentric shaft design and manufacturing. Eccentric and crank shafts are important components in cycloidal gear drives and indexers, planetary and cyclo-type speed reducers, and many other mechanisms. The technical staff of Trogetec has earned top awards and recognition for its practical design and fabrication of eccentric and crank shafts of miniature to large sizes, in prototype to production quantities, for everyday and unusual engineering requirements.

Trogetec also offers one-tooth gears for speed reducers, gear indexers, and other applications. One-lobe prolate epitrochoidal gears are in constant full-conjugacy (full-mesh) internal gearmesh engagement with two corresponding cylindrical rollers or pins of respective follower wheels. The main advantages of the new gear design include: smooth and quiet operation, because the rollers never lose driving contact with the gear; large-size rollers and lo be

AGMA Introduces Career Center

AGMA is pleased to announce its new AGMA Career Center, designed to connect companies with the largest and most-qualified audience of gearing professionals. This unique opportunity to connect with the gear industry's best employers will prove to be ideal for both employer and employee.

For job seekers, the center's services are free, providing them with access to the best employers and jobs in the gear industry, plus:

- Advanced job searching options
- Control over your career advancement
- Increased exposure for your resume
- Optional e-mail alerts of new jobs

For employers, since AGMA represents more than 80 percent of the gear industry, the Career Center offers the most targeted advertising for gear industry job openings, plus:

- Quick and easy job postings
- Quality Candidates
- Online reports that provide you with job activity statistics
- Simple pricing options

Job seekers can search the jobs database for opportunities meeting their criteria. Applications for positions to job seekers are free of charge. For employers, AGMA members can post their listing for 30 days for $250 ($400 for non-members). A special introductory offer is currently being offered.

For more information online, access the career center directly at [careers.agma.org], or call AGMA at (703) 684-0211. Visit their main Web site at [www.agma.org].

for strength in high-load carrying capability can be realized in miniature to large size applications, which include 2:1 ratio speed reducers and one-station cardioid drive indexing of highly favorable motion characteristics, and; the two-lobe and other epitrochoidal gear design schemes represent a logical extension of the one-lobe gear design focused on above. Fabrication to tooling tolerances of +/-0.0003" (0.0127 mm) or less is optional for the gears and followers.

To learn more, contact the company at (307) 856-0579, or visit its Web site at [www.trogetec.com].

Philadelphia Gear's Birmingham Facility at Full Capacity

In a press release dated July 30, 2003, Philadelphia Gear Corporation—a full-service provider of gearing and power transmission solutions—announced the upgrading of its Southeast Service Center to include grinding and gear checking capabilities. The facility, located in Birmingham, Alabama, now offers full service and maintenance capabilities for Philadelphia Gear customers throughout the Southeastern United States.

The Birmingham facility is the newest of Philadelphia Gear's five regional service centers strategically located across the United States and will continue to provide the rapid repair and overhaul response the facility was previously offering, in addition to full-service maintenance capabilities.

New to the facility are a Hofler 1250 gear grinder and a Maag 130 electronic gear checker, as well as several accompanying support pieces of equipment. Existing technical capabilities include 14,000 square feet of workspace and a 25-ton crane capacity. These additions, along with the hiring of several key employees, will put the Birmingham facility at the forefront of the aftermarket gear repair industry, while reinforcing Philadelphia Gear's mission of complete customer service and satisfaction.

The driving force behind the equipment and personnel upgrades has been a team commitment to supplying engineering solutions, manufacturing and technical services, all while focusing on reducing customer downtime and long-term operating expense. "The end user is beginning to recognize the value of higher quality and more serviceable pieces of equipment," says Greg Stephenson, engineer manager for Philadelphia Gear. "This equates to more-reliable, less-expensive operations of drives and components."

The Birmingham location provides Philadelphia Gear access to the many manufacturing and industrial centers throughout the South, as well as faster, more-timely response to business opportunities that in the past would have been sent to Philadelphia Gear facilities in New Castle, Delaware, or in Houston. The facility services several regional companies including Drummond Coal, Lehigh Portland Cement, Goodyear Tire and Rubber Company, National Cement, USX, and Alabama Power.

Like all other Philadelphia Gear regional service centers, the facility has Internet-based access to Philadelphia Gear's world-class Engineering and Technical Center in Norristown, Pennsylvania, and its vast library containing millions of drawings, engineering standards, and manufacturing process standards.

A founding member of the American Gear Manufacturers Association (AGMA), Philadelphia Gear offers products and services

found in use worldwide; from conveyor gear drives used in long-wall coal mining operations, to emergency repair services critical to the power generation industries. The company serves thousands of customers across the globe from its regional service and manufacturing facilities in New Castle, Delaware, and Birmingham, Alabama, as well as in Chicago, Houston, and Los Angeles. Philadelphia Gear is headquartered in Norristown, Pennsylvania.

For more information on Philadelphia Gear, call (800) 766-5120, or visit them online at [www.philagear.com].

The Lovejoy Configurator Simplifies Online Coupling Selection

Lovejoy has transformed the highly technical experience of sizing and selecting couplings into a simple and comprehensive series of questions. With the new Lovejoy Configurator, not only is selecting the right coupling easier, but users can download a CAD drawing for immediate use or examine a 3D reproduction of the product. Coupling selector advantages include:

- The Lovejoy Configurator is an "intelligent agent" that assists users in finding the appropriate coupling for their purposes based on their application parameters.
- Users have access to the entire Lovejoy database of couplings—over 20,000 in all—with little or no pre-existing experience with Lovejoy product lines. (Lovejoy engineering assistance may be needed for highly specialized couplings.)
- Inch or Metric data entry is supported.

The Lovejoy Configurator presents the user with detailed information for the couplings they have selected including: a side-by-side comparison of different coupling styles; the ability to view coupling photographs, specifications, and performance data; the option to view and/or download CAD drawings for some products; the ability to email drawings, photos, and dimensional data; the ability to view part number listing, and; custom configuration/re-engineering of select coupling types.

For more information, contact Lovejoy at (630) 852-0500, or via e-mail at feedback@lovejoy-inc.com. Visit the company's Web site at [www.lovejoy-inc.com].

Bodycote Installs Automated Atmosphere Line

Bodycote Thermal Processing, Inc., has announced the installation of an automated integral quench furnace line in its Canton, Michigan, facility. The furnace line consists of two atmosphere furnaces with oil quench. The third furnace has top cool and hot oil quench capability. The line also maintains two washers and three temper furnaces. Companion equipment includes an automated charge car and multiple handling tables. Load sizes up to 5,000 pounds can be processed. The new equipment will be capable of providing Lindure, carburizing, ferritic nitrocarburizing, and other various atmosphere processes. The equipment is ideal for processing shafts, gears, stampings, and other engine, transmission, and driveline components. The Canton furnace line is the first fully automated line commercially available in Southeast Michigan.

Randy Call, general manager of the ISO 9002 and QS 9000 registered plant, says, "Being a major supplier to the automotive industry requires ever-improving process control and risk reduction. Our new furnace line will allow us to optimize our efficiencies and better achieve short turn around time for our customers."

Call also points out that the new atmosphere capability is a nice compliment for the already established induction hardening facility in Canton. Bodycote maintains more than 40 induction-hardening systems in the Canton plants.

For more information please contact Jeff Pyne, regional director for Bodycote Thermal Processing, Inc., at (517) 487-4989, or via e-mail at jpyne@bodycote-na.com. The company's Web site is [www.bodycote-na.com].

New Software from ACR Industries

ACR Industries announces the implementation of its new ERP (Enterprise Resource Planning) software called Visual Manufacturing by Lilly Software Associates. This software is used company-wide in the areas of: quoting & estimating, customer order entry, purchasing, engineering, material requirements planning, master production scheduling, shipping & receiving, inventory control, EDI, and financials

The data generated by this client/server-based software can be shared between the different modules of the system improving on performance and helping to keep costs down. The strong point of this software is its Finite Scheduling Ability. Further modules to be implemented are shop floor data collection and serialization tracking.

ACR Industries is a manufacturer of turbine engine gearboxes, helicopter transmissions, actuators, and detail systems gearing for the commercial and defense sectors of the global aerospace industry. Its capabilities include program management, concurrent engineering, prototype and production manufacturing, gear and master development, flow-pressure and dynamic load testing equipment design and fabrication, and FAA overhaul and repair. ACR Industries offers its customers award-winning performance, a high level of expertise, and customer satisfaction.

For more information call (586) 781-2800 or send e-mail to sales@acrind.com. The company's Web site is [www.acrind.com].

Tyrolit Takes Over HAUG Verzahnungen

In a press release dated July 23, 2003, Tyrolit—the worldwide leading manufacturer of grinding, cutting, and drilling tools—announced that it took over the German HAUG Verzahnungen GmbH on July 4, 2003.

The HAUG company was founded in 1990 in Holzmaden, near Stuttgart. The company specializes in the production of tools for the hard finishing, or honing, of all types of gear wheels. Activities are focused on the automotive-related gear industry. Following the takeover by Tyrolit, the founder of the company, Erich Haug, will continue to play an active role.

The purchase of HAUG is an ideal addition for Tyrolit. Tyrolit Reineke, in Werdohl, Germany, already enjoys a first-rate reputation

in the market for the hard finishing of gear wheels as a consequence of its outstanding quality and service. Above all, the geographical diversification of the Tyrolit subsidiaries throughout the world is of great import to the gear industry.

"Networking and globalization of markets rendered the search for a reliable partner in the gear industry desirable. With HAUG, we have gained an internationally renowned and very strong addition to our group," says Tyrolit CEO DI Jakob Mosser.

Tyrolit offers the gear industry a whole range of one-source complex systems, from internal and external cylindrical grinding to the honing of gear devices. In this way Tyrolit guarantees improved service, combined with superior technology.

A global operation with 21 production facilities and 3,400 employees, Tyrolit shows annual sales of approximately $465 million (euro) worldwide. Within the group, around 160 employees work on the development and continuous improvement of high-quality products. Precision and innovative products are the keys to Tyrolit's success.

For more information, visit the company's Web site at [www.tyrolit.com].

Dana Corp. Announces New Lightweight Spicer Tag Axle

The Dana Corporation's Commercial Vehicle Systems Division has introduced a new patent-pending tag axle specifically designed for 6x2 vehicle configurations requiring reduced weight in a variety of heavy-duty truck applications. Weighing in at only 255 lbs., the Dana Spicer® tag axle features the same external geometry as a standard drive axle to enable the use of conventional torque rod brackets and axle seats that are compatible with air-ride suspension systems. This is achieved without adding the complexity, cost, and weight associated with common tag axle configurations.

According to Patxi Garcia, engineering supervisor for Dana, the new tag axle provides operators with one of the lightest 6x2 packages in the commercial vehicle industry when specified with a Dana Spicer® 23,000 lbs., or 21,000 GAWR single-reduction, single-drive axle.

"We've also maintained the excellent durability and reliability features that are a hallmark of Dana axles," Garcia adds. "The axle is fabricated at Dana's technologically advanced manufacturing facility in Humboldt, Tennessee, utilizing highstrength, hot-formed steel with a very strong square-edge box section. This is the perfect tag axle selection for customers looking to reduce weight, reduce cost, reduce maintenance, and standardize suspension brackets."

Designated as axle model number R22BS and rated up to 22,000 lbs., the tag axle housing profile and box size are common with the popular Dana Spicer DS404 tandem drive axle for 6x4 configurations. The R22BS also includes standard "R" series spindles, which are compatible with standard truck wheel-ends or the Dana Spicer LMSTM hubs to help ensure consistent, reliable road service.

For more information on the new Dana Spicer tag axle and other Roadranger® products and services, visit the Internet at [www.roadranger.com] or call (800) 826-HELP.

The Roadranger® Solution is an unbeatable combination of the best drivetrain, chassis and safety components from the Dana Corporation and the Eaton Corporation, all backed by the Roadrangers—the most experienced, expert, and accessible drivetrain consultants in the business.

Dana's Commercial Vehicle Systems Division designs, manufactures, and markets front-steer, rear-drive, trailer, and auxiliary axles; driveshafts; steering shafts; brakes; suspensions; and related systems, modules, and services for the commercial vehicle market. Major components and modules are marketed under the Spicer brand name.

The Dana Corporation is a global leader in the design, engineering, and manufacture of value-added products and systems for automotive, commercial, and off-highway vehicle manufacturers and their related aftermarkets. The company employs more than 60,000 people worldwide. Founded in 1904 and based in Toledo, Ohio, Dana operates hundreds of technology, manufacturing, and customer service facilities in 30 countries. The company reported 2002 sales of $9.5 billion.

For more information contact Rich Zesiger at (269) 342-3199, or visit the company's Web site at [www.dana.com].

Balzers Showcases Unique Coatings at Gear Expo 2003

Balzers, Inc., the global market leader in performance enhancing coatings for tools and precision components, is proud to highlight two of its successes in gear manufacturing at Gear Expo 2003 in Columbus, Ohio: Balinit® Futura Nano, a high-performance TiAlN-based coating for gear production, and Balinit® C, a tungsten carbide/carbon coating for friction and wear resistance. Balzers will be displaying at booth #900.

Balinit Futura Nano has proven successful with cutting gears out of tool steels, stainless steels, and other materials, along with high-speed steel and solid carbide hobs. The high hardness (3300 HV 0.05) and oxidation resistance (1650° F) of the coating allow for the reduction, if not elimination, of coolants. In a test conducted by the automotive industry, high-speed steel hobs coated with Balinit Futura Nano produced 50 percent more gears under dry machining conditions than those coated with a competing TiAlN coating.

Balinit C enhances reliability, extends service life, and increases performance of precision components, in particular gears. The coating reduces wear and friction, and its low coefficient of friction (0.1 to 0.2) even provides wear protection to uncoated frictional partners. When tested under defined conditions against uncoated case-hardened steel gears, gears coated with Balinit C increased the service life of tooth flanks and bases by a factor of four or higher.

Balzers, Inc., is the global leader in PVD coating technology for tools and precision components. Balzers has developed the PVD coatings marketed as Balinit and currently operates 50 coating centers at key industrial sites in Europe, North and South America, and Asia. All centers are equipped with the latest generation systems to guarantee the reproducibility of the company's high-quality standards worldwide.

For more information contact Torsten Doering, marketing director, at (716) 564-8557 ext. 1110, or via e-mail at torsten.doering@balzers.com. Further application and test results can be found at [www.bus.balzers.com], or requested at info.us@balzers.com.

Mitsubishi Heavy Industries Lands Texas Windfarm Project

In a press release dated July 24, 2003, Mitsubishi Heavy Industries, Ltd. (MHI), announced that it has signed a substantial contract to supply 160 wind turbine generators, each with a rated output of 1,000kW, to the Brazos Windfarm, to be constructed in Texas.

This is the largest such project for MHI, with total windfarm rated output of 160MW, making it one of the world's largest. This sends the aggregate total of MHI's orders for wind turbine generator units past 1,500 units, to reach 1,652.

This windfarm will be constructed in the western part of Texas (Borden County and Scurry County), which is said to be an optimal location for wind-power generation due to the constant winds throughout the year. A power purchase contract has been concluded with a local utility company to sell all of the generated electricity, equivalent to the power needs of 56,000 average households.

The wind-turbine generators being delivered are MHI's newly developed "MWT-1000A" type, which applies a newly designed blade that is longer than the existing unit to enable highly efficient power generation even in low winds. The new design may aid in generating as much as 15 percent more power annually. The rotor diameter is approximately 60m, and the tower height is approximately 70m, giving it a maximum height approaching 100m.

The wind turbines and the control systems will be produced at MHI's Nagasaki Shipyard & Machinery Works, and the blades will be manufactured at VienTek, a blade manufacturing base established in Mexico last year as a joint venture with a U.S. firm. The field installation of the units will be handled by Texas Wind Power Company. The units are scheduled to start operating in December of 2003.

Shell WindEnergy Inc., a U.S. subsidiary of the Royal/Dutch Shell Group of companies, owns 50 percent of the project. MHI has already delivered 130 wind-power generation units to Shell WindEnergy Inc., and the high performance and reliability of those units led to MHI being awarded this order.

Wind power generation, which has mainly been utilized in Europe and North America, is now increasingly being introduced around the world as an environmentally friendly energy source that doesn't emit CO2 and other gasses. Presently there are roughly 61,000 units installed globally, with a total installed capacity of 32,000MW (as of the end of 2002).

Since manufacturing its first wind turbine generator in 1980 (a 40kW unit) at the Nagasaki Shipyard & Machinery Works, MHI has been supplying its wind turbine generators to clients in Japan and overseas. MHI is now positioned as the one and only world-class producer of large wind turbine generators in Japan.

