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Customer Communication

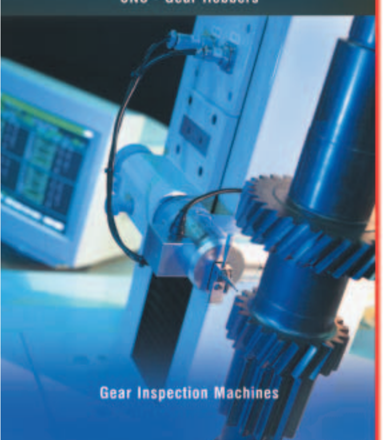
SAFETY MATTERS: Recording Responses

TOOTH TIPS: Re-Cutting Worn Gears

Q&A with Robert Handwerk / RLH & Associates

A MEDIA SOLUTIONS PUBLICATION

APRIL 2004



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GEARSolutions

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

APRIL 2004

A MEDIA SOLUTIONS PUBLICATION

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departments

features

special advertising sections

From the Publisher

Among the many things we enjoy about publishing *Gear Solutions* magazine—learning more about the companies we profile in each issue, and the people who run them in our Q&A section—is the fact that we provide members of the gear-manufacturing industry with the opportunity to share their expertise with their colleagues both here in the United States and beyond. We've published papers from authors who are based at companies around the world, and we mail each issue of the magazine to an international audience, as well—to Germany, England, China, Italy, Japan, India, and Korea, just to name a few.

And that's *every* issue, not just once a year.

Even though this costs us quite a bit in terms of our mailing expenses, we see it as a worthwhile investment, since it helps to foster the worldwide dialogue between professionals representing all aspects of the gear-making industry, and it also promotes our advertiser's products and services in new markets that will help them prosper as we shift into a global economy. That's our promise to you, and one that we plan to keep.

That said, we hope you'll enjoy our editorial lineup for this issue. First we have an article by Hastings Wyman III, an application engineer with the Klingelnberg-Oerlikon Tech Center in Saline, Michigan, and Hartmuth Muller, Ph.D., managing director of research and development for Klingelnberg GmbH, which is based in Huckeswagen, Germany, on their 3F BladeRunner proprietary dry-cutting technology. We're also featuring an article by Sandor Baranyi, president of Trogetec, Inc., on his company's animated CAD solutions for gear and gear-mechanism designs. Also, Riten Industries, Inc., has provided us with a feature on workholding, while Greg Allen's contribution on tool sharpening is sure to make for an interesting read.

Our company profile this month is on Dragon Precision Tools—with background information provided by Greg Allen, president of the Greg Allen Company, the company's sole U.S. representative—and our Q&A features Bob Handwerk, president of RLH Associates. We're also pleased to include an insightful column by guest contributor Ann Pettibone, CEO of Drewco Corporation, Terry McDonald's monthly column on workplace safety issues, which all of our readers have come to anticipate and expect, and another installment of "Tooth Tips," by Donald R. McVittie, P.E.

In closing, I'd like to expand a little more on the philosophy behind our enterprise. We see ourselves as an "all-inclusive" publication, where everyone has a seat at the table. And we pledge to present this valuable information in a format that engages the eye—thanks to our excellent designer, Andy Spain—as well as the mind. We will continue to explore all aspects of this industry in a comprehensive fashion, and we invite all of our readers to contact us with story ideas, press releases, and comments and suggestions about what we're doing right—and could be doing better—in our coverage of this fascinating industry.

So thanks to all of you who have supported our efforts so far, and to everyone else, get involved! We promise you'll be pleased by our reception to your ideas.

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industryNEWS

New Products, Trends and Developments in the Gear-Manufacturing Industry

Mitutoyo Introduces First IP-66 Protected Digital Caliper

In a recent press release, the Mitutoyo America Corporation, of Aurora, Illinois, announced that it has introduced the world's first IP-66 rated digital caliper for use in extremely harsh environments where coolants and moisture are prevalent in the manufacturing process.

The IP-66 rating is the highest level of protection yet seen in a digital caliper. It is sealed against coolants and water up to three feet deep, dust, and chips. This rating allows users to take precise measurements without removing and cleaning the workpiece. It is ideal for use in milling, grinding and lathe operations.

This new caliper also features Mitutoyo's patented "Set 'n Forget" absolute encoder technology that prevents operator error, and the need to reset the zero position each time the caliper is used. The IP-66 caliper is also SPC-capable without compromising its protection rating. Available in 6", 8" and 12" models, the IP-66 caliper has an accuracy of +/-.001" and resolution of .0005".