While MHI's orders surpassed 1,000 units cumulatively in 1998, the subsequent orders have expanded rapidly in recent years due to the global trend of constructing windfarms. Just last month, MHI received an order for 41 of the same 1,000kW units for an Oregon windfarm. The regional breakdown of the 1,652 units both ordered and delivered to date shows 131 for Japan, 1,389 for the U.S., and 132 for Europe and other regions.

MHI will strengthen its marketing activities in Japan and overseas, focusing on the MWT-1000A as its mainstay unit for large windfarms.

continued on page 62 >>

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terryMcDONALD

Member of the ANSI Subcommittee on Gear Safety

SAFETY MATTERS

With the rising cost of workman's compensation and medical insurance—and skyrocketing personal-injury claims—addressing safety concerns in advance is more important than ever before.

Today, as I was having lunch, the television was on a station showing a half-hour newscast. During the course of this newscast there were three different advertisements for law firms promoting injury claims. I find this reason enough to renew my efforts to convince all of my fellow employers in the gear industry to please make that extra effort to limit personal injuries in our workplaces. I am sure that none of us wish to make the lawyers rich. From the number of law firms promoting personal injury cases, it is obvious that there must be way too many workers out there who are being injured on the job. I am convinced that we will never totally be without injuries, but if we can limit the amount of injuries, or even the severity, we will be ahead of the game.

Of course, another prime concern we all have is the escalating costs of our workman's comp insurance. The above paragraph indicates the reason the insurance companies are increasing the costs. There are also the escalating costs of the medical care required in the course of treating an injury. Since we are required by law to carry workman's comp on our employees, it has long been considered just a cost of doing business, and it is. However, the cost is rising at an alarming rate: I read recently in the *Wall Street Journal* that small shops were experiencing a one-third to one-half percent increase in costs, with some as much as a 100-percent increase. I think that we can all see that improving our own and our employee's vigilance in the safety aspects of our jobs will result in savings that we can all benefit from.

My purpose in writing this column is not to bring brand-new revelations that will magically make all the accidents go away, but to help remind all of us of things that we know but somehow let slip through the cracks. If this column helps one company prevent one injury, then it will be a success. If you've read my previous columns, you will realize that all I'm doing is trying to remind you of things you already know. The usual safety literature either promotes the sale of a device or service, or is written in such an esoteric manner that: 1) It is not interesting enough to read and digest, or; 2) It references sources that will require so much effort to find that it's easier to ignore it. I try to make this column readable, and by that I mean that I try to discuss safety in a conversational manner rather than taking a "you must do it this way" approach. I hope that a dialog of this sort helps make us all think of the safety aspects of our job and work environment from a positive standpoint rather than an "*Oh gee, I have to do another stupid safety report*" mentality.

> "If this column helps one company prevent one injury, then it will be a success. All I'm doing is trying to remind you of things you already know."

How many of us simply read safety literature—OSHA, NIOSH, NFPA literature, and other similar items—that come across our desks with the attitude of: okay, now what do I have to do to keep from getting sued, fined, or otherwise inconvenienced? Unfortunately, too much of the literature is written in this vein. I think we need material that helps us realize that if we make just a few small changes, we will improve safety and decrease the chances of anyone being hurt. That, to me, is the important thing.

I hope you all are attending Gear Expo this year, since it's the premier show for our industry. As you look at all of the new equipment, I recommend that you look at it with an eye to safety. Does the machine reflect the "state of the art" guarding and protections available? Does it have good easy access to the load/unload station? Is the coolant system well thought out? Are the controls accessible and well marked?

These things, and others like them, can make a big difference in the true value of a machine purchase. Of course, the machine has to perform, too, but don't ignore the safe operation aspects of a machine purchase.

ABOUT THE AUTHOR:

With more than 30 years of experience in the gear industry, Terry McDonald is a manager with Repair Parts, Inc., a partner with Re-New Machine & Maintenance, Inc., and a current member and past-chairman of the American National Standards Institute B11.11 Subcommittee on Safety Requirements for Construction, Care, and Use of Gear Cutting Equipment. McDonald writes this monthly column specifically for *Gear Solutions* magazine. He can be contacted through the magazine at editor@gearsolutionsonline.com. Responses and reactions to his column are also welcome.

New England Gear

By Russ Willcutt

Whether you're in the market for a late-model, retrofitted Fellows gear shaper, or a part for a machine you already own, New England Gear is the company to call.

Growing up, Jeff Barnes spent his days neck-deep in machinery. He and his father were into racing—circle tracks, with modified cars—and after working on the engines, frames, and bodies in their spare time, they would take to the racetrack on the weekends, putting their work to the ultimate, real-world test.

These days, Barnes is still doing the same thing, in a way. But the cars have been replaced by Fellows gear-cutting machinery, and the track by a long list of satisfied customers who purchase rebuilt and retrofitted machines from New England Gear, which Barnes established nearly a decade ago.

"When I was 17, I started working for a gear shop while I was a junior in high school, and I progressed from basically shoveling snow off the driveway to designing special tooling and machinery for difficult jobs," he says. "We had a lot of Fellows equipment on hand, and I started taking them apart to learn about how they worked. After awhile, I began disassembling and completely rebuilding later-generation Fellows gear shapers for sale to our customers, and it went really well."

After some 15 years with the company—the last five spent on the Fellows retrofitting operation—Barnes came to the realization that he'd reached the limits of what he could achieve working for someone else and decided that it was time to realize his dream of starting his own company. He knew the market was there, and he also knew a man in the machinery business—who would eventually become his partner—who was willing to give him a corner of his warehouse. So he took a deep breath, jumped in, and he hasn't looked back since.

"The biggest motivation was that I wanted to own part of the company," he says. "I don't know how you sugarcoat that. But these newer-generation Fellows machines are rock-solid, all they need are updated controls and electronics. So I went out and started buying every single machine I could find, and there were a lot of them out there. I'd buy them, do all the necessary upgrading and retrofitting, clean them up, paint them, and I had a machine that was ready for the customer to buy and go straight to work—and at anywhere from 40 to 60 percent the cost of a new machine, depending on the electrical package they chose. And with new machines costing in the neighborhood of $300,000, that's a pretty significant savings."

With some 200 machines on his warehouse floor—and he's moved into his own 13,000 square-foot facility since the early days—Barnes says he probably has the largest selection of used, retrofitted Fellows equipment in the world. But it's about more than inventory, he says: "When somebody who has a Fellows machine needs help with it, and they call somebody to get some answers, most of the time all they're going to get is a bunch of talk," he says. "But I know these machines inside and out, and if they'll call me, they're going to find out what they need to know. I'll give them straight answers, and we'll find a way to solve their problem, no matter what it is."

Sometimes the solution is as simple as a part that will get the machine back up and running, of which New England Gear has plenty. "We have a vast selection of new and used parts in stock, and we can get them out the day they're ordered," Barnes says. "When you buy as many machines as I do, you're going to have plenty of spare parts, so we want to be the first company that comes to mind whenever somebody is looking for a part for their Fellows machine."

An acknowledged "gearhead"—"I'd much rather be working with the machines than hanging out in the office"—Barnes spends a significant portion of his time in the office these days. Apart from organizing the company's workload, he spends a great deal of his time doing mechanical drawings for use on the plant floor.

"We have seven employees," he says. "I've got a computer guy who handles all the invoicing and computer-generated drawings for CAD/CAM, and the electrical drawings and schematics and operational procedures, that's all done in-house. In fact, everything is done in-house. We have an electrical engineer who designs all of the custom software for us, and all of the parts are made complete right here.

"I also have people to help me with the business side of things—like my partner, who has more than 35 years of experience in the manufacturing and machinery business, and whose help has been invaluable—so that I can spend my time working with customers to make sure they get exactly what they need, whether that's machines or information."

In addition to rebuilding and selling Fellows machines and parts, the company has some exciting new developments in the works, involving a machine they've developed themselves. "We're building these machines complete from scratch, from castings all the way up to the final assembly, and we have a lot of ideas that are currently on the drawing board," says Barnes. "We're developing what they call a sliding-head gear shaper for true cutter positioning. That's something that we're developing

now, and we'll be offering it on the market shortly."

No matter what form the company's growth takes, it all revolves around building a reputation as the number-one source for rebuilt Fellows machines and parts, and on developing strong relationships with its current and potential customers. "In the beginning we were doing a lot of mechanical rebuilding, with only standard electrical upgrades," Barnes says. "But then, with my partner's strong CNC electrical background, we were able to add major electrical retrofitting to the package. At this point, all the machines that we rebuild have between one- and six-axis controls, depending on what the customer wants, and we're also rebuilding and retrofitting Hydrostrokes, which is a line that we developed here. Plus we try to have one of everything in stock, and the machines we have on the floor are in all different configurations."

Barnes also takes pride in the fact that New England Gear has helped a number of companies actually get into the gear business. "We're a small company with a loyal customer base, and that's because we're always willing to go the extra mile," he says. "We've helped put people in the gear business that weren't in it before. In fact, General Electric's largest supplier of rotating turbine hubs uses our machines exclusively, and we helped get them in the splining business about five years ago. The thing that I probably enjoy the most about being in this business is visiting a happy customer and seeing them using our machines.

"I want people to know that, when they need something for a late-model Fellows machine, we're the guys to go to. We've got the machines in stock, we've got the parts in stock, we offer service, and we've got the technical knowledge that's required. If they call here, they can get real answers, because I know that product. That's the word that I want to get out there.

"I think people are begging for that type of service, but they just don't know who to call," Barnes says. "With our parts inventory, we can get just about anybody back up and running. And

another thing is that we own all these machines—we're a debt-free company, solid as a rock. And many times, we'll actually loan a machine to a customer while we're rebuilding theirs, to prevent them from having downtime. So that's another nice thing that we're able to do.

As for racing, Barnes says he still thinks about it from time to time. "Once you get it in your blood, it's always in your blood. But I think I'm a lot more likely to be a sponsor than a racer these days."

For more information on New England Gear, call Barnes at (860) 223-7778, or send e-mail to jeff@newenglandgear.com. Visit the company's Web site at [www.newenglandgear.com].

High-Performance Grinding Solutions

for small or LARGE lots

Combined with "line-dressing" software, the Reishauer RZ 400 can be used to efficiently grind batch sizes as small as FIVE, or as large as 5,000.

By Dennis Richmond

It used to be that if you needed to grind gears, your decision was limited to a slow-form grinder that was better suited for small lots, but not regarded as competitive for larger production runs or, alternatively, a machine considered to be a production-style "threaded wheel" generating grinder. The latter was well suited for 3,000 gears, but it was not competitive for the 30-piece stuff because of the development time required. Now you can have your cake and eat it, too.

Since the mid-forties, there were threaded wheel grinders. Some in our industry have had the audacity to call them "stone age" hobbing machines; that is to say machines that used a stone (vitrified grinding wheel) that worked with a thread, like a hobbing machine. This was an oversimplification, but an analogy that most people could understand. In principal, the process of generation was easy to understand, but sometimes difficult to execute. As gear profiles became increasingly complicated, convoluted, and contorted, the wheel form was no longer just a simple straight-sided rack made up of two sides that corresponded to the pressure angle of the gear. It was necessary to have special diamond dressing discs that were lapped and had specific modifications containing the desired profile.

Fast forward nearly 60 years. With the development of "line dressing," a gear manufacturer now describes the curved, straight, and twisted characteristics of the involute and fills in a prompted blank in one of the set-up screens of the control. Now a single diamond disc does the work of several special sets of diamond discs. Not only can it dress single start wheels, it is suitable for multi-starts—up to seven—as well.

The RZ 400 is like no other generating grinder found on the market today. It is a 10-axis CNC machine (14 optional) that has been designed and built to be integrated into today's factory environment. The machine is configured in such a way as to make it easily attended, whether for set-up of the dressing unit or manual loading of the work spindle. Everything has been carefully engineered from the perspective of the operator. The entire column that carries the grinding spindle rotates into three discrete positions where dressing of the wheel, loading of the work spindle, and wheel change are affected. With the appropriate dressing unit, the RZ 400 can be used to efficiently grind batch sizes as small as five, or as large as 5,000.

Figure 1 — Diamond Radius Dressing Roll

Figure 2 — Line Dressing of the Grinding Worm

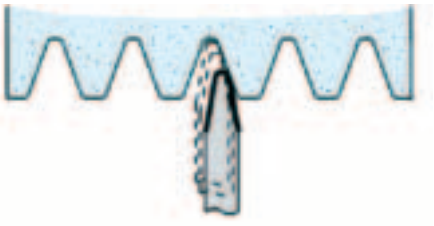


Figure 3 — The Reishauer RZ 400

Set-up and development of a job can be accomplished quickly and efficiently with the use of "line dressing," a Windows-based software program that coaches the operator through the process. If the profile is not just the way you want it the first time, program in a correction, and in about 20 minutes you're ready to grind the next gear. Acoustic touch dressing simplifies the dressing disc alignment with the wheel and can prevent damage and premature wear to your diamond tools.

It used to be that machines employed single-start wheels to assure the highest accuracy possible. While accuracy was of paramount importance, productivity sometimes suffered due to the number of starts in the wheel. Multi-start hobs have been used for decades in CNC hobbing machines, so why not use multi-start wheels to achieve higher productivity in the grinders as well? A huge hurdle had to be overcome to successfully use multi-start wheels on the new generation of machines. In particular, the stiffness of the work spindle had

Figure 4 — Surface structure of gear teeth continuous generating grinding

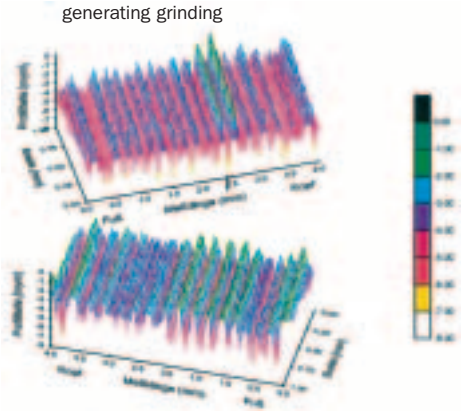
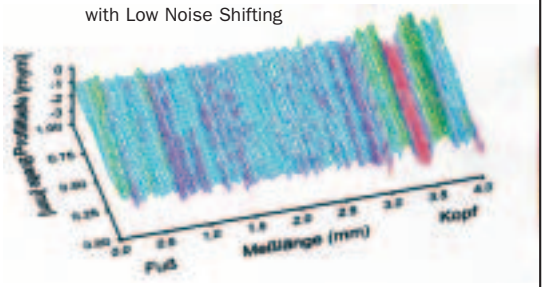


Figure 5 — Surface structure of gear ground with tooth attained with Low Noise Shifting



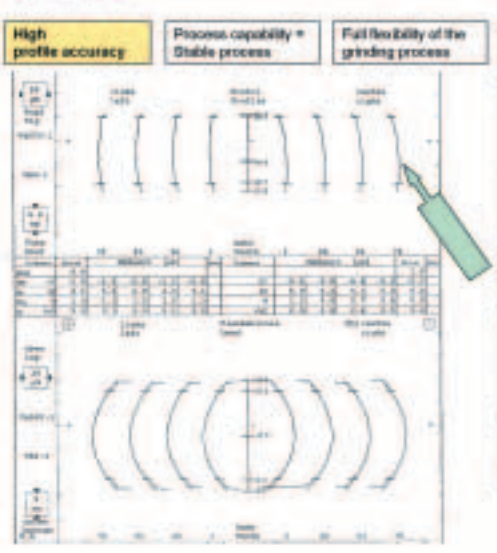
to be improved to counteract the forces created when using multi-thread wheels. A patented design of the work spindle using a planetary friction drive allowed us to improve the dynamic rigidity of the work spindle sixfold over the previous model, and because we do not use gears to transmit the motion to the work spindle, there are no ghost frequencies, or "fingerprints," on the gears ground on these machines. The stiffer work spindle design allows grinding wheels with a greater numbers of starts, resulting in higher productivity.

"LNS," or low noise shifting, is another new technology developed by Reishauer specifically for ground gears that must be honed. The implementation of this new technology obviates the need to hone gear teeth after grinding for high-speed applications that are sensitive to noise.

Further, RZ 400 productivity enhancements have been made by incorporating automatic fine balancing of the grinding wheel on the grinding spindle. Between grinding cycles, and after all dressing operations, the wheel is rebalanced and made ready for the next part to be ground. A non-contact probe is responsible for aligning the spinning threaded wheel to the workpiece to evenly divide the grinding stock, which further reduces non-productive time.