Mitutoyo America Corporation's nationwide network of M3 Solution Centers and support operations provide application, calibration, service, repair and educational programs for the industry. This ensures that its 6,000+ metrology products will deliver measurement solutions for our customers throughout their lifetime.

For more information call (630) 978-5385, or send e-mail to info@mitutoyo.com. The company's Web site is [www.mitutoyo.com].

Mitutoyo's new IP-66 rated digital caliper is the world's first.

Michigan Automatic Turning Lowers Spline Costs

For a number of manufacturers, Michigan Automatic Turning has been able to reduce spline manufacturing costs by converting hobbed splines into rolled splines. This process reduces the spline manufacturing time by tenfold.

Rolled splines not only offer a tremendous costs savings, they are also significantly stronger. The rolling process increases grain structure density and reduces stress concentrations which will reduce fatigue failure and yield better torque load ratings. Many high-volume shaft applications are being engineered with rolled splines to take advantage of the inherent low cost and strength of this process.

Michigan Automatic Turning is offering spline rolling services for shafts from .375" to 3.625" diameter and up to 50" long. Splines as coarse as 16/32 pitch and 17 teeth can be produced using Michigan Automatic Turnings' spline rolling machines. With both large and small machines, Michigan Automatic Turning has the flexibility to tailor a solution for a wide variety of applications. Spline rolling can be economical on lot runs as small as 500 pieces, or as high as 500,000 pieces.

Accuracy and precision are maintained as Class 6 splines are routinely produced. Rolling can also produce block tooth splines and very accurately aligned splines if necessary. Additionally, a wide variety of special forms can be rolled into shafts.

For more information, contact the company at (810) 227-3520, or send e-mail to sales@michiganautomaticturning.com. Visit online at [www.michiganautomaticturning.com].

AGMA Repeats Wind Turbine Seminar

Due to high demand, the American Gear Manufacturers Association (AGMA) and the National Renewable Energy Laboratory (NREL) are co-hosting a repeat performance of "An Introduction to ANSI/AGMA/AWEA 6006-A03: Design and Specification of Gearboxes for Wind Turbines." While speakers are still to be announced, the specifics of the event are as follows:

Program: "Design and Specification of Gearboxes for Wind Turbines: An Introduction to ANSI/AGMA/AWEA 6006-A03"
Hosts: the American Gear Manufacturers Association (AGMA) and the National Renewable Energy Laboratory (NREL)
Dates: April 26-27, 2004
Location: Omni Interlocken Resort and National Wind Technology Center in Boulder, Colorado

For more information contact Jan Potter, AGMA vice president for membership, at (703) 838-0052, or via e-mail at potter@agma.org. AGMA's Web site is [www.agma.org].

Precision Gear Names New President

In a recent press release, Precision Gear, Inc., of College Point, New York, announced the appointment of M. Briggs Forelli as president. He succeeds Matthew S. Forelli, who will continue to serve as chairman of the board, guiding the company's strategic direction. Briggs has more than 16 years of experience in a variety of successful assignments of increasing responsibility in operations, marketing, and finance.

For more information on Precision Gear call (718) 321-7200, or send e-mail to info@precisiongearinc.com. The company's Web site is [www.precisiongearinc.com].

Magnom Magnetic Filter Technology by Fluid Conditioning Systems

The filtering of contaminants is subject to many problems, not least consumable and environmental costs. And filtering to sub-micron level increases these costs considerably. Or, to be precise, this was the case before Magnom™, which was designed for the grueling Formula One environment.

Using magnetic field technology, Magnom filters can reduce or even eliminate the requirement for consumable filter elements and the associated disposal costs. It achieves this without incurring the age-old problem of pressure drop, even when the filter element is full. This yields incredible benefits: for example, for the first time this allows fine filtration on the suction side of the pump. Even the viscosity of the fluid has little, if any, effect on the performance of Magnom. This is due to the design of the magnetic filter element, in which the flow channels have an area equal to 110 percent of the inlet, giving the filter a flow area greater than the pipe that feeds it, thereby allowing Magnom to be installed at zero risk.

Tom Hulme, chief executive of Fluid Conditioning Systems (FCS), the company formed to take Magnom global, says that "Magnom has proved itself in a wide variety of application areas under diverse operating conditions. The key applications currently are transmission, machine tools, hydraulic, and water and engine filtration, but we are confident that Magnom can improve filtration in any process involving any liquid with an element of ferrous contamination," he says. "We have successfully worked in applications varying from 1 CSt water right up to 8,000 CSt (like thick treacle) open gear lubricant. Existing customers range from a front-running Formula One team right through to global oil companies and power stations."