With nearly 90 machines on order and delivered, Reishauer has been able to verify its claim that it is the most productive gear-grinding machine on the market.

Figure 6 — RZ 400 Process Studies



Workpiece	
Module	1.75 – 2.00 mm
No. of teeth	100
Face width	24 mm
Helix angle	20°
Grinding wheel	
No. of starts	7
Process data	
Grinding time	0.80 min
Floor-to-floor time	1.12 min
Feature: Profile	
Profile form error	DIN 2

About the author:

Dennis Richmond is vice president of the Reishauer Corporation. He can be reached at (847) 888-3828, or via e-mail at dennis.richmond@reishauer-us.com. The company's Web site is [www.reishauer.com].

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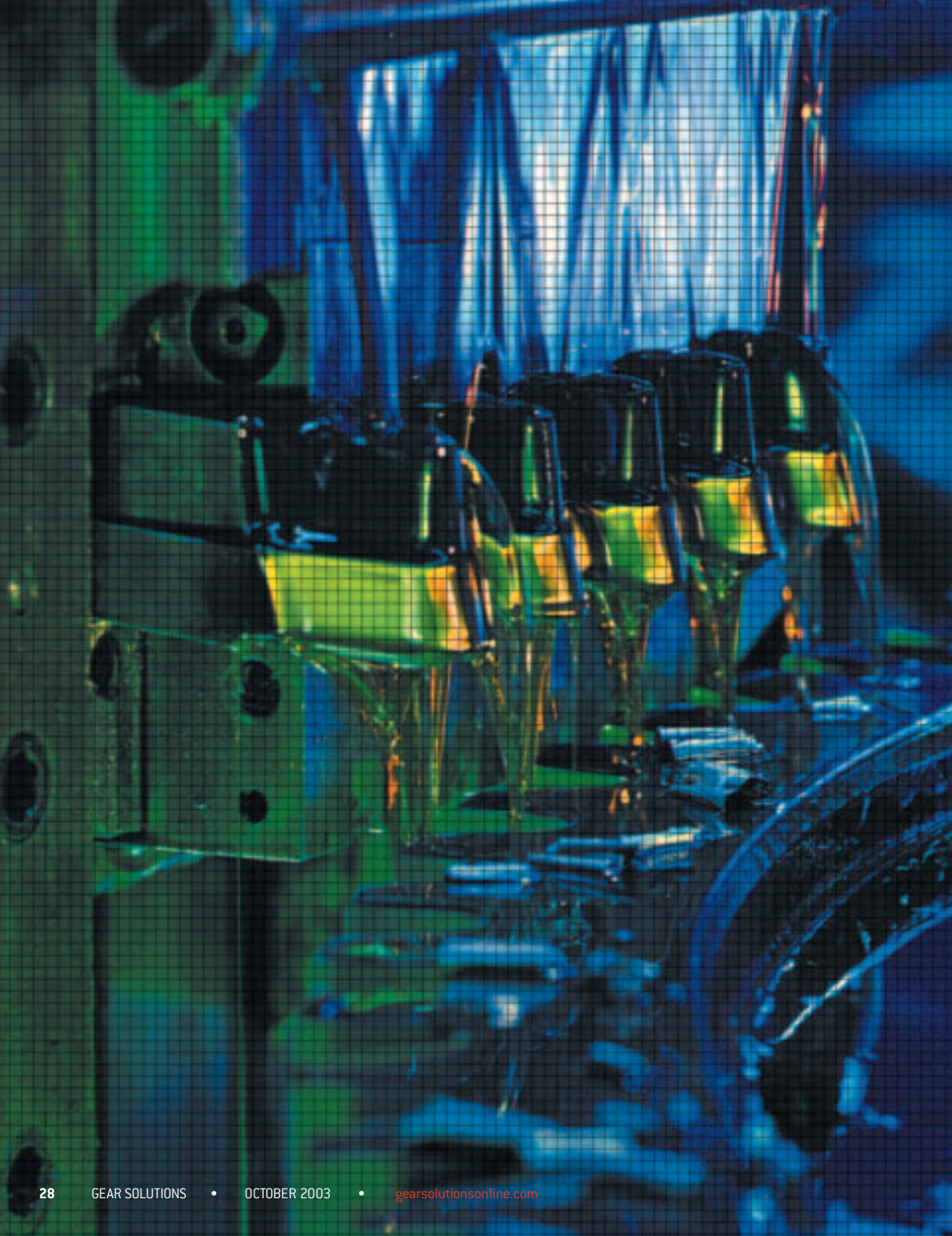


more MAAG for the Money

MAAG gear-cutting machines have a reputation for precision and dependability—that's why there's still so many of them around. Savvy owners may now consider protecting their investment by upgrading their machines with CNC technology and related software.

By Norman C. Laurens

Since the last MAAG gear-shaping machine was built and delivered in 1990, it's safe to say that the many outstanding advantages and capabilities that these machines provide are known and appreciated by only a few people in the gear industry. However, the great number of MAAG gear-cutting machines in worldwide operation—along with intermittent opportunities to purchase them as used machines—has resulted in a certain amount of invention borne of necessity. Those not totally familiar with the MAAG series of gear-cutting machines may not understand why they are still highly valued for many gear-manufacturing applications.

The well-known MAAG gear-cutting machine, as well as the MAAG gear-cutting methodology itself, were developed by Dr. Max Maag of the MAAG Gear-Wheel Company of Zurich, Switzerland, in 1913. Initially, Maag's principal aim was to produce gears of superior quality and precision than those being manufactured at the time. Needless to say, his efforts led to the development and subsequent introduction of the world-famous MAAG gear-cutting and grinding machines. The very name soon became synonymous with the highest degree of precision, and many machine-tool builders actually began touting the fact that their particular machines incorporated MAAG-cut and ground change gears in each of their machine's respective drives and mechanisms. For both small- and larger-diameter gears, the MAAG gear-cutting or gear-shaping machines soon became even better known as one of the most versatile and economical machines to be found.

Figure 1 — Standard Cutters with straight teeth: Roughing cutters Finishing cutters Pre-grinding cutters

It can probably be said that the basic simplicity of the MAAG gear-cutting methodology—generating gears utilizing "rack-type" tools—factors most importantly in realizing this versatility and economy. The rack-type tools are significantly less expensive than hobs; especially heavy-pitch, large-diameter hobs. They are also easier to manufacture, and with relatively quick delivery. In a great many instances, gear houses have actually learned to manufacture their own cutters (typical MAAG cutters, Figure 1). Special "step-type" cutters, which usually have just three teeth, are utilized for coarse-pitch, heavy-duty "plunge" cutting (scheme sketches, Figures 2 and 3). The step-type cutters are normally used after the tooth spaces are gashed out with a single-tooth cutter.

The rack-type cutters are also relatively inexpensive to maintain, with their simplicity of design permitting precision in their manufacture and reliability in their inspection. Especially for coarse-pitched and/or profile-corrected teeth—with tip relief, crest chamfer, protuberance, etc.—these advantages are not to be underestimated. Also, when sharpening the cutter by regrinding the face, the cutting-edge profile remains unchanged. Since a "backing-plate" takes up forces when cutting, the rack-type cutter can be ground and reground until it's only a few millimeters thick. Actually, the same cutter can produce spur gears or right- or left-hand helical gears, no matter the number of teeth or the helix angle.

Also, the rack-type tools—combined with today's new coating and carbide technologies—make the later-generation, larger-diameter capacity MAAG gear shapers formidable enough to finish shape-hardened gears, and capable of achieving precision parameters that can sometimes eliminate the need for an additional grinding operation (MAAG machine series SH-250, SH-250/300, SH-450, SH-450/500, and larger models).

At the same time, it's important to point out that even the older-vintage MAAG machines, if properly maintained, have been found capable of delivering almost unbelievable accuracy when compared to other types of gear-cutting machines—including some more-modern models. All MAAG gear-shaping machines are capable of both external spur and helical cutting, and with an "unlimited" maximum helix angle.

When fitted with type "JV" or "JVE" internal cutting attachments, internal spur gears can be shaped using conventional disc-type, or pinion-shaper, cutters, and/or "single-point" cutters (JV and JVE, Figures 4 and 5). Utilizing the "HV-type"

Figure 2

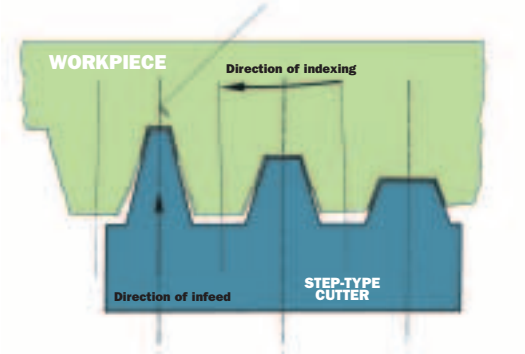
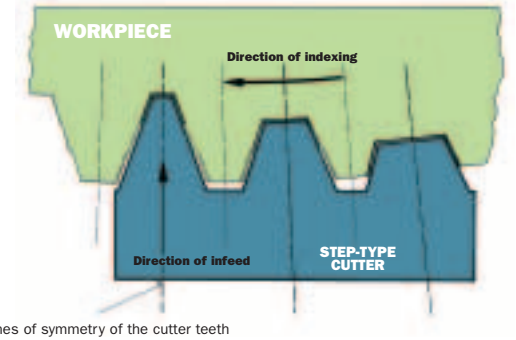


Figure 3



Lines of symmetry of the cutter teeth converge onto the workpiece axis.

internal cutter head, internal helical gears can also be cut, using an appropriate helical guide. Most MAAG gear shapers are also capable of cutting precision spur and helical racks, with the addition of a table mounted rack-holding device or fixture.

Consequently, the simplicity of the methodology, economical tooling, coarse pitch-cutting capability, easily attainable extreme and "bastard" helix angles, and the internal/ external capability are all advantages brought to the table via MAAG gear cutting/shaping. Even all these advantages combined, however, can't compare to the single most-important MAAG feature: that there are many geared part members found in the industry today that can only be cut on a MAAG—or cut most efficiently on a MAAG. These parts are normally larger-diameter, wide-face, heavier-pitch spur or helical gears, where the geared portion is located near a shoulder or protuberance; or, even more specifically, very close-gap double-helical or gap-type herringbone gears. The "type-DS" swiveling tool holder, utilizing rack-type cutters with "oblique" teeth, enables the cutting of single- or double-helical gears with a narrow relief groove or clearance. This device also enables you to shorten the cutter-ram stroke when cutting gears with a large helix angle (DS, Figure 6). Many conventional gear hobbers and gear shapers simply don't have the capacity or ability to cut this type of part, and there are many in the industry who would prefer that this particular advantage remain a "well-kept secret."

On the other hand, MAAG machines, with all of their advantages, normally carry a high acquisition cost. Again, when they were still being manufactured, they were probably the most expensive gear-cutting machine you could buy, when compared to other gear cutters in a similar diameter/capacity range. The cost of "Swiss precision" was included in the robust nature of their construction, and the breathtaking price tags on some of the larger models was enough to put a smile on the face of many a Swiss banker.

Figure 4 — JVS Internal Attachment

Traditionally, the MAAG gear-shaping machines maintained a high resale value, and this is still true, to some extent, today. The relatively few MAAG gear-shaping machines that become available on the used market continue to be priced beyond the budgets of many buyers. Those manufacturers who currently utilize MAAG shapers—as well as those contemplating acquiring them—have made, or are considering making, a significant investment. In my considerable experience, I can say that this investment is always a good one, and that I can't recall a single scenario in which this was not the case. For those manufacturers engaged in emergency breakdown and repair work, the MAAG gear-cutting machines continue to rule as the best overall gear cutters of all time.

Since MAAG machines are no longer being manufactured, replacement parts have become costly and are often difficult to obtain. This is especially true where electrical spares are concerned, as the older Brown Boveri electrical switchgear cabinets will inevitably need to be replaced with modern, compact electrical

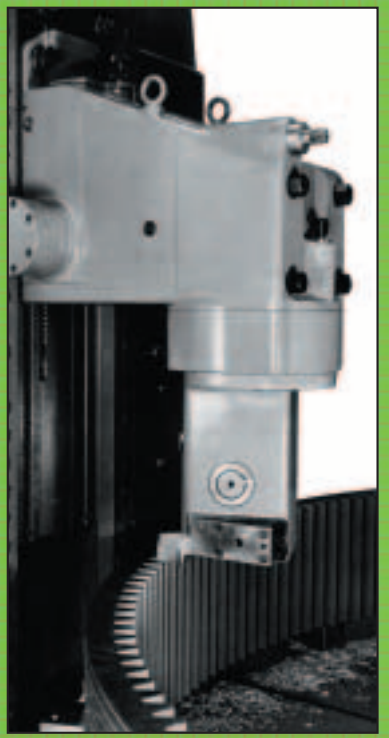


Figure 5 — JVE Internal Attachment

cabinetry with PLC controls, etc. On the larger, later-vintage MAAG gear-shaping machines, such a project can be costly, since it could also involve replacing some of the motors and drives to be compatible with the newer-generation electrical systems. Once again, this investment is inevitable. Anyone who wishes to continue realizing the advantages of their in-house MAAG gear-cutting machines will have to do this. Those planning to invest in a refurbished MAAG machine should certainly consider this and factor it into the initial cost of the machine itself.

The news gets worse when one considers the machine downtime that's necessary to perform such a retrofit. If the MAAG machine scheduled to be retrofitted is one of the company's principal moneymakers, the project and required downtime need to be planned properly. When the purchase of a newly acquired MAAG machine is finalized, and when the machine is dismantled and being prepared for shipment, the new electrical system should already be ordered, with its delivery

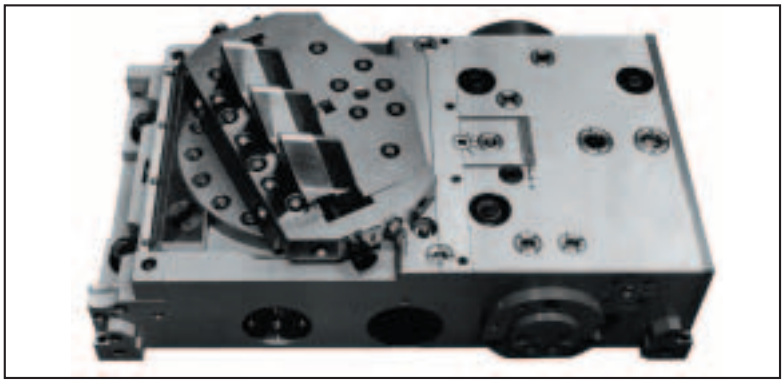


Figure 6 — DS Swiveling Tool-Holder

Figure 7 — NUM control

coordinated with completed foundation requirements and the ultimate machine reinstallation.

Now that one has begun contemplating the expense of electrical upgrade and recontrol of their existing MAAG machine, why not take the project one step further?

In 1997, Walter Grell in Moehlin, Switzerland, in conjunction with Richard Welter Maschinen in Lahr, Germany, began delivering the first of several older-generation MAAG gear-cutting machines that had been refurbished and fitted with the new-generation NUM 1060 digital CNC control and gear-cutting software. This control and software can be retrofitted into any MAAG gear-shaping machine, from the smallest SH-10 series up to the largest SH-12 (12-meter) gear-shaping machines, including new electrical switch gears and the appropriate motor and drive packages.

The new Walter Grell CNC system for MAAG gear shapers is normally rendered in five-axis execution, incorporating table rotation, table-generation motion, radial/infeed, cutter-ram stroking, and cutter-head swivel axes. There would be an additional sixth axis and digital motor for cutter

rotation included for machines utilizing disc-type shaper cutters with an internal attachment (SH-180 photos, Figures 7 and 8). The control features operator-conversational dialogue in nearly any language, an electronic hand wheel to facilitate work and fixture truing, and a compact "pendant-type" control with CRT for the larger-diameter machines.

While it is true that such a retrofit would be more costly than a more-simple electrical PLC upgrade, the rationale and justification for the additional expenditure is as plain as the smile on the face of that very same proverbial Swiss banker. The multiple advantages of the CNC retrofit option would include:

- Elimination of all shafting, change gears, clutches, older drives, and motors provides a 70-percent reduction in moving parts, overall. This, combined with the all-new electrics, reduces maintenance costs to a fraction of what they were, and an infinitely smaller fraction of what they might be, given the fact that many costly replacement parts will no longer be required.

Figure 8 — Model SH-180 w/JVS Internal

- MAAG machines being utilized for cutting double-helical gears with the DS-type head and oblique cutters create more stress and wear in the shafts and drive train. This elimination of the change gears and shafting—which are subject to wear and ultimate replacement—also serves to eliminate vibration, which can sometimes show up in the cutter. This lessens the impact on sharpening, should there be a minor error in the cutter, and improves performance when performing double-helical cutting with the oblique cutters. The elimination of the cause enhances the effect.

- Elimination of the control-disc mechanism in the MAAG gear shapers completely removes what is sometimes referred to as "wind-up." The control disc and automatic stopping device served in the past as a means of compensating for a degree of overall drive-train wear, or wind-up, created by working in conjunction with the automatic gear box

and feed mechanism. The CNC control more efficiently handles the feeding of the blank into the tool, the generation of one or more teeth, the indexing, and the now-quicker return motion of the table.

- Enhances and improves performance when "hard cutting," or when cutting through-hardened material. Hard cutting requires a substantial increase in cutter speed—i.e. cutter surface feet—which can be increased from 20 to 30 percent with the CNC using a single-point tool. Also, with increased cutter-ram speeds, the stopping point before the return stroke is rarely found to be consistent. With the CNC, the stopping point becomes exact, every time, and within .005? accuracy. In addition, when using CBN tools, the CNC provides the capability of varying the cutter speed, increasing or decreasing precisely during the same single stroke, and eliminating any harmonious chatter or harmonic vibration.

The overall cutting-time savings can be enhanced as much as 25 percent with the full CNC software

system. This becomes more significant when cutting larger-diameter, coarse-pitch gears with longer face widths.

The set-up time savings is also a factor, but much less so when one considers the time it takes to fixture and true-up a large, heavy workpiece. The time it takes to change a few change gears and properly set a few trip or stop dogs becomes negligible when it might take hours to actually set the part up for cutting.

The CNC also provides more-efficient monitoring of the cutting condition, as well as monitoring both lubrication and hydraulic systems. In addition to other safety features, a battery backup with an emergency "quick carriage retract" system is also installed in case of electrical power failure.

Lastly—and perhaps most importantly—is the fact that the CNC will enable the operator to more-easily realize or achieve what is known as "the optimum cutting condition." Tedious trial cutting can be eliminated by the operator's ability to develop the optimum feeds and speeds for all of his different workpieces, types of materials, and different tooling/cutters. Any and all of the more-aggressive machine settings, and/or those that might maximize cutter life or enhance surface finish, can be saved in the controller's memory and recalled when that particular workpiece repeats itself within a production period.

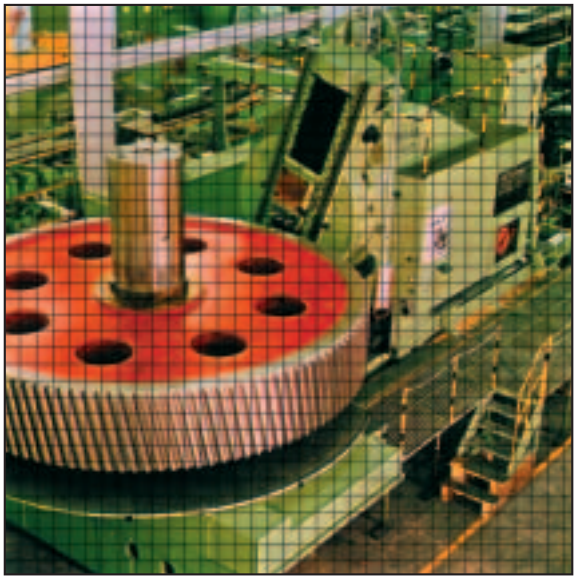
After the CNC control, electrical switch-gear cabinet, and the drive and motor package is ordered and ready, it takes between three and four weeks to complete the installation and begin test cutting. Obviously, it would be prudent to perform any refurbishing of the base machine during this same time. The Walter Grell CNC control and MAAG cutting-software system is normally installed at the Richard Welter Maschinen facility, where the base machine is usually refurbished in preparation for the retrofit. It is also possible to perform the retrofit on the larger-diameter MAAG machines in the field, as it is quite costly to move and ship the larger machines.

As mentioned previously, most of the MAAG gear-cutting machines represented a substantial investment when they were purchased. Can the owner say that this particular capital investment did, indeed, pay off in the end? Can he say that the time of the MAAG gear cutter is gone, and that it's time to put the old girl out to pasture? The smarter move may be to renovate, rejuvenate, protect, and even enhance that initial long-term investment.

The MAAG gear-cutting machines were all precision built, and they are highly versatile, extremely productive, and super-accurate. The fact of the matter is that there will not be any new MAAG machines. But the technology is now available to make the existing machines more accurate, more productive, and even better than new.

A total of six machines have been delivered with this new CNC system retrofit. So far, the only orders placed for the full CNC system have been received from buyers in Central Europe. It is now time to bring this technology to the United States so that current MAAG owners can protect their original investment and enjoy the benefits of 21st-century productivity.

The proven MAAG gear-cutting methodology, combined with today's state-of-the-art CNC technology, is a retrofit option that is well worth considering.



MAAG SH-600/735E

About the author:

For more than 25 years, Norman C. Laurens has been dealing almost exclusively in new, used, rebuilt, and CNC-retrofitted gear-manufacturing equipment of all types. He can be reached at (513) 771-1952, or via email at n.laurens@worldnet.att.net. More information on the MAAG CNC retrofit package will be available during Gear Expo, at the Richard Welter Maschinen & Zahnradfabrick GmbH booth #634.

Credits:

MAAG Gear-Wheel Company Ltd. Prospectus H-64-E-12.69-2000

MAAG Gear-Wheel Company Ltd. Bulletin 1-13-E 2000 (u) 11.73

The Web site [www.maag-gear.com/home_zurich_history.htm], and my teachers

Josef Zimmerman, formerly with MAAG Gear-Wheel Ltd., Zurich

Peter Welter, Richard Welter Maschinen und Zahnradfabirk GmbH/Lahr

Walter Grell, Walter Grell/Moehlin

Heinz Britsch, formerly with Bucyrus International

Dick Borelly, formerly with Philadelphia Gear

Fritz Schroeder, Manfred Chi, Roland Ramberg: The Gear Works-Seattle, Inc.

Nicholas J. Laurens (deceased), formerly with Laurens Bros., Inc.

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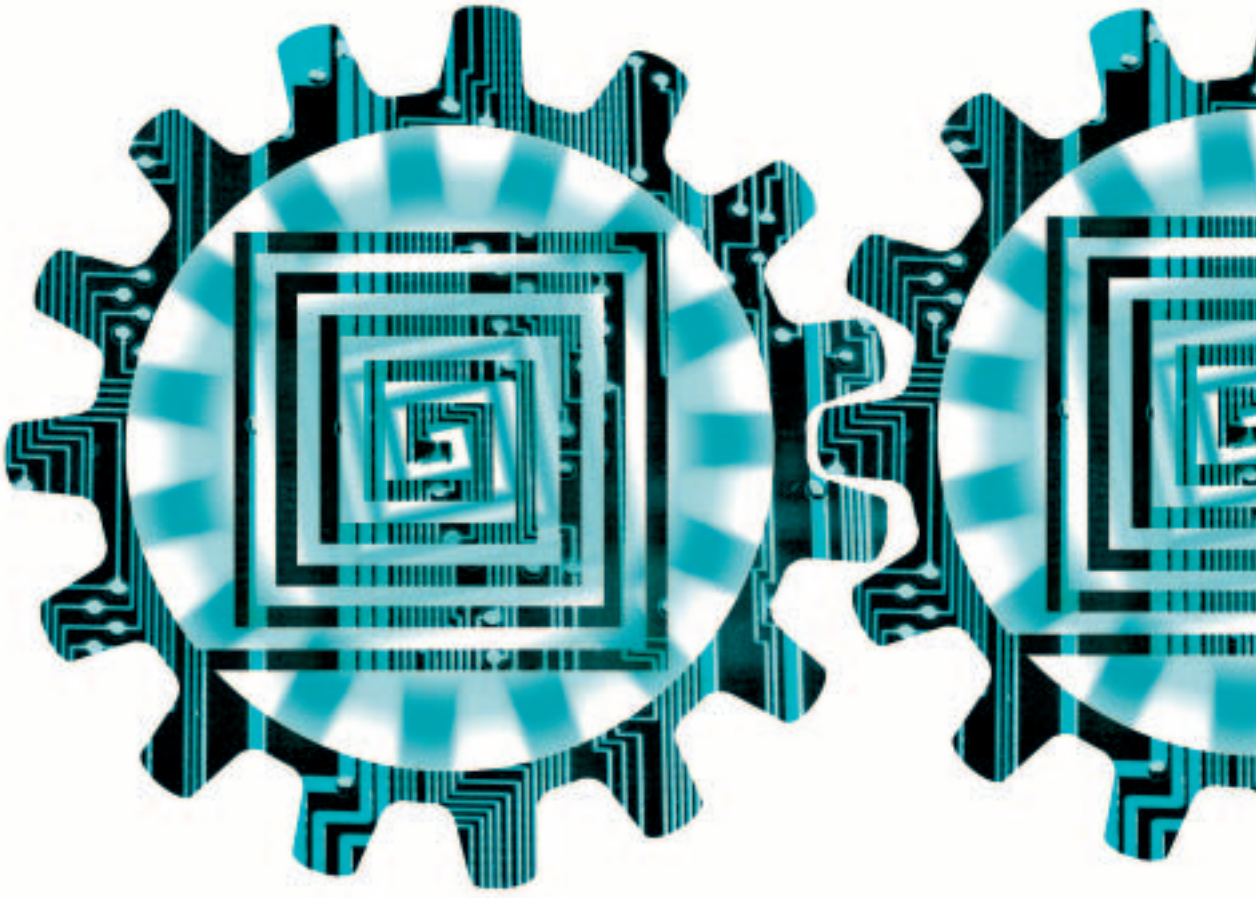
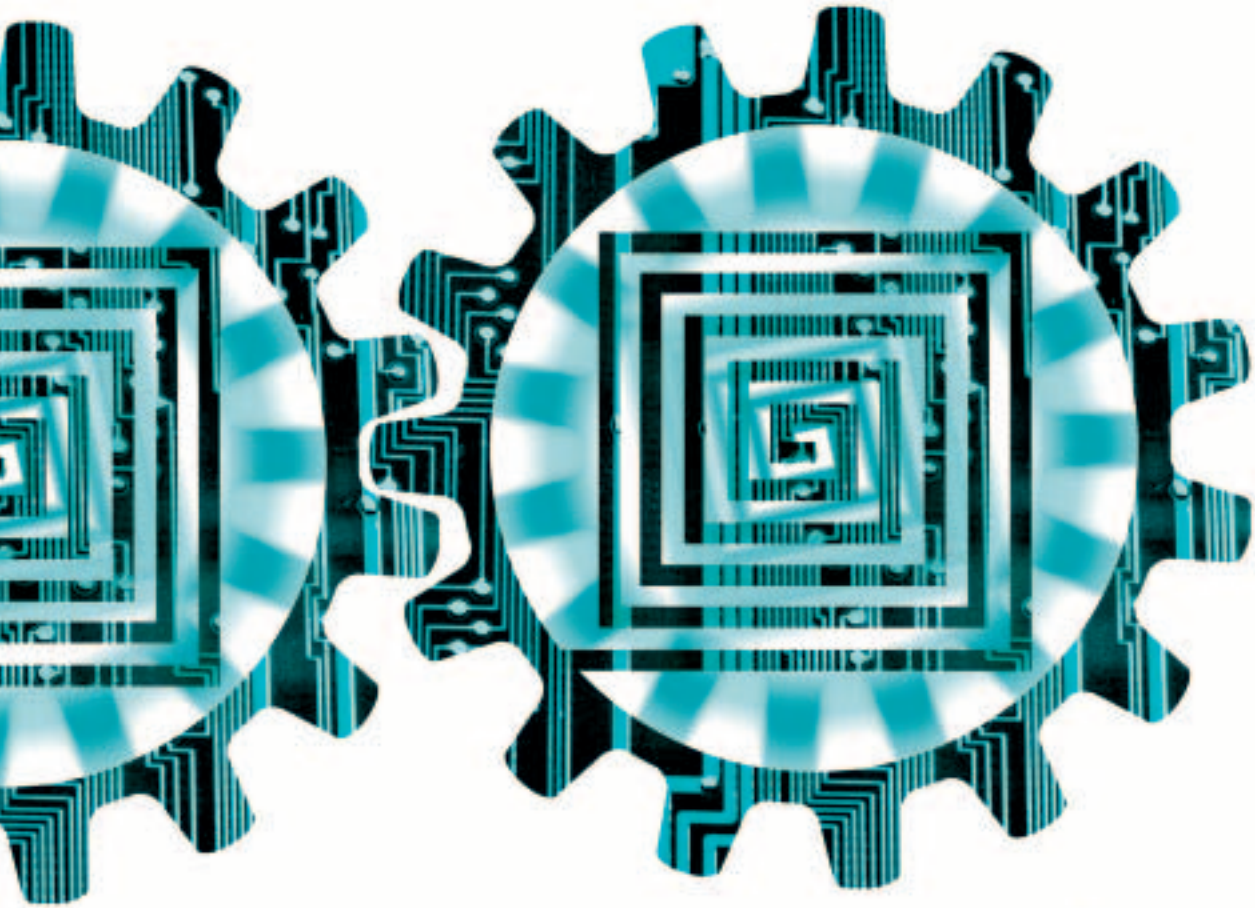
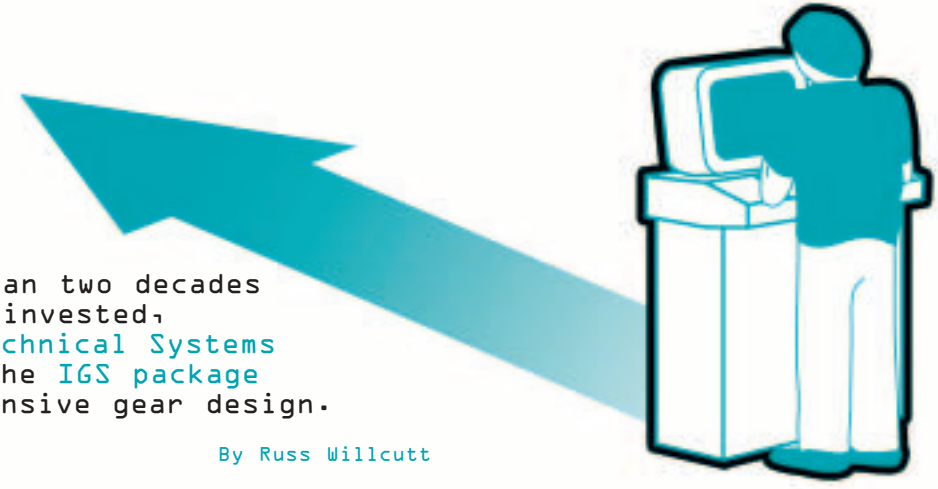


Transforming Design with Integrated Gear Software





With more than two decades of research invested, Universal Technical Systems introduces the IGS package for comprehensive gear design.

By Russ Willcutt

S.M. "Jack" Marathe—the president of Universal Technical Systems, Inc.—isn't exactly modest when he talks about the power and usefulness of his company's Integrated Gear Software (IGS). "It's a complete design and manufacturing environment for gears and gear sets," he says. "IGS will take an OEM or a gear shop completely through the process—design, tooling, inspection, testing, and tolerance analysis. It's all that a gear designer and manufacturer needs."

Marathe isn't shy about pointing out his reasons for making such a bold statement, either. "Look, we've been at this for 20 years," he says. "Twenty years of creating and refining gear software, working with gear people, getting their input, hearing what they need, and building it into the software. Companies like Boeing, Ford, GE, and GM are using our software and trust it. This is gear software by engineers, for engineers. By using it, many of our customers have been able to reduce noise, increase life, and lower costs."

During those two decades, UTS developed a total of 83 different gear programs, ranging from a first-response gear design and analysis program, to over-the-pin calculation programs, to sophisticated expert systems. So there is some justification when UTS refers to IGS as "the premier gear design and manufacturing software system in the industry."

All these different programs come under one roof with Integrated Gear Software, but the company stresses that it's about more than simply pulling software together. The word they use is "transformation," and their customers back them up.

"The thing I like best about the new software is not its functionality, ease of use, or reporting, etc., though all those things are great," says Lee Watson, engineering specialist with Ryobi Technologies in Pickens, South Carolina. "The thing I like best is the fact that UTS has put out a new product that attempts to help users design gear sets."

From the beginning, the goal was to make IGS an expert system that was much easier to use, Marathe says. "It makes calculation not just faster, but smarter. It provides data entry sequences and messages to guide the whole process. More than using it to design gears, engineers can use the software to learn about gear design by playing around with it. We have invested more than 15 man-years in upgrading to this latest release of the product."