Fluid Conditioning Systems' Magnon™ Magnetic Filter

As a magnetic filter, Magnom is ideal for applications where ferrous material from build or wear processes is likely to contaminate the lubricating or cooling fluid. Interestingly, FCS was alerted by one of its customers to the fact that 60 percent of the contamination that Magnom removed in their application was non-magnetic. Subsequently, FCS has commissioned a report from the University of Salford to explain this phenomenon, called heterocoagulation.

Magnom's core consists of a series of annular magnets with larger steel plates shrouding them. These plates, which have a series of flow channels running through them, become fully magnetized. When the fluid to be filtered is run through these plates, it is subjected to a high magnetic flux gradient, caused by the focusing of the magnetic field at the tips of the plates. The result is that any contaminant is drawn into collection areas (out of the fluid flow) between the plates. This contaminant is trapped, preventing it from washing off back into the fluid as is the case with magnetic sump plugs, for example. Magnom's filter life is also considerably longer than traditional barrier methods, due to the greater contaminant retention capacity of these plates by volume.

FCS provides advanced fluid conditioning solutions that benefit customers and the environment. It cooperates closely with customers, distributors, suppliers, and universities in a diverse cross-section of applications within the $25 billion global market for filtration services. Located on the University of Warwick's Science Park, in England, FCS heads a network of technical, commercial, and academic expertise to deliver continuous improvements in fluid conditioning.

For more information contact Tom Hulme at +44 (0)1926 623 170, or via e-mail at enquiries@fluidcs.com. The company's Web site is [www.fluidcs.com].

Process Equipment Launches ND430 Next Dimension Gear Measurement System

For more than 50 years, Process Equipment Company has been designing and building special machines. The ND430 Next Dimension® Gear Measurement System is the latest development, moving Process Equipment toward its vision of "nurturing ideas that continually improve the productivity of our world."

The Next Dimension ND430 Gear Measurement System is a CNC Analytical Gear Measurement System that is Windows-based and has a volumetrically mapped measuring zone which allows for high precision actual tooth size measurements and accurate generative measurements throughout the "work zone" of the machine. The ND430 comes equipped with the latest in 3-D scanning technology.

By combining the positive aspects of both generative and coordinate measurement, Process Equipment Company has the solution for relating gear features to other geometric features. The ND430 Next Dimension Gear Measurement System allows for easy inspection of complex parts in a true Microsoft Windows environment. The company also has the capability of capturing digital video of your component inspections to send via e-mail or view across the Web.

In other news, the Process Equipment Company announces that Brian Everson has recently joined its Metrology Systems Division as a software engineer. Everson previously worked at M&M Precision Systems for more than 17 years in various technical capacities with an emphasis on gear metrology software development. He will be joining the Next Dimension Gear Measurement System software development team.

For more information contact Brian Slone, business unit manager of the Metrology Systems Division, at (937) 667-7105. Also go to [www.gearinspection.com], or to the company's main Web site [www.processeq.com].

Green Unikleen by IPAX Cleanogel

Ipax is a pioneer in bringing to the industrial market environmentally safe water-based products which substitute as solvents in parts cleaning applications. Ipax is the only North American company awarded both the U.S. Green Seal and the "Enviromental Choice" Eco-Logo, which is a Canadian certification.

The Green Unikleen product is an all-purpose, water-soluble, human-safe, environmentally friendly, heavy-duty degreaser/ cleaner that is replacing part cleaning and hazardous floor degreasing solvents and acids worldwide. It is a non-toxic, non-flammable, odorless solution that will not irritate the skin, eyes, or lungs. It's used as a general cleaning agent or with steam, spray, or mechanical cleaning devices. Green Unikleen is used in virtually any manufacturing facility in dip tanks to remove grease and lubricants from engine blocks, machine parts, gears, transmission cases, and other metal parts. It can also be used by machine shops for removing lubricating oils, and it will not etch metal or leave a residue. Green Unikleen is environmentally and ecologically compatible and will not contaminate aquifers, streams, rivers, and other water sources.

For more information, contact IPAX Cleanogel at (800) 930-IPAX or (313) 933-4211. Send e-mail to unikleen@aol.com, and visit their Web site at [www.ipax.com].