According to Jim Marsch, a longtime gear engineer and UTS's gear software product manager, "In the past, engineers had to go through a costly, time-consuming cycle in designing gears and gear sets—design, evaluate, redesign, and so on until you finally got it right. With IGS, you get it right the first time, so it means big-time savings."

First things first. The gear programs are grouped in five packages: Basic Gear Design and Manufacturing for Metal Gears; Basic Gear Design and Manufacturing for Plastic Gears; Advanced Gear Design and Manufacturing; Crossed Axis Gear Design; Epicyclic Gear Design; and Spline Design and Manufacturing.

The metal gears basic package covers design and analysis, preliminary sizing, tooth thickness and coordinates, mesh geometry, profile shift coefficients, stress and life analysis, and measurement over pins. The plastic gear basic package does all of that and adds programs that cover such factors as temperature, moisture, and mold design. The advanced

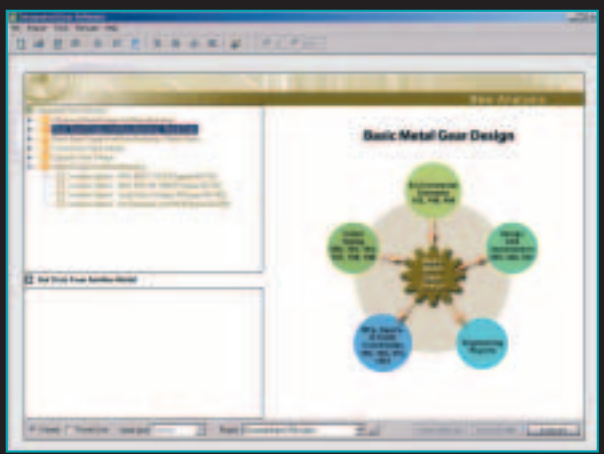


Fig 1. - IGS New Analysis

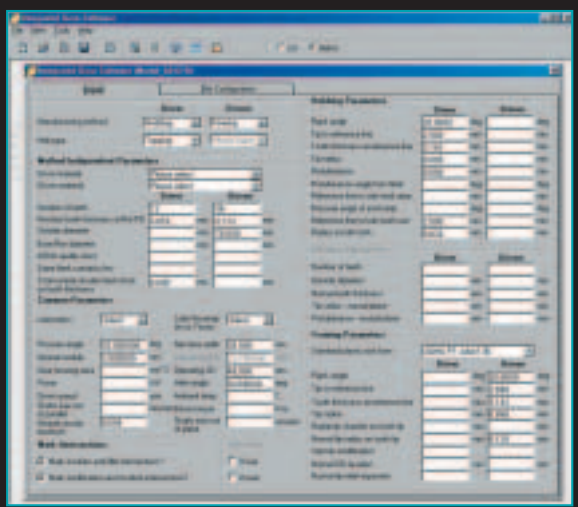


Fig 2. - IGS Wizard Form

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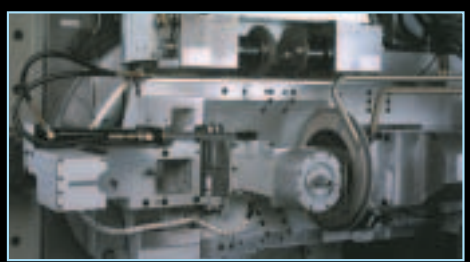

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package covers such issues as specific types of hobs and cutters, yield stress, involute geometry, scoring analysis, tip relief, and even minimum-weight gearbox.

Apart from the completeness of the various programs, UTS is most proud of the way it all hangs together in IGS. The system passes data back and forth among the different programs, does tolerance analyses, and produces both standard and customized reports. It also organizes designs horizontally, by programs, and vertically, by project.

"You begin with initial sizing, proceed to detailed gear design and analysis for metal or plastic gears, model the environmental extremes, do a full optimization with tolerance analyses, generate manufacturing specifications and mold coordinates, and finish with a complete set of reports," Marsch says.

The first screen you see is a multi-pane affair with a menu window on the left, a toolbar across the top, and a larger window on the right that isn't activated until you actually pick a package from the menu tree. Doing so calls up an attractive, informative, hub-and-spoke diagram that shows how all the programs in the package are related. (See Figure 1, page 42.)

When you select a program, text appears in the right-hand window describing in detail what the program does. Sooner or later, you may end up learning the number coding of the programs. The opening screen also has a window for bringing in data from already-completed work. You fill in a checkbox, and another hierarchal menu tree appears, showing what's available.

You also choose the project you're working in from a list on the opening form. If you're just starting a project, you create it by clicking a toolbar button, then giving it a name on the form that appears. This name is then added to the list.

On the opening screen, you also pick one of two input methods—"wizard," and "power user." Wizard is intended to be a structured, sequential input method for users of all levels of expertise, while the power-user form is just that—for experienced designers who want to tweak or optimize a design by switching input and output values.

This opening sequence represents UTS's assumption that a user will come into the application to make a new design. If you want to open an existing design, click a toolbar button—or the keystroke "control-O"—and a different screen appears, with its own menus and the program descriptions.

The data input forms range from simple to very complex, depending on which program is used—the latter being complex because they have to be, as experienced gear people know. The wizard form steps you from one input field to another: you enter the inputs you want and IGS then solves it, notifying you that it has done so. It will also notify you of any appropriate cautions and warnings, with the goal of guiding you through the design process. (See Figure 2, page 42.)

On the power-user form, there's an input field and output field for each variable in the program. Again, you enter the inputs you wish and solve, then read the output values directly on the form. (See Figure 3, below.)

Some forms have additional tabs for configuring plots, filling in data tables, and, depending on the program, other specific calculations. For the more-complex programs, it's worthwhile to look at the documentation—available in hardcopy and Adobe PDF format—and try one or more of the examples.

Choosing the power-user form lets a user "backsolve," a feature of IGS's calculation engine known as the "TK Solver."

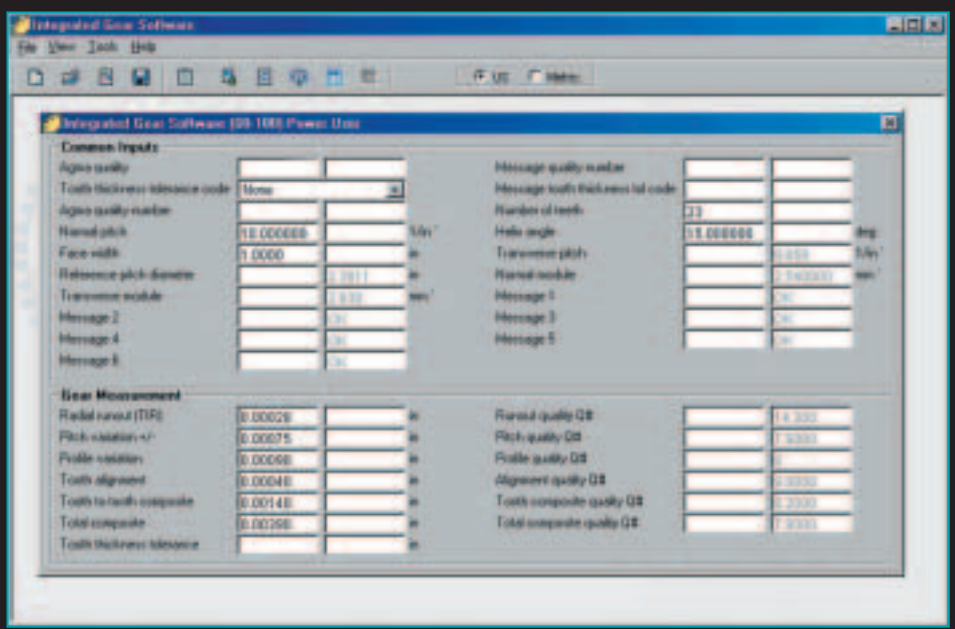


Fig 3. - IGS Power User Form

GEARING FUNDAMENTALS

"Fundamentals of Gearing" is an interactive, Web-based training course. Regular classroom courses at UTS have been so successful that the company wanted to make them available as self–paced Web courses. To that end, UTS has started an online gear-training series called Gear University, with "Fundamentals of Gearing" as the first course in this series.

The course is available 24/7, and it takes about four hours to complete. The course provides an overview of basic gear theory and nomenclature, and a foundational understanding of metal and plastic gearing. Chapter units include: Basic Gear Nomenclature; Involute Curve; Involute Gear Teeth; Gear Geometry; Gear Standards, and; Gear Modifications. The course includes thorough quizzes, self-progress measures, review notes and a comprehensive interactive glossary, as well as graphics and animations.

UTS says the intended audience includes engineers, machine operators, sales reps, quality control personnel, and others involved in any aspect of manufacturing gears and gear boxes. The $299 cost provides a full license and 15 hours of online time.

To learn more, go directly to [http://uts-rkfd-1.uts.com/GearUniversity/GS.aspx].

Backsolving is really reverse engineering: you can solve forward or backward, with whatever combination of inputs and outputs you want. It's handy for optimizing and testing "what if?" scenarios.

Many programs have standard report formats, and all programs allow custom reports, with inputs, outputs, and plots that you choose, plus headers and footers, and even a logo. Available plots include teeth in mesh, hob geometry, life data, and stress data (shown below). IGS also supports comparative reports that pull in data from two or more saved runs. (See Figures 4 and 5, page 46.)

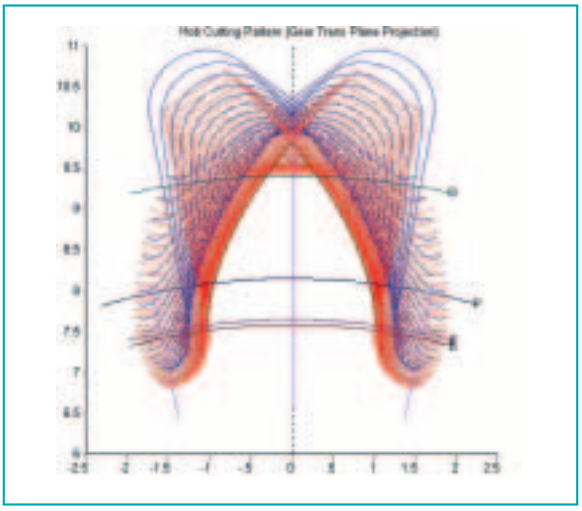


Fig 4. - Hob Geometry Plot

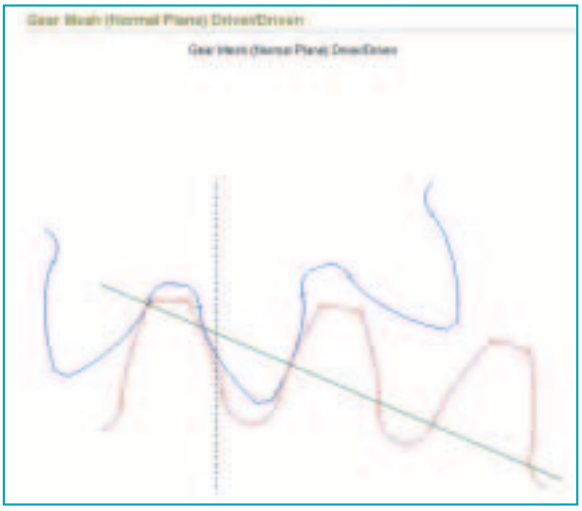


Fig 5. - Gear Mesh Plot

If all of this sounds complicated, it is, but not unnecessarily so. The architecture of IGS is logical and comprehensible enough, and certainly reflects the real world of project management.

Jim Marsch used the UTS software as a gear engineer for Harnischfeger, where he worked for 22 years, and now uses it for gear consultation at UTS. "For a longtime user like me, the versatility of the UTS gear software had both pros and cons," he says. "As opposed to a big, all-inclusive program—which is never really all-inclusive—the UTS modular approach let you take one piece of a project at a time."

But there was a downside, Marsch adds. "For a big project, you had to enter data several times, and cut-and-paste to make reports. The new software preserves the modularity, but all the data is kept in one database and can be brought into any program. The enhanced reports are a great time-saver, and the comparative reports are a much, much bigger time-saver."

Marsch says he uses the wizard only for initial data entry. For designing gears, he prefers the power-user form.

"Accuracy and speed were greatly improved by the 'Get Data From Another Model' feature," Ryobi's Watson says. "We also like the ability to locate the manual with a click of the mouse, and the ability to review designs in a true side-by-side comparison with the reporting feature."

Tom Pijaca, technical manager of Smiths Aerospace in Whippany, New Jersey, says that his company particularly likes the visual plots of the UTS software—and the fact that there are programs for designing worm gears.

"The UTS software helps us produce predictable gear sets," he says. "And because we can use it to validate tooling, we can lower costs by using existing tooling."

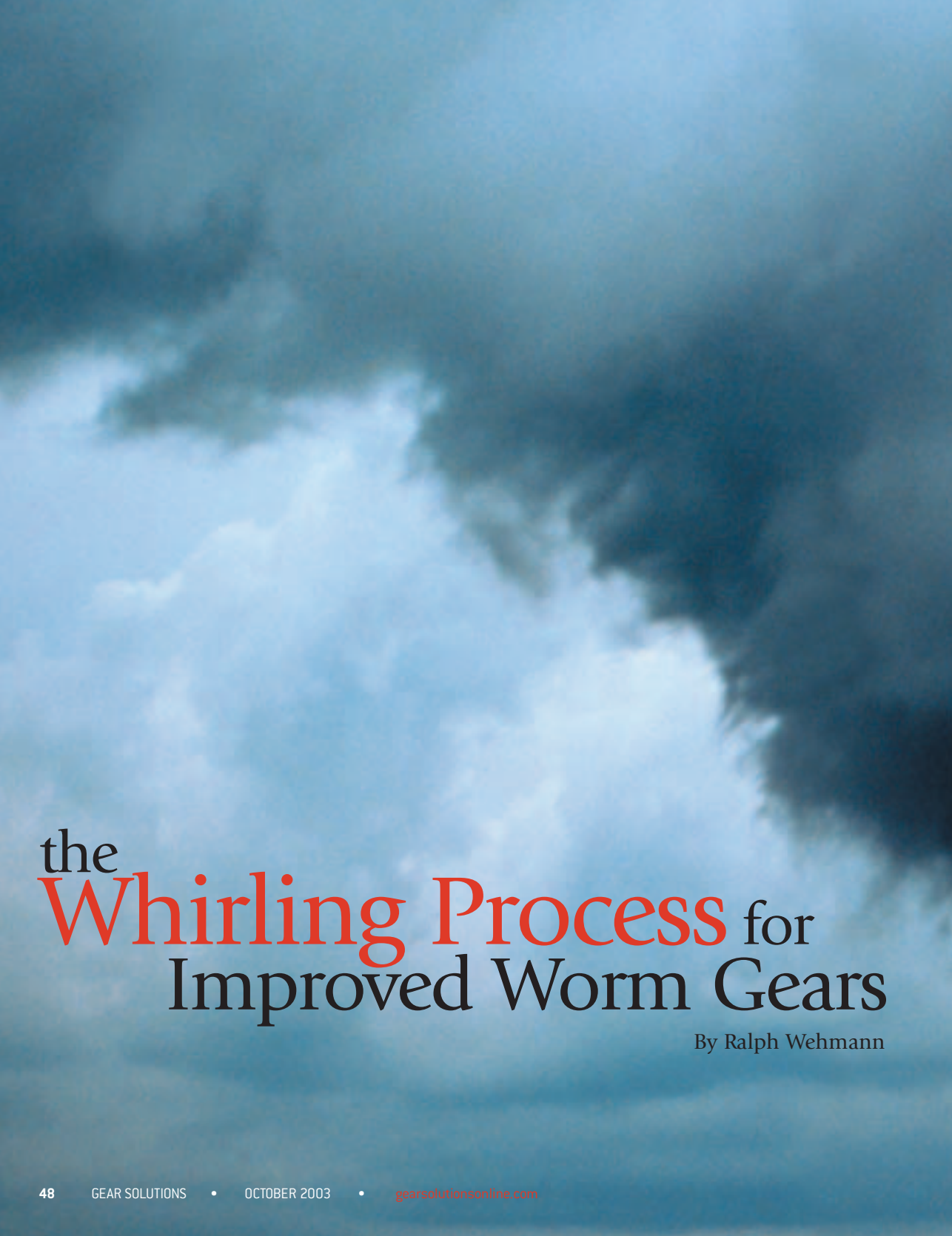
James Blalock—a project engineer for Parker Hannifin's Chelsea Products Division in Olive Branch, Mississippi—praises IGS for its usefulness in training. "The graphical interface allows the gear designer to actually visualize what information the software is prompting the designer for," he says. "This will be extremely valuable in guiding the less-experienced gear designer. If they do make a mistake, or want to modify some input value, the interface makes it very easy to retrace their steps, change the desired value, update the output, and see how the change affected the final gear set."