KOMET Introduces Toolholders for Precision Edge Cutting

Located in Schaumburg, Illinois, KOMET of America has introduced a series of toolholders that enable precise, eccentric adjustment of the cutting edge radii on tools with fixed insert seating. These toolholders feature KOMET's ABS® connection. Easy to adjust, these holders—by means of an integral eccentric sleeve in the ABS connection—allow sensitive setting of both fine boring and solid drilling tools for the purpose of adjusting the diameter. To achieve this, the ABS clamping screw is simply loosened and the eccentric sleeve is adjusted to the correct dimension against the scale. Once the ABS clamping screw has been tightened again, the tool is ready for use.

The precision adjustment provides for incremental graduation equal to 0.02 mm / 0.0008 inch on the diameter and total adjustment +0.25 mm / 0.0098 inch on the diameter. The scale on the tool makes adjustment easy.

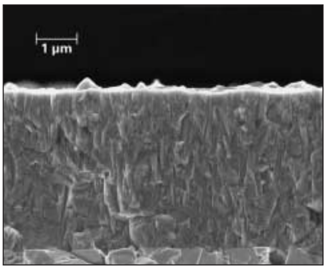
The compact design of the ABS Eccentric Adjusting Holders facilitates its use for both single- and multi-spindle machine tools. The overall dimensions of the ABS eccentric holders are the same as its standard non-adjusting counterpart. This allows you to replace a standard ABS holder with a KOMET eccentric ABS holder without a change in overall dimensions.

Some of the advantages of the ABS eccentric adjusting device include a high degree of static and dynamic rigidity with minimal imbalance, performance at high spindle speeds, and internal coolant supply.

For more information call (847) 923-8400, or send e-mail to marketing@komet.com. The company's Web site is [www.komet.com].

Balzers Presents a New Generation of PVD Coatings

The first TiN coated twist drills by Balzers appeared on the market in 1980. Since then, PVD coatings contribute to the continuous performance improvement of tools in metal and plastic processing. Titanium compounds (TiN, TiCN, TiAlN, AlTiN, etc.) have almost exclusively determined industry standards. Exceptions, among others, are the carbon coatings (WC/C, DLC) developed by Balzers for precision components of vehicles and machines. These also have advantages as coatings for tools used in specific applications.



G6 cross section. AlCrN based coatings are oxidation resistant up to temperatures of 1,100 °C

Balzers has now developed an entirely new generation of coatings that will push tools for metal working to thus far unknown performance limits. This leap forward is made possible by AlCrN based coatings which clearly exceed the performance of titanium based coatings. After intensive development efforts, Balzers is the first and only company to produce AlCrN based coatings that meet all requirements of successful practical application. The corresponding patent is pending.

G6, the new generation of AlCrN based coatings, is characterised by substantially greater wear resistance. In systematic test series, considerably longer service life was demonstrated in comparison with currently available coatings. AlCrN based coatings are more oxidation resistant and have a markedly greater hot hardness than conventional coatings. This means they are stable even under extremely high thermal load and generally perform better.

Performance limits are clearly increased when AlCrN coated tools are used for milling (up to 55 HRC). For example, when finishing Ck45 steel at cutting speeds of both 200 m/min and 400 m/min, AlCrN coated milling cutters attained a substantially longer service life than TiCN and TiAlN coated cutters.

These tests were carried out in a newly established machining lab that makes it possible for Balzers to proceed immediately to the testing of coated tools under real-life conditions and use the results to advance development efficiently and with well-defined objectives.

On the basis of the G6 coating generation, the development of BALINIT® coatings is directed specifically toward applications that allow the coating and re-coating of both carbide and HSS tools. The first G6 BALINIT® coating by Balzers offers great promise.

For more information contact Torsten Doering, marketing director, at (716) 564-8557 ext. 1110, or via e-mail at torsten.doering@balzers.com. The company's Web site is [www.balzers.com].

Baldor's BE$T Software Wins Magazine Awards

It has been announced that Baldor's energy saving software, BE$T, has won two awards from industrial magazines: *Plant Services*, circulated to more than 110,000 plant and maintenance engineers, and *Processing*, which reaches some 100,000 engineers in processing industries. *Plant Services* voted BE$T their "Product of the Year Gold Award," and *Processing* labeled BE$T its "Breakthrough Product of the Year." Both magazines are published by Putman Publishing Co., which is located in Itasca, Illinois.