Blalock also predicts IGS will fill an important need for companies in an era of greater employee mobility. Most companies, he says, have a long-standing employee who is the repository of gear knowledge.

"When the 'gear expert' leaves, what happens?" he says. "Hopefully, that's where the software comes into play. The wise company will train other 'gear experts' before it's too late, and the latest version of UTS can only help in that training. The time and investment required to get someone competent in using Integrated Gear Software has to be a lot less than any homemade gear software that I've seen."

UTS has also produced an online training course that can stand alone, but that also supplements and corresponds with IGS. "Fundamentals of Gearing" is the first course in UTS's projected Web-based "Gear University" training series. The course is aimed at experienced engineers who are new to the gearing industry, and toward experienced operators who want to become more familiar with gearing theory and nomenclature. The course includes curriculum provided by qualified instructors, and multimedia provided by designers whose first priority is effective teaching.

For more information, contact Phil Cooper at (815) 963-2220, or via e-mail at sales@uts.com. Visit the company's Web site at [www.uts.com].



the Whirling Process for Improved Worm Gears

By Ralph Wehmann

Image Courtesy of the National Oceanic and Atmospheric Administration/Department of Commerce

For those looking for a faster, more-economical means of producing worm gears, WHIRLING (combined with induction hardening) may be just what you're looking for.

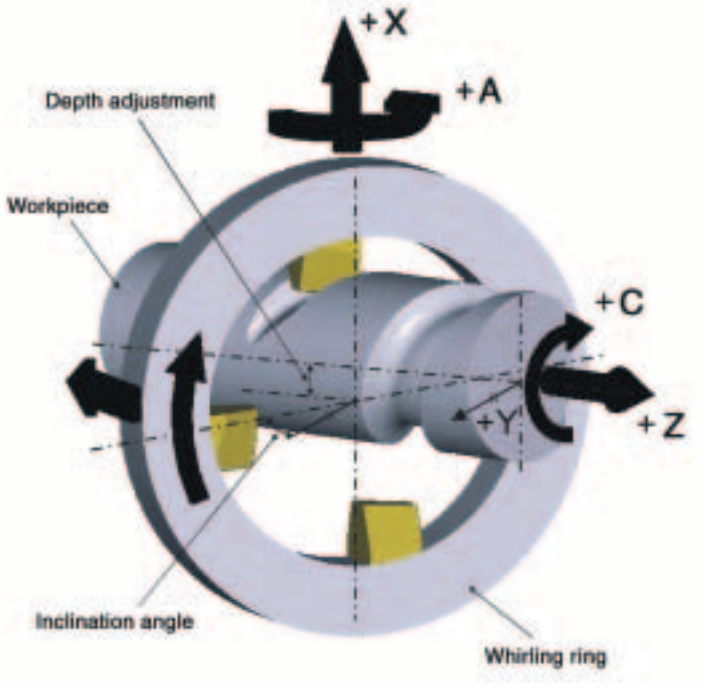
Worm designs and manufacturing methods have changed very little over the past half century. Finishing a worm in soft material and then hardening it offers huge savings to worm manufacturers, but has not been considered viable because of distortions in the material from heat treating. Thread grinding has long been used as a finishing operation to removing a mere 0.01-0.02 μm to achieve the necessary worm tolerances for lead, pitch diameter, and run-out, etc. Grinding, which comes at a big cost, is no longer required.

Progress, however, has been made. To compete with imports, mostly from Asia, U.S. manufacturers are reevaluating their products. Gear worms can be produced much better and more economically using nontraditional methods. Focusing on speed reducers—specifically right-angle worm reducers—many well-know suppliers have raised the bar on performance and pricing. And they have done so through whirling, induction heating, and new design approaches.

Whirling

The little-known process of whirling is showing impressive returns in producing worms for gear worm reducers. Methods such as hobbing or thread milling are actively being replaced by this relatively new cutting process. Improvements in many areas of manufacturing, including cutting tool materials and geometry, the machine tools themselves, and induction hardening procedures, have all allowed manufacturers to reduce the number of process steps by 60 percent or more. By machining the worm to finished tolerances and surface roughness using the whirling process and then induction hardening, the worms are not only produced faster, less expensively, and with less handling, but to greater tolerances than ever before. This method completely eliminates the need for thread grinding. Cylindrical grinding of the bearing journals can also be eliminated by turning the soft blanks to finished tolerances and surface roughness prior to whirling the worm section. The journals can remain soft, and thus do not require subsequent finishing operations. The induction heating process of hardening and then quenching only the worm section does not distort or add stress to the material. The worm shaft does not require straightening, which eliminates yet another normally manual operation.

Figure 1



The latest advancements in tooling design, cutting materials, and machine tools have made the benefits of thread whirling even greater than before. Difficult threading operations, such as very long shafts or very wide profiles, can easily be machined by whirling. The superior surface finishes and closer tolerances of screws machined by whirling are ideal for today's very strict SPC requirements. CNC control has added to machine threads the possibility of variable or unusual pitches, tapered or variable-root diameters, and multiple starts. Production rates of whirling, when compared to thread milling or hobbing, are at least four times faster. The recent introduction of insert tooling systems has greatly reduced the changeover, or set-up times. Tooling costs are also greatly reduced. Since most materials are whirled dry, without coolants, the problem of proper coolant disposal or recycling is reduced.

Leistritz—a machine tool builder based in Nürnberg, Germany, with a branch office in Allendale, New Jersey—has developed a complete line of multi-axis CNC whirling machines. These machines have been designed specifically for whirling and have the inherent rigidity for cutting deep, wide profiles in tough materials and the necessary accuracy for cutting precision, close-tolerance screws. These machines are ideally suited for production environments where there is minimal time to do routine maintenance. The slant bed design, of cast iron construction, utilizes zero-maintenance AC servos for all axes. The main spindle is actually an ultra-precision rotary "C" axis having high torque and a resolution of 0.001 degrees.

What is Whirling?

Whirling is a machining operation in which a series of profiled cutters remove material by passing over the workpiece moving at cutting speeds of 350-650SFM and advancing at "lead" to produce a helical form. Whirling removes material similarly to milling; in whirling, however, the carbide cutters are arranged along the inside of a ring to a predetermined cutting circle diameter calculated from the worm data (outer diameter, pitch, lead, etc.). The whirling head is tilted to the nominal helix angle of the worm. Material removal is the result of the whirling ring rotating at high speed around a slowly rotating workpiece. The rotating workpiece, combined with the advancement of the longitudinal slide, produces the required pitch of the worm. The eccentric amount of the worm centerline to the whirling ring determines the over-pin dimension. The tangential cutting action of the whirling process leaves the tool in contact with the workpiece for a much longer time along the arc of the "cutting circle" of the inserts. Subsequently, each pass of the insert removes four to six times the amount of material. In addition the tangential cutting action also permits much higher cutting speeds, thus shortening cycle times again. The low approach angle of the insert when it first makes contact with the workpiece ensures that the whirling tools achieve a good tool life.

The above characteristics combine to give yet another benefit: dry machining. In most cases the whirling process is done dry, without coolants or cutting oils. Nearly all of the

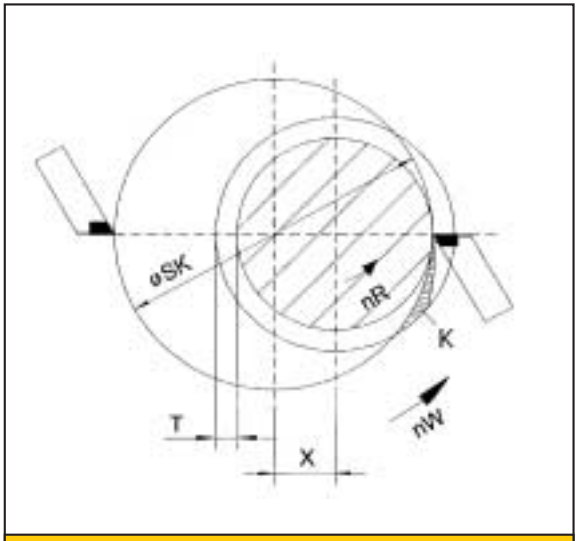


Figure 2

nW	Rotation of whirling tool	**T**	Depth adjustment
nR	Rotation of workpiece	**X**	Eccentricity
SK	Cutting circle	**K**	Comma-shaped chip

heat generated by the cutting action is carried away by the blue-colored, comma-shaped chips.

Induction Heating

Manufacturers take the full benefit of the positive aspects of whirling by induction hardening, normally in a lean manufacturing cell. When an alternating current flows through a coil, eddy currents are induced in metallic objects placed inside the coil. Heat is developed where these eddy currents flow. The higher the frequency, the more the heat becomes concentrated at the surface. The latest sensors and computer controls provide the ability to regulate the electrical frequency. Induction heating can be programmed to harden only certain areas of a worm shaft. For example, the bearing journals can remain soft and only the worm section hardened.

The induction hardening process is very repeatable and achieves a high hardness quality with consistent results. Modern induction equipment requires very little set-up time and normally produces a hardness in tolerance from the very first workpiece in a lot. Computer files store the control and position parameters to be recalled for each worm part number.

In many cases, the best way to harden a worm shaft is to scan the worm section. In this process, the induction coil—a ring-shaped copper element—has a length much shorter than the worm-face width. To heat the entire worm, the coil must advance in the axial direction over the worm length.

This is typically performed vertically from the bottom of the worm, moving in the "up" direction. Just below the induction coil is an annular quenching ring to douse the worm in solution to evenly cool the material. A variety of quenching fluids can be used and must be determined by the material and desired hardness/depth. The scanning rate controls the heating temperature and quench and controls the resulting hardness along with frequency of the electrical current. Often, the worm is heated a second time to temper the hardness back to give a more-even hardness from outer diameter to worm root.

Design Considerations

To take full advantage of the benefits described above, some changes in worm design will be necessary. These changes could be limited to the steel used, but should also include a shortening of the worm length to raise the load ratings of the gear-box assembly.

Material Selection

The induction process only requires a ferrous material to create heat in the work. To harden steel, however, an alloy with

relatively higher carbon amounts is required. Common steels used in this processing for producing gear worms are 4150 or 1050. The latter is less expensive but has a lower machinability. Typically, alloys having carbon levels of 0.4 to 0.6 percent carbon offer excellent induction hardening characteristics for both depth and pattern. Depending on the hardness level or tolerances, a variety of steels are available that offer good induction hardening ability. The machinability of the steel is very important in this processing, because the worm is being finished with a cutting process, so surface roughness is critical. Since worms typically run with brass or bronze gears, wear is also critical. The smoother the surface, the better the life of the gear. Although 16rms (0.4Ra) is possible, and not unheard of, 20 to 24rms is more typical and controllable.

No Undercuts Needed

Worm designs which people are most familiar with include an undercut or relief at each end of the worm section. This has been the standard, and it was probably incorporated to suit much older gear-hobbing machines. The undercuts acted as clearance areas to start and finish the worm. The width of the undercut was determined by the arc of the hob radius. Since whirling does not require undercuts at the ends of the worm area, the worm face width can be optimized and the overall shaft length reduced. This makes a more rigid, compact, and stronger design. The bearing journals can be much closer together, and the overall housing smaller and lighter. Not having undercuts also eliminates the need for deburring the worm-teeth ends at each undercut. This

also saves time when turning the worm blanks. A simple straight diameter of the worm O.D. is perfect. In designs that absolutely require the undercuts, possibly for assembly purposes, the whirling operation can include a higby cycle to remove the sharp edges where the worm teeth break into the undercuts.

Conclusion

Modern design, machining, and heat treating amount to huge savings for worm-gearing manufacturers. Anyone presently making worms should evaluate new technologies. The investment that may include a redesign due to material changes and capital equipment will reap benefits very quickly. Even in applications with low to medium production volumes, this new processing can offer huge savings and quality improvements. The end result will be a speed reducer drive with higher efficiencies, greater power ratings, and lower weight, as well as lower costs and shorter lead times.