BE$T software easily and accurately calculates a motor's annual electricity usage based on its nominal efficiency—versus the annual electricity usage of Baldor Standard-E® and Super-E® premium efficiency motors. It then recommends, by catalog number, the best Baldor motor for the application and notes the payback period, in months, for replacing the existing motor. BE$T also calculates savings for a group of motors and creates a report showing the savings when all motors in the group are changed to Baldor Standard-E or Super-E designs. BE$T can also calculate and compare annual electric savings when an adjustable speed drive is used. BE$T is available on its own CD-ROM and is also part of Baldor's CD-ROM, version 8.0. For a copy of BE$T call (800)828-4920.

Baldor also has also introduced a new line of coupling guards made of rugged, high-impact molded polyethylene. These are available from stock in either safety orange or washdown white. There is some overlap between sizes to accommodate a larger coupling. Size 5 covers NEMA 48 through 215T frames, size 15 covers NEMA 184T through 286T frames, and size 25 covers NEMA 284T through 449T frames. These guards comply with OSHA, ASME, and ANSI standards. Risers are available to raise the coupling to the correct level on installations where the motor and pump are mounted to pads above the floor. Stainless or painted versions of the risers are in stock. Baldor's new, easy to install coupling guards are ideal for harsh environments, virtually eliminate all guard maintenance and allow you to save more than 50 percent over custom alternatives.

For more information contact your local Baldor representative, or visit the company's Web site at [www.baldor.com].

Fairfield Appoints Vice President of Quality and Process Improvement

In a recent press release the Fairfield Manufacturing Company, Inc., announced the appointment of Dan Phebus as vice president of quality and process improvement. Phebus joins Fairfield after serving as vice president of sales for Carraro North America, Inc. In total, he has more than 20 years of experience in the power transmission and specialized component industries, and he has served in senior engineering, sales, and quality roles throughout his career. He holds an MBA from Indiana University and a bachelor's degree from Rose-Hulman.

In accepting his position, Phebus says that "Fairfield Manufacturing has made remarkable progress in exceeding the quality expectations of our customers through process improvement. I am looking forward to building upon this foundation, and I am very proud to be a part of this management team."

Gary Lehman, president and CEO, adds that "We are very pleased to have Dan as a member of our team. His technical background and management experience will prove an invaluable asset as we continue to make significant advancements in our business."

Fairfield Manufacturing is the world's largest independent designer and manufacturer of custom gears, custom gear sets, power transmission assemblies, and the world-renowned line of Torque-Hub® planetary drives.

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

Drake Names Vosmik President and COO

An innovator in CNC grinding systems, Drake Manufacturing has named James L. Vosmik as president and chief operating officer.

Vosmik comes to Drake from Precision Threading Corp., where he served as its president with responsibility for day-to-day operations. During his nine-year career at PTC, he managed the company's transition from an old-line, product-oriented company into a modern, customer-centered provider of highly engineered threading solutions. In the process, he developed an extensive knowledge of grinding, machining, and measuring threads, as well as advanced manufacturing processes.

"Our customers will benefit from Jim's manufacturing experience," says John Drake, the company's CEO. "He knows the pressures facing manufacturing today, and he has innovative ideas that will help our customers. We expect him to build on our reputation for quality, service, and delivery."

Drake Manufacturing designs, builds, and services state-of-the-art precision CNC grinding and gear hobbing machines that help maximize productivity, improve quality, and reduce production costs for a wide variety of demanding applications.

For more information contact Leigh Girard at (330) 847-7291. The company's Web site is [www.drakemfg.com].

Nachi Names New Southeastern Regional Sales Manager

In a recent press release, Nachi Machining Technology Co. announced the appointment of David Petrimoulx to the position of regional sales manager of the Southeastern United States. He relocated to Charlotte, North Carolina, in February and will be responsible for all sales in North and South Carolina, Georgia, Florida, parts of Tennessee, and Virginia.

Petrimoulx has been with Nachi for 25 years. He began his career as a machine operator and broach grinder. He received a degree in electronic engineering technology and has held the positions of service engineer and CNC programmer in the Industrial Engineering Department, broach and forming rack designer in the Engineering Department, manufacturing supervisor, and product manager for broaches and forming racks in the Sales and Marketing Department. Most recently Petrimoulx has been manager of the Forming Rack Division.

continued on page 54 >>

terryMcDONALD

Member of the ANSI Subcommittee on Gear Safety

SAFETY MATTERS

When you're implementing your safety plan, document your procedures. When an injury occurs, document your response. And when you're considering your operation's procedures, view them all with an eye toward safety.

Last month we discussed data retrieval in this column. I thought it might help if we discussed what the courts would be looking for in the circumstance that we would have to defend our company in a safety-related suit. I sincerely hope that none of you ever have to defend yourselves in such a lawsuit, but you must be prepared just in case. Of course, this discussion can't cover all the possible things a plaintiff's attorney may request via discovery, but certain records must be kept, and kept current.

As a gear manufacturing facility, we must keep a complete and accurate record of any and all injuries that occur during any employee's working hours. Just as important is keeping the same records for any injuries occurring to visitors to our facilities. These records must, at a minimum, include the date and time of the injury, a very complete description of the injury, the steps taken for treatment of the injury, the results of the injury, a formal review of the cause of the injury, and the steps taken to prevent similar injuries in the future, as well as a review of safety procedures that were in place prior to the injury. This sounds like a lot of record keeping, but a simple database setup will enable you to enter and retain this information very easily.

One of the most important documents you can keep in each employee's file is verification that they've received and had the opportunity to read your company's safety handbook. This can be a separate document, or part of the handbook. If you haven't created such a document, it should be at the top of your priority list to do so. This document alone can save your company in the event of a lawsuit. It's also suggested that you maintain a file containing all of the operating instructions and safety documents furnished with each of your machines. Your employee handbook should include instructions that the employee should read and understand prior to operating the machine. If you're not the first owner of the machine—as is the case with many of us—it is important that you obtain at least a copy of the original documentation for your machine. This will be valuable in the case of a lawsuit.

Two of the topics the magazine is covering this month are "tooling/workholding" and "tool sharpening." I have already discussed some of the safety issues with tool sharpening in previous columns, but it doesn't hurt to review the issues.

> "One of the most important documents you can keep in each employee's file is verification that they've received and had the opportunity to read your company's safety handbook—this should be at the top of your priority list."

Tools are sharp. That is what we accomplish by sharpening them and, as such, they must be handled with respect. Make sure that all of your employees are aware of the hazards and properly trained in the handling of sharpened tools.

Tools are dull… a contradiction? No, just a fact. When tools are dull, they not only impact production, they present a very different safety hazard. When a tool is dull, it can create a greater amount of heat in the part being cut, as well as in the cutter itself. This heat can actually cause burns during the unloading process, or the tool-changing process. A dull tool also creates a different chip form that causes problems such as cuts when cleaning the parts, or the machine. Of course, a worse-case scenario is that the hob gets so hot that it breaks apart under the cutting forces and throws pieces that can cause serious injury, or even death. Training your employees to recognize a dull tool before it becomes a hazard is the solution.

The major safety hazard concerning tooling/workholding is when it's not sufficiently designed to do the job. If the blanks are not held securely, they can be thrown by the cutting pressure and, again, cause serious injury or death. Many of us are small operations that must adapt our tooling/workholding to a great number of parts. This can lead to dangerous conditions, and the articles that are included this month should be helpful—so read them with an eye toward safety.

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.

donaldr.McVITTIE P.E.

President of Gear Engineers, Inc.

TOOTH TIPS

Information you can use to prevent problems and prolong gear life.

When gears are worn, they lose their accuracy. Like an engine camshaft, gears need a smooth, accurate shape to carry their load. When the correct profile is lost to wear, the mating gear tends to bounce on the pits and rough spots, increasing the load and speeding up the wear process. The only cure is to get the gear back to its original accuracy.

If the gears aren't too badly worn, they can be re-cut to clean up the damage, leaving a fresh, accurate surface. This also produces increased backlash, but that can often be tolerated, particularly if the drive doesn't see load reversals in service.

If backlash must be controlled, it's often possible to re-cut the gear and make a new, thicker pinion to mate with the thinner gear at the same center distance and the original backlash. These oversize pinions are actually stronger than the originals and, in most cases, improve the capacity of the gear set.

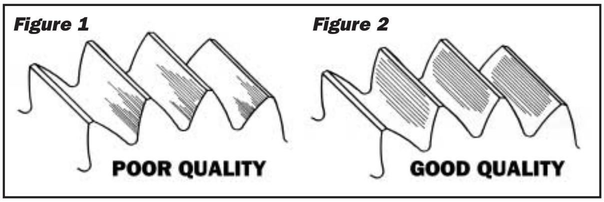
The cost of this repair is much less than replacing both gears, and the results are really better than the original.

Sometimes the use of oversize pinions should be avoided. When the pinion is driven by the gear, an oversize pinion requires careful profile modification to maintain good lubrication conditions. This is one of the "finer points" of gear design, and it should be approached with caution. As long as the pinion is the driving member, the oversize pinion design is easy, and highly recommended.