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BARBER-COLMAN 6-10 B&C Ltd, S/N 8079, Triple Thrd **REF#110**
BARBER-COLMAN 6-10, S/N 4573, '57 Triple Thrd **REF#110**
BARBER-COLMAN 6-10, S/N 4626, '57 Triple Thrd 3" Hob Slide **REF#110**
BARBER-COLMAN 6-10, S/N 4659R, '56 Triple Thrd Adj Ctr Assy **REF#110**
BARBER-COLMAN 6-10, S/N 4664R, '57 Triple Thrd **REF#110**
BARBER-COLMAN 6-10, S/N 4665, '57 Fine Pitch Prec Triple Thrd **REF#110**
BARBER-COLMAN 6-10, S/N 4701, '58 Triple Thrd w/Power Down Feed **REF#110**
BARBER-COLMAN 6-10 M/C, S/N 4754, '59 Triple Thrd w/MC Conversion **REF#110**
BARBER-COLMAN 6-10 M/C, S/N 4755, '59 Triple Thrd w/MC Conversion **REF#110**
BARBER-COLMAN 6-10 Multicycle, S/N 4778R87, '60 ('87 Rebuild), Sgl Thrd Hi-Spd **REF#110**
BARBER-COLMAN 6-10, S/N 4813, '60 Triple Thrd, 800 RPM **REF#110**
BARBER-COLMAN 6-10 M/C, S/N 4913, '63 Triple Thrd w/90 Deg Hob Slide **REF#110**
BARBER-COLMAN 6-10, S/N 4941, '63 Triple Thrd **REF#110**
BARBER-COLMAN 6-10 Multicycle, S/N 5055, '66 Triple Thrd, 800 RPM **REF#110**
BARBER-COLMAN 6-10, S/N 5066, '66 Triple Thrd, 800 RPM **REF#110**
BARBER-COLMAN 6-10, S/N 5141, '67 Triple Thrd w/Prec Hob Shift **REF#110**
BARBER-COLMAN 6-10 Multicycle, S/N 5148, '68 Triple Thrd, 800 RPM **REF#110**
BARBER-COLMAN 6-10 Multicycle, S/N 5259, '75 Triple Thrd w/Auto Hob Shift **REF#110**
BARBER-COLMAN 6-10 M/C, S/N 5330, '75 Sgl Thrd Prec **REF#110**
BARBER-COLMAN 6-10, S/N 5351, '77 Triple Thrd w/3" Hob Slide, 800 RPM **REF#110**
BARBER-COLMAN 6-10, S/N 5353, '77 Triple Thrd w/3" Hob Slide, 800 RPM **REF#110**
BARBER-COLMAN 6-10, S/N 5394, '81 Fine Pitch Triple Thrd w/Dwell & Hob Rev **REF#110**
BARBER-COLMAN 6-10 M/C, S/N 5432, '87 Sgl Thread Prec **REF#110**
BARBER-COLMAN 6-16 Auto, S/N 5044, '66 Auto Loader **REF#110**
BARBER-COLMAN 6-16 Auto, S/N 5045, '66 Auto Loader **REF#110**
BARBER-COLMAN 6-16 M/C, S/N 5121, '68 Triple Thrd, 800 RPM **REF#110**
BARBER-COLMAN 6-16 M/C, S/N 5238, '70 Triple Thrd, Recon '02 **REF#110**
BARBER-COLMAN 6-10 Auto, S/N 5245, '70 Auto Loader **REF#110**
BARBER-COLMAN 6-10, S/N 5407, '82 Auto w/PLC Control **REF#110**
BARBER-COLMAN DHM, S/N 105, '42 Double Thrd **REF#110**
BARBER-COLMAN DHM, S/N 129, '42 Sgl Thrd **REF#110**
BARBER-COLMAN 14-15, S/N 336R, '49 Dbl Thrd, Fact Reb **REF#110**
BARBER-COLMAN 14-15, S/N 537R, '51 Dbl Thrd, Fact Reb **REF#110**
BARBER-COLMAN 14-15, S/N 635R, '53 Dbl Thrd, Fact Reb **REF#110**
BARBER-COLMAN 14-15, S/N 741, '55 Sgl Thrd **REF#110**
BARBER-COLMAN 14-15, S/N 745, '55 Dbl Thrd w/Dwell **REF#110**
BARBER-COLMAN 14-15, S/N 793, '56 Dbl Thrd w/Hyd Tailctr **REF#110**
BARBER-COLMAN 14-15 Dual Fd, S/N 926, '62 Dbl Thrd **REF#110**
BARBER-COLMAN 14-15 Dual Fd, S/N 938, '62 Dbl Thrd, Comp Recon **REF#110**
BARBER-COLMAN 14-15, S/N 957, '63 Dbl Thrd **REF#110**
BARBER-COLMAN 14-15, S/N 1033, '65 **REF#110**
BARBER-COLMAN 14-15, S/N 1055, '65 Dbl Thrd w/New Hyd Sys **REF#110**
BARBER-COLMAN 14-15, S/N 1068, '65 **REF#110**
BARBER-COLMAN 14-15, S/N 1114, '66 Dbl Thrd **REF#110**
BARBER-COLMAN 14-15, S/N 1131, '66 Dbl Thrd w/Hyd Tailctr **REF#110**
BARBER-COLMAN 14-15, S/N 1162, '66 Dbl Thrd **REF#110**
BARBER-COLMAN 14-15 Dual Fd, S/N 1169, '66 Dbl Thrd w/Hyd Live Ctr **REF#110**
BARBER-COLMAN 14-15 Dual Fd, S/N 1261, '67 Dbl Thrd w/Hyd Live Ctr **REF#110**
BARBER-COLMAN 14-15 Dbl Cut, S/N 1278, '68 Dbl Thrd w/4-1/8" Bore **REF#110**
BARBER-COLMAN 14-15, S/N 1383, '72 Sgl Thrd w/Hyd Live Ctr **REF#110**
BARBER-COLMAN 14-15 Dual Fd, S/N 1438, '75 Dbl Thrd **REF#110**
BARBER-COLMAN 14-30 Dual Fd, S/N 1371, '71 4-Thrd w/Sizing Cycle **REF#110**
BARBER-COLMAN 22-15, S/N 923, '62 Dbl Thrd **REF#110**
BARBER-COLMAN 16-11, S/N 148, '45 Dbl Thrd w/Hollow Wk Clamp Cylinder **REF#110**
BARBER-COLMAN 16-11, S/N 184, '50 Dbl Thrd w/Vert DRO **REF#110**
BARBER-COLMAN AHM, S/N 1896, '42 Sgl Thrd w/3 Jaw Chuck **REF#110**
BARBER-COLMAN AHM, S/N 2133, '44 Sgl Thrd **REF#110**
BARBER-COLMAN AHM, S/N 2448, '46 Dbl Thrd w/Cam Down Fd **REF#110**
BARBER-COLMAN 16-16, S/N 2745, '51 Sgl Thrd w/90 Deg Hd **REF#110**
BARBER-COLMAN 16-16, S/N 3169, '53 Sgl Thrd **REF#110**
BARBER-COLMAN 16-16, S/N 3171, '53 Dbl Thrd, Spanish Nameplates **REF#110**
BARBER-COLMAN 16-16, S/N 3409, '56 Sgl Thrd **REF#110**
BARBER-COLMAN 16-16, S/N 3572, '58 Sgl Thrd **REF#110**
BARBER-COLMAN 16-16, S/N 3580, '59 Dbl Thrd w/Diff & Auto Hobshift **REF#110**
BARBER-COLMAN 16-16 Multicycle, S/N 3682R, '59 Dbl Thrd, Air Operated w/Diff **REF#110**
BARBER-COLMAN 16-16 Multicycle, S/N 3641, '60 Dbl Thrd w/Diff **REF#110**
BARBER-COLMAN 16-16, S/N 3660, '57 Sgl Thrd **REF#110**
BARBER-COLMAN 16-16 Multicycle, S/N 3718, '61 Dbl Thrd w/Auto Hob Shift **REF#110**
BARBER-COLMAN 16-16, S/N 4061R, '66 **REF#110**
BARBER-COLMAN 16-16, S/N 4111, Dbl Thrd, "C" Style End Brace **REF#110**
BARBER-COLMAN 16-16, S/N 4136, Dbl Thrd, "C" Style End Brace w/Diff **REF#110**
BARBER-COLMAN 16-16 Multicycle, S/N 4170, Dbl Thrd w/Jump Cut Cycle "C" Style **REF#110**
BARBER-COLMAN 16-16, S/N 4175R, '67 4-Thrd, "C" Style End Brace **REF#110**
BARBER-COLMAN 16-16, S/N 4176R, '67 4-Thrd, "C" Style End Brace **REF#110**
BARBER-COLMAN 16-16, S/N 4182R, '67 4-Thrd, "C" Style End Brace **REF#110**
BARBER-COLMAN 16-16, S/N 4257, '68 4-Thrd w/Workclamp Cyl "C" Style **REF#110**
BARBER-COLMAN 16-16, S/N 4259, '68 **REF#110**
BARBER-COLMAN 16-16, S/N 4473, '73 4-Thrd w/Workclamp Cyl "C" Style **REF#110**
BARBER-COLMAN 16-16 Multicycle, S/N 4520, '75 Dbl Thrd w/Gooseneck Slide **REF#110**
BARBER-COLMAN 16-16 Multicycle, S/N 4631, '79 "C" Style End Brace, 4W Adj Ctr **REF#110**
BARBER-COLMAN AHM (36"), S/N 572, '39 Dbl Thrd **REF#110**
BARBER-COLMAN AHM (36"), S/N 1152, '42 Dbl Thrd **REF#110**
BARBER-COLMAN 16-36, S/N 3613, '59 Sgl Thrd **REF#110**
BARBER-COLMAN 16-36, S/N 4090, '66 Dbl Thrd, "C" Style End Brace **REF#110**
BARBER-COLMAN 16-36 Multicycle, S/N 4232, '68 Dbl Thrd "C" Style End Brace w/Diff **REF#110**
BARBER-COLMAN 16-56, S/N 3136R84, '53 (Reb '84), Dbl Thrd **REF#110**
BARBER-COLMAN 10-20, S/N 6700045890, '76 Dbl Thrd w/2 Cut Cycle **REF#110**

GEAR PINION HOBBERS & SPLINE MILLERS

HECKERT GFL-250X, 2000, New '80s **REF#108**

GEAR HOB & CUTTER SHARPENERS (incl CNC)

ARTER #A-12, 12" Rotary Surface Grinder **REF#108**
BARBER-COLMAN #10-12, Dry Machine **REF#108**
BARBER-COLMAN #4-4, 4" Diam, 4" Long, Yr '51 **REF#108**
BARBER-COLMAN #6-5 & #4-4 **REF#108**
DAVID BROWN #MH-100, 149" Diam, 54" Length, Yr '60 **REF#108**
FELLOWS #6SB, 6" Diam, 3" Long, Yr '60 **REF#108**
HEALD #22, Rotary, 13" Diam, 12" Chuck **REF#108**
KAPP #AS204GT, 10" Diam, New '82 **REF#108**
KLING #AGW-30A, 11" Diam, 16" Length, Yr '62 **REF#108**
KLING #SNC-30, CNC, 12" Diam, 18" Length, Yr '84 **REF#108**
STAR #2 VHS-EZ, 6" Max Hob, New '73 **REF#108**
UTMA #LC-35-NC4, 10" Diam, 10" Length, New **REF#108**
MAAG #WS, 2 Rack Cutter Sharpener **REF#100**
BARBER-COLMAN 10x10 Hob Sharpeners, Qty 2 **REF#101**
BARBER-COLMAN 4x4 Hob Sharpeners, Qty 2 **REF#101**
MIKRON #121, (2.1" Dia), Hob Sharpener **REF#106**
BARBER-COLMAN #2 1/2-2, (2.5" Dia) Straight Flute Hobs **REF#106**
BARBER-COLMAN #3-4/4, Index Plates **REF#106**
BARBER-COLMAN #6-5, (6"Dia, 5" Face), Yr '57-'70 **REF#106**
MIKRON #A62, (6" Dia), Auto Dressing, Coolant **REF#106**
KLINGELNBERG #AGW-230, (10" Dia), Index Plates **REF#106**
KLINGELNBERG #SNC-30, (12" Dia), CNC Hob Sharp, New '84 **REF#106**
KLINGELNBERG #ZS-231, Wheelhd for AGW-232, 230, 231, 301, 421 **REF#106**
FELLOWS #6SB, (6" Dia), Helical, 50° Helix Angle **REF#106**
MAAG #WS/3, Rack-Type **REF#106**
GLEASON #2JST, (6" Dia), Straight Bevel Coniflex **REF#106**
GLEASON #13A, (18" Dia), Bevel **REF#106**
KLINGELNBERG Index Plates and Arbors **REF#106**
STAR #VHS, 6"x6", Coolant System, Vitrified Wheel Grinding **REF#109**
BARBER-COLMAN #6-5, Hydraulic Dresser,12 Index Plate **REF#109**
BARBER-COLMAN 2 1/2 -2, S/N 3, '64 Wet Manual Feed **REF#110**
BARBER-COLMAN 2 1/2 -2, S/N 16, '66 Wet w/Auto Feed **REF#110**
BARBER-COLMAN 6-5, S/N 47R, '53 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 51R, '53 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 110R, '55 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 157, '56 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 264, '62 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 265, '62 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 296, '63 Wet **REF#110**
BARBER-COLMAN 6-5, S/N 392, '66 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 396, '66 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 424, '69 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 6-5, S/N 433, '69 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 4HS, S/N 332, '51 Dry w/Mist System **REF#110**
BARBER-COLMAN 4HS, S/N 381, '52 Dry **REF#110**
BARBER-COLMAN 10-12, S/N 520R82, Wet w/Auto Dress & Sparkout, Fact Reb '82 **REF#110**
BARBER-COLMAN 10-12, S/N 598, '65 Wet w/Auto Dress & Sparkout **REF#110**
BARBER-COLMAN 10-12, S/N 643R83, Wet w/Auto Dress, PC Control, Fact Reb '83

GEAR LAPPERS

GLEASON 503 Hypoid Gear Lapper **REF#102**
GLEASON #503, (10.5" Dia), Hypoid, 90-Degree **REF#106**
OERLIKON SL3 Gear Lapper, 30" Diam, 4.3" Thru Hole, New '83 **REF#108**

GEAR SHAPERS CNC

FELLOWS #10-2 & 10-4, 10" Diam, 2"-4" Face, Rebuilt '03 **REF#108**
FELLOWS 100", 12" Stroke, Retrofitted in '98 **REF#108**
FELLOWS #FS-400-90, 5 Axis, 16" Diam, 4" Face, Yr '90 **REF#108**
FELLOWS #50-8, 51.18" Int/Ext Diam, Yr '03 **REF#108**
LORENZ #LS-180, 4 Axis, 7" Max, New '87 **REF#108**
LIEBH/LORENZ #WSC-1202, 48" Diam, 12" Face, Yr '90 **REF#108**
LORENZ #MCS-60, 9 Axis, 40" Diam, 8" Face, Yr '91 **REF#108**
MITSUBISHI SC-15, 5-Axis, 6" Diam, Pinion Support, New 93/94 **REF#108**
FARREL-SYKES #2A Herringbone Gear Shaper **REF#101**
FELLOWS Type 6 Gear Shapers **REF#101**
LORENZ #MCS-40, (20" Dia), 6" Face, 6 Axis Ret w/Warr, New '90 **REF#106**
LIEBHERR #WS-501, (20" Dia), 5" Face, 5 Axis SIEMENS 840D, New '89/'03 **REF#106**
FELLOWS #50-8, (51" Dia), Sgl Axis NC, 3 Axis PLC, New '76 **REF#106**
MAAG CNC Retrofit Pkgs for Both Crank-Type & Screw Type Machines **REF#106**
FELLOWS #10-4/10-2, Qty 150 **REF#107**
HYDROSTROKE #50-8, Qty 2 **REF#107**
HYDROSTROKE #20-8, Qty 5 **REF#107**
HYDROSTROKE #FS630-125, Qty 1 **REF#107**
HYDROSTROKE #FS400-90, Qty 2 **REF#107**
FELLOWS #20-4, Qty 6 **REF#107**
FELLOWS #48-8Z, Qty 1 **REF#107**

36" Shapers, 14" Throat Risers, 53" of Swing, Qty 3 **REF#107**
FELLOWS #4AVS, 4" Stroke, Spur Guide, Auto Cutter, Riser **REF#109**

GEAR SHAPERS

BARBER-COLMAN #HD-200, 2.75" Stroke, New '84 **REF#108**
FELLOWS FS-630-200, 24" Diam, 8" Face, Yr '95 **REF#108**
FELLOWS #10-2, 10" Diam, 4" Face, Yr '82 **REF#108**
FELLOWS #10-4, 10" Diam, 4" Face, Yr '96 **REF#108**
FELLOWS #120-8, 8" Stroke, Rebuilt '88 **REF#108**
FELLOWS #18-5, 18" Diam, 5" Face, Yr '74 **REF#108**
FELLOWS #185-8, 200" Diam, 9" Face, Yr '98 **REF#108**
FELLOWS #200, 8" Stroke, 200" Diam, Reb '88 **REF#108**
FELLOWS #20-4, 20" Diam, 4" Face, Yr '75 **REF#108**
FELLOWS #3-1, 3" Diam, 1" Face, Yr '62 **REF#108**
FELLOWS #36-6, 36" Diam, 6" Face, Yr '68 **REF#108**
FELLOWS #36-6, 36" Diam, 6" Face, Yr '51-55 **REF#108**
FELLOWS #36-8, 36" Diam, 8" Face, Yr '53 **REF#108**
FELLOWS #36-8Z, 36" Diam, 9.5" Face, Yr '95 **REF#108**
FELLOWS #4AGS/#4GS, 6" Diam, 2" Face, Yr '68 **REF#108**
FELLOWS #50-8, 51.18" Int/Ext Diam, Yr '86 **REF#108**
FELLOWS #6, 15" Diam, 3" Face, Yr '70's **REF#108**
FELLOWS #612A, 18" Diam, 5" Face, Yr '40-60's **REF#108**
FELLOWS #615A, 18" Diam, 5" Face, Yr '40-60's **REF#108**
FELLOWS #645A, 18" Diam, 3" Face, Yr '40 **REF#108**
FELLOWS #645A, Several Available **REF#108**
FELLOWS #6A, Adj Helical, 15" Diam, 3" Face, Yr 70's **REF#108**
FELLOWS #7/7A Face Cutter, 7" Diam **REF#108**
FELLOWS #7/7A, 7" Diam, 1.5" Face, Yr '43 **REF#108**
FELLOWS #712, 7" Diam, 1.5" Face, Yr '48 **REF#108**
FELLOWS #7125 & 7125A, 7" Diam, 1.5" Face, Yr '50's **REF#108**
FELLOWS #72, 7" Diam, 1.5" Face, Yr '48 **REF#108**
FELLOWS #725, 7" Diam, 1.5" Face, Yr '50's **REF#108**
FELLOWS #75, 7" Diam, 1.5" Face, Yr '50's **REF#108**
FELLOWS #8AGS, 8" Diam, 2" Face **REF#108**
FELLOWS #Horiz Z, 6" Stroke, New '50's **REF#108**
MAAG #SH-100K, 47" Diam, 12" Face, Yr '60's **REF#108**
MAAG #SH-180/300, 118" Diam, 17" Face, Yr 60's **REF#108**
MAAG #SH-350/500, Ext Gen/Int Gashing Heads, New '60's **REF#108**
MAAG #SH-75C, 9" Stroke, Yr '65 **REF#108**
MAAG #SH-75K, 9" Stroke **REF#108**
MICHIGAN #18106, 10" Diam, 4.5" Face **REF#108**
TOS #OHA-50A, 20" Diam, 5" Face, Yr '85 **REF#108**
TOS #OHA50A, Auto, 20" x 5", Yr '85 Low Hours **REF#100**
MAAG #SH100, w/JV100 **REF#100**
MAAG #SH75C, Sub Table, Steady, Nice **REF#100**
SLOTER HOV 63 24" Stroke, Dividing Table, Feeds & Rapids **REF#100**
FELLOWS 7125A, 2" Riser, Fresh Rebuild, Full Warranty **REF#103**
TOS #OHA-12A, Shaping Machine, Yr '02 **REF#104**
TOS #OHA-12A, Shaping Machine, Yr '84 **REF#104**
TOS #OHA-50A, Shaping Machine, Yr '86, Reb '03 **REF#104**
MAAG #SH75, Shaping Machine **REF#104**
MAAG #SH180/300, Yr '53, Reb '03 **REF#104**
FELLOWS #3, (3" Dia), Fine Pitch, w/Change Gears **REF#106**
FELLOWS #4AGS, (6" Dia), 2" Riser, 2" Face **REF#106**
FELLOWS #4GS, (6" Dia), 2" Raising Block, 2" Face **REF#106**
FELLOWS #725, (7" Dia), 1.5" Face **REF#106**
FELLOWS #8AGS, (8" Dia), 2" Face **REF#106**
FELLOWS #10-2, (10" Dia), 2" Face **REF#106**
FELLOWS #10-4, (10"Dia) 4"Face **REF#106**
MICHIGAN #18106, (14" Dia), "Shear Speed" **REF#106**
MITSUBISHI #SH-630, (26.8" Dia), 8" Face, 3.2 DP, New '88 **REF#106**
MAAG #SH-75K, (29.5" Dia), Std & DS-75 Cutter-Holders **REF#106**
FELLOWS #36-6 (36" Dia) Cutter-Elevating, 6" Riser, New '69/'70 **REF#106**
FELLOWS #50-8, (51" Dia), "Hydrostroke", 8" Face **REF#106**
MAAG #SH-250/300, (121.3" Dia), 26" Face Width, New '76 **REF#106**
Insert MAAG #SH-180/300K (118" Dia), 17" Face, DW-Swivel Hd **REF#106**
BARBER-COLMAN Model 10, '73 Three Cut Machine **REF#110**
FELLOWS 615A, S/N 22520 **REF#110**
FELLOWS 645A, S/N 20683 **REF#110**
FELLOWS 6A, 2 1/2" Riser **REF#110**
FELLOWS 7125, S/N 23090, '42 **REF#110**
FELLOWS 4GS, S/N 31381-85, '56 **REF#110**
FELLOWS 4GS, S/N 31378-852, '56 **REF#110**
FELLOWS #3, S/N 19268 **REF#110**
FELLOWS 645A3, S/N 20716, '41 **REF#110**
FELLOWS 7125A, S/N 27805, '50 **REF#110**
FELLOWS 6A, S/N 20212, '41 **REF#110**