On a related note, what is gear quality? Think of each gear tooth as a cam, like those on an engine camshaft. They must be accurately spaced so that each is in the right place to pick up the load when the previous tooth rolls off its mate. That's a good picture of what happens 40,000 times a minute in a typical industrial input gear set. If those cams are the wrong shape or out of place by just .001", impact loads are added and gear life is shortened.

If the teeth aren't exactly parallel, the load is carried at one end, rather than across the whole face width. The overload at the high spots causes premature gear failure, either by pitting or tooth breakage.

The contact patterns in Figure 1 show all of these defects: overload at the ends (lead or helix error); non-uniform load from tip to root (profile or form error); and variation from tooth to tooth (spacing or index error). Figure 2 shows ideal contact, with the same centralized pattern on each tooth.



The AGMA classification system for gear quality has tolerances for tooth spacing, profile variation, and lead (tooth alignment or helix angle) variation, all organized by tooth size, gear size, and "quality number" (they run from five to 15, which are the best—and the most difficult—to make). There is an appropriate quality for every application, depending on speed, acceptable noise, reliability, and cost. Typical examples would be:

- Auto transmission: Q12
- Machine tool: Q10-12
- Paving machine: Q7
- Agricultural machines: Q7
- Industrial gearing: Q8-10

Here are some suggestions by pitch line speed (pitch diameter x 3.14 x RPM/12):

- 500 ft/min: Q7
- 1,000: Q8
- 2,000: Q9
- 4,000: Q10
- 7,000: Q11

Accurate gears carry more load than inaccurate ones, because the contact covers a larger portion of the gear teeth.

Using the AGMA system requires testing machines that are usually found in a gear shop, but not common elsewhere. A reasonable substitute for exact quality measurement is contact checking: examination of the pattern left when gears polish in, or the pattern made in marking compound as the gears are rolled together in the gear box or on true bench centers.

ABOUT THE AUTHOR:

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MARRIAGE, WAR, AND GEAR HOLDING

by Ann Pettibone: CEO, Drewco Corporation

How to get the best results when purchasing workholding fixtures for gear manufacturing.

Just as it is with most things in life—including marriage and military operations—both clear communications and the collection of the right information are essential to getting maximum results.

To create a perfect union between our company and our customers, and to fight the good fight to produce highly effective gear-holding tooling, Drewco has developed a series of information gathering questions. As the designers and manufacturer of workholding fixtures for 56 years, we have found that the process of asking these questions produces a project definition "funnel effect" that, in turn, creates a highly successful end product.

Each section of questions helps clarify the project in a different way. They facilitate the process of taking our initial conversation with a customer—which often starts out simply with "I need a fixture"—to the end result of creating a tool that meets all the needs of our customer, and also gives them even more than they expected in terms of performance and flexibility.

The initial questions help us give a new customer a ballpark cost estimate, so that they can see if the project they're considering fits their budgetary requirements. They also address one of the most important aspects of gear holding, which is rigidity. Having the correct information from the "machinery specifications" questions (i.e. cutting tool size, or hob size, etc.) is essential to creating the proper rigidity required for high-quality gear cutting. Furthermore, how a company approaches fixture design in the initial stages defines the flexibility and future utilization of the tooling (see *Gear Solutions* July 2003: "Custom Solutions for Workholding Challenges"). By carefully discussing the information customers provide in the "process overview" section, we can often suggest ways they can utilize the same tooling for more than one operation: e.g. both rough and finished runs. This information also lets us discover whether we can design tooling to cover a larger range of part sizes. Designing "up front" can save both project dollars and production costs.

In addition, making sure your workholding supplier asks you these questions, and that you answer them fully, will ensure that everyone is on the same page about the project's size, costs, delivery, and expected performance.

Production Requirements

What are your run quantity requirements? What operations are being performed (i.e. hard turn, hobbing, grinding, shaping)? What surfaces are being machined? Will the gears be automatically or manually loaded? How many gears per fixture do you want to run? Do you plan to cut dry or wet?

Form and Function

Are you manufacturing a new gear, or refixturing one you already produce? If it is an existing gear what improvements would you like to see? Will this be a dedicated fixture or a change over fixture? If there is a change over, how many are there and how often?

Gear Specifics

What class of gear do you want to hold (AGMA standards)? Are there other required tolerances? What's most important, and what are your project's most critical aspects (e.g. run-out requirements, concentricity requirements, surface finish requirements)?

Whole Process Overview

What is the planned sequence of operations? Where in that process is the fixturing being used, green, finished? What is the range of tolerance being presented (really)?