GEAR DEBURRING/CHAMFERING/POINTING

CROSS #55, Deburrer, 18" Diam, Yr '52 **REF#108**
HURTH #ZK-10, 16" Diam, Yr '60's **REF#108**
HURTH #ZK-5, Twin Spindle Chamfering & Deburrer **REF#108**
REDIN #18, 28" Diam, New '90's **REF#108**
REDIN #24, 25" Diam, Yr '95 **REF#108**
REDIN # 6, 6" Diam, 3" Face, .33 to 14 RPM, 4" Internal **REF#108**
CROSS #75, Chamferer, 10" Diam, New '52 **REF#108**
SAMPUTENSILI #SCT113, 14" Diam, Yr '97 **REF#108**
SAMPUTENSILI #SM2TA, 10" Diam, New '95 **REF#108**
SAMPUTENSILI #SM3TA, 10" Diam, Yr '89 **REF#108**
SAMPUTENSILI #SU-41/370-1, 15" Diam, New '90's **REF#108**
SAMPUTENSILI #SCT-3, 14" Diam, New '82 **REF#108**
SAMPUTENSILI #SCT-3, 14" Diam, New '97 **REF#108**
WERA #DRT-250, CNC Pointer, 9.84" Diam, New '97 **REF#108**
CROSS #75, (10" Dia) **REF#106**
CROSS #65, (10" Dia), 9" Face, 4 DP **REF#106**
SAMPUTENSILI #SCT-3, (13.78" Dia), '97/'98 **REF#106**
WERA #DRT-250, (9.8" Dia), CNC **REF#106**
REDIN #24 (28"Dia) CNC Twin Spindle Deburring Mach, Yr '90 **REF#106**

GEAR HONERS

FASSLER #K-400, 12.6" Diam, 12" Stroke, New '95 **REF#108**
FELLOWS #4 Fine Pitch, 4" Diam, Yr '48 **REF#108**
NAT BROACH #GHH/12, Pneumatic Centers, Crowning **REF#109**

GEAR SHAVERS

RED RING #GF-300, 7 Axis, 12" Diam, Yr '90 **REF#108**
RED RING #GCX-24, 3"-24" Pitch Diam, Yr '74 **REF#108**
RED RING #GCU-8, 8" Diam, Yr '82 **REF#108**
RED RING #GCU-12, 12" Diam, Yr '91 **REF#108**
RED RING #GCY-12, 12" Diam, 6" Stroke, Yr '68 **REF#108**
RED RING #GCY-18, 18" Diam, 6" Stroke, Yr '64 **REF#108**
RED RING Shaver 12" **REF#101**
RED RING #GCY-12, (12" Dia), 9" Cutter-Head **REF#106**
RED RING #GCU-18, (18" Dia), Crowning **REF#106**
RED RING #GCX-24, (24" Dia), 12" Cutter-Head **REF#106**
RED RING #GCJ-36/60, (60" Dia), 12" Cutter-Head **REF#106**
NAT BROACH #GCU12/8, Up-Feed, Pneumatic Ctrs **REF#109**
NAT BROACH #GCY18, 12" Cutter Head, Crowning **REF#109**

GEAR GENERATORS, STRAIGHT BEVEL

GLEASON #104 Coniflex, 8" Cone, Yr '58 **REF#108**
GLEASON #114 Coniflex, 7" Cone, 2.5" Face **REF#108**
GLEASON #12, 12" Cone, 3.5" Face, Yr '50's **REF#108**
GLEASON #14 Coniflex, 12" Cone, 3.5" Face **REF#108**
GLEASON #24A Coniflex, 1.5 DP, 6" Face **REF#108**
GLEASON #37, 26" Cone, 10" Face **REF#108**
GLEASON #54, 38" Cone, 17" Face **REF#108**
MIKRON #120.1 & #132.02, 1.6" Cone, Yr '50-60's **REF#108**
GLEASON #3", (4.45" Dia), 2-Tool w/Segments & Gears **REF#106**
GLEASON #710, (10" Dia), Coniflex **REF#106**
GLEASON #114, (16" Dia), Coniflex **REF#106**

GEAR GENERATORS, SPIRAL BEVEL (HYPOID)

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MARKETPLACE

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At the same time, MHI is striving to diversify its wind power business portfolio including, for example, development and introduction of a 2,000kW unit in April of this year.

MHI intends to reinforce its wind power business in Japan and furthermore extend its business strategy to the European market, the world's largest windmill market, in addition to the U.S., the primary market of its current wind power business.

This significant order is a major business development for MHI and showcases its competitive edge in wind power generation technology. The inclusion of this considerable order brings MHI closer to their next goal of surpassing accumulative sales of 2,000 units.

Mitsubishi Heavy Industries, Ltd., headquartered in Tokyo, is one of the world's leading global heavy machinery manufacturers, with fiscal 2002 (ended March 31, 2003) consolidated sales of 2,593 billion yen (U.S. $21.6 billion). MHI's diverse lineup of products and services encompasses shipbuilding, steel structures, power plants, chemical plants, steel plants, environmental equipment, and machinery for industrial and general use, aircraft, and space rocketry and air-conditioning systems.

For more information, contact Chris Grams at +81-3-5721-2521, or via e-mail at cgrams@golinharris.com. Visit the company's Web site at [www.mhi.co.jp].

BMPTA Fatigue Strength Research Gearing Up

In a press release dated July 16, 2003, the British Mechanical Power Transmission Association (BMPTA) announced a new development program to improve fatigue strength and rating of high-performance gears.

The new research will develop cost effective specifications for heat treatment and shot peening of case carburized and nitrided gears. It will also resolve outstanding issues relating to fatigue strength data given in BS-ISO 6336.

BMPTA says that, most importantly, the research program will follow up previously identified promising techniques for significantly improving bending fatigue strength. The research includes work to quantify the improvements which can be achieved by root grinding, combined with shot peening, on both carburized and nitrided gears, and by vacuum carburizing and superfinishing.

The program will also investigate the fatigue strength at long life, and the influence of oils and oil additives on gear strength.

This collaborative research and development program follows the successful work carried out under the umbrella of BMPTA—formerly the British Gear Association—by 13 companies, as well as the design unit of the University of Newcastle, from 1996 until last year.

BMPTA says that the six years of collaborative research and development have already generated a massive amount of important data for surface and bending fatigue strength and significantly improved the understanding of gear failure.

BMPTA is now actively seeking additional partners for the next phase, and companies with an interest in taking part are invited to contact Andrew Harry at 01283-515521 or andy@bga.org.uk. The organization's Web site is [www.bga.org.uk].

Worcester Gear Accepts CAD, Image Files Online

To provide greater speed and convenience to gear buyers seeking quotations for custom gearing, Worcester Gear has added the ability to accept CAD files and other image files that describe gearing projects to its Web site. The quotation page is at [www.wgear.com/general/quote.asp] and remembers gear buyers' contact information to further quicken the quote submission process.

"We're committed to finding ways to make the process of buying gears as convenient as we can. This Internet initiative seemed a logical decision in that direction," says Mike Vasel, president. "The areas that we feel differentiate Worcester Gear in the marketplace are our commitment to quality, our long-standing reputation for quality, and our emphasis on making gear buying as positive and painless as possible. That's why we make both gears and racks, and it's why we've added field reps in much of the United States—and we'll be adding more. That's also why we've gone ahead and added this measure for gearing buyers who use the Internet."

For more information contact Blaine Senecal, MIS coordinator, at (800) 440-7407, or via e-mail at bsenecal@wgear.com. The company's Web site is [www.wgear.com].

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with Norbert Weiss
Frenco GmbH

Norbert Weiss is a technician in the sales department of Frenco GmbH. He can be reached at 01149-9187-9522-16, or via e-mail at nw@frenco.de. The company's Web site is [www.frenco.com]. Call Jerry Kowalsky at (262) 781-6777, or send e-mail to jerry@eurotechcorp.com. The Euro-Tech Web site is [www.eurotechcorp.com].

GS: Frenco is known worldwide as a premium manufacturer of spline and gear inspection equipment. Could you tell us a little about the company's history?
NW: Frenco was founded in 1978 by Rudolf Och, who is still the company's president, so we've been in business for 25 years now. It was a small shop then, with only five employees, but we now have around 43, and I was the eighth employee to be hired. We've worked primarily with the automotive industry from the start, with customers such as DaimlerChrysler, and probably the biggest step for the company came during its second or third year, when a customer wanted a gauge with an indicator that would allow him to measure the tooth thickness or spaces on the spline. We'd had a design shop from the beginning, so we made it for him, and that was our first patent. We call them the "AVM" and "IVM" gauges, and we now have about five additional patents.

GS: How did you come to be Frenco's eighth employee?
NW: Before joining the company, I was employed by Siemens, working on a lathe machine. When I started with Frenco I was working on the shop floor, on the lathe, milling, and grinding machines. Then I moved into the assembly area, and I later took on the organization of the shop floor before moving into quality assurance. At that point I started taking night classes, with four years of studying technical engineering, and when I graduated I moved into the design department. I then took an additional two years of classes in economics and moved into the sales department, where I've been for the past 10 or so years.

GS: That's a very interesting background, with everything from hands-on experience to classroom training. You know the product inside and out, as well as the market for it.
NW: Yes, and that's especially helpful with one aspect of the work I'm doing now, which involves training customers in all technical aspects of splines. This training is for operators, designers, and people working in quality assurance, and the topics include how to use the inspection equipment, how to read and work with standards, and how to make decisions regarding the acceptance or rejection of parts. I've probably trained nearly 1,000 people at many well-known companies in the U.S. over the last five years.

GS: So you've moved from the student to the teacher. Tell us about these classes.
NW: We do on-site training for customers who have purchased our equipment. They pull together a group of 10 or 15 people, and I travel to their plant so we can use their drawings, their parts, and they can ask questions about their specific problems, which we work together to solve. Sometimes we also rent a hotel conference room in a central location and invite companies that may only have one or two individuals in need of spline training. This is interesting because we can then bring experiences from several different companies into the same room. The sessions usually last about two days, and I spend around 40 or 50 days a year conducting them.

GS: Where are these customers located?
NW: All over the world, but I'm getting more involved with our customers in the United States since our business is growing so rapidly there. I work with Jerry Kowalsky, who is president of the Euro-Tech Corporation, which is our U.S. representative. Over the past decade, our business in the United States has grown every single year, and it now represents about 10 percent of our annual sales, so that's become a major focus for us.

GS: What sets Frenco's product apart from other inspection equipment?
NW: The major difference is that our machines are designed to be used on the shop floor, in the actual manufacturing environment instead of in a separate laboratory, and they can be operated by just about anyone, with a high degree of repeatability and reliability. We also place a great deal of emphasis on working directly with our customers so that we become more of a partner than a vendor.

GS: I understand that you're also heavily involved in developing industry standards, both here and in Germany.
NW: Yes, that's true. Rudolf Och and I help develop DIN standards here in Germany, but we are also members of the German delegation that helps craft ISO and ANSI standards in the United States. We have about six employees at Frenco who also help in this work, and we consider this time—including airline tickets and lodging, which we pay for ourselves—to be a good investment in raising technical knowledge around the world. We are attached to the committees who work in the area of splines, of course, but that's definitely in our interest, because that's what we do. Splines are how we make our living. We want to be competitive in the marketplace, as any business does, but providing technical solutions to our customers and to the industry at large is really much more important for us.


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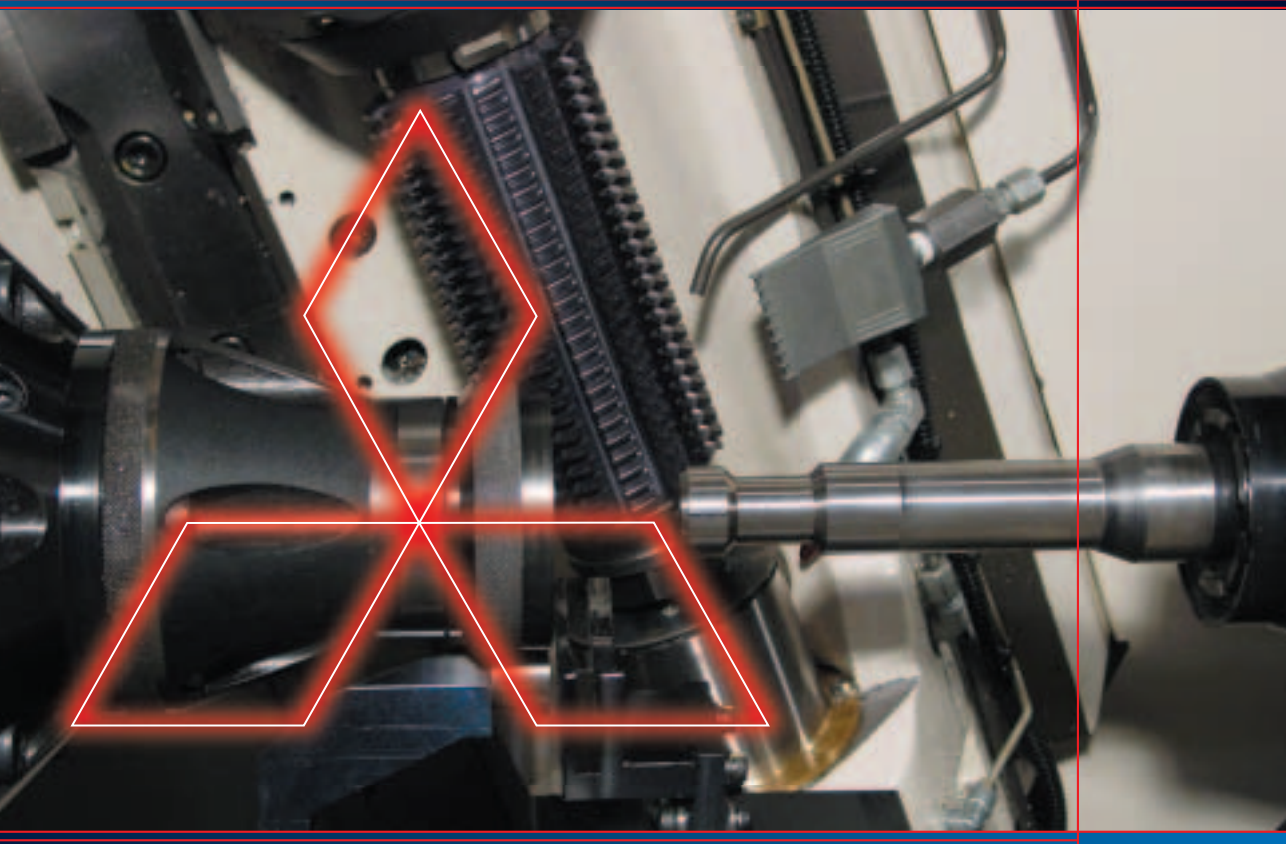

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