Sometimes the part print we are using for design purposes may call out + or -.005, when a cast part, for example, may in reality be +or- .020. Your workholding supplier can work with this range, but to get the best fixture the first time, the actual part tolerance is important. If it is a rough or cast part are there parting lines?

Machine Specifications

Working envelope? What is the cutting tool /hob size? Are there any other clearance issues? Type of actuation? Is there a drawbar? What does the drawbar connection look like? Is there a spindle? What does the spindle connection look like? What is the tailstock stroke? What is the hob or grinding wheel diameter? Machine table-mounting data ?

Whether you're rallying your forces to win a production war with a hard-to-hold gear family, looking to enhance the marriage of your tooling to your part, or improve your working relationship with your current tooling supplier, utilizing this checklist will deliver optimal results.

ABOUT THE AUTHOR:

Ann Pettibone is CEO of the Drewco Corporation. She can be contacted at (262) 886-5050, or via e-mail at ann@drewco.com. The company's Web site is [www.drewco.com].

Dragon
Precision Tools Co., LTD

As the world grows smaller each year, via the Internet and highly efficient delivery systems, acquiring quality products is no longer subject to geographical proximity.

by Russ Willcutt

Nearly three decades ago, in 1976, a man by the name of Yong Bae, Chun decided to start a company of his own. He wanted to call it the Dragon Precision Tools Co., in part because his name, "Yong," literally translates to the word "dragon."

Chun had made his start in the gear business. At that time, South Korea was well on its way to becoming an industrial force in the Pacific Rim, and the automotive, heavy equipment, and machine-tool industries were just beginning to emerge. Chun recognized that the potential for growth was enormous, with one of the world's most productive workforces to rely on as employees.

Over the years, however, he'd grown frustrated by the lack of a domestic supplier of quality gear-cutting tools to support South Korea's gear industry. He had a hunch that a man who could start a company making his own hobs would do well, and his instincts were right on the mark. As South Korea's gear industry flourished, so did the fortunes of Dragon Cutting Tools. As president, Chun's main focus turned to the manufacturing of gear hobs and gear milling cutters that would not only satisfy South Korea's requirements, but would also become a premier source for gear-cutting manufacturers around the world.

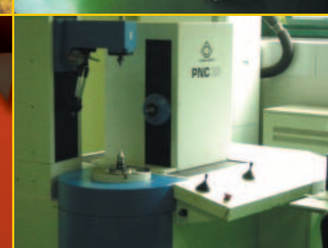
As Dragon's sole representative in the United States, Canada, and Mexico, Greg Allen—president and founder of the Greg Allen Co.—has gotten to know the company, and its founder, very well. "I get to the plant at least twice a year, and every time I visit I'm impressed by the culture of continuous improvement that permeates every aspect of their organization," he says. "Producing the highest-quality gear tools in the world is their primary mission, which translates into a faithful customer base made up of the most demanding consumers in the world."

This corporate culture is fueled by a significant investment in machinery and technology, Allen goes on to say. "Late last year they moved into a newly constructed, four-story, 3,300-plus square meter manufacturing and administration facility. All the manufacturing, up to and including five heat-treat furnaces, is being performed in the original facility, which is right next door."

The building is as state-of-the-art as the equipment it houses, which includes 10 CNC hob profile grinding machines, eight of which are Reishauer RG 500 and RG 1000 series, with two new units soon to be delivered. In addition, there are seven CNC Klingelnberg hob flute sharpeners that feed them, "and every hob is certified by one of three Klingelnberg CNC PNC series hob/gear inspection machines," Allen says. "One of the first installations in the new building was a PVD coating machine manufactured by Cemecon, which increased their coating capacity to three machines. The formal dedication of the new plant will take place later this year, which I'm really looking forward to. Dragon also has sales offices in Nagoya and Osaka, Japan, representatives in Europe and Asia, and through our distribution here in Cleveland, Ohio."

At present, Dragon's largest customers include Hyundai, Kia, Daewoo, and General Motors. As the only domestic supplier to be found in South Korea, the company supplies virtually all segments of the gear industry, which includes agriculture, heavy equipment, aircraft, and commercial gearing. Dragon's mix of equipment enables it to manufacture hobs of the highest quality for all segments of the parallel axis gear market.

Allen—who began representing the company after a meeting with Chun at the IMTS show in 2000—says that his customers have reacted "extremely well" to the company's product line. "It's been a rewarding challenge introducing a company of Dragon's caliber to a market as sophisticated as the gear industry," he says. "Once we inform the marketplace of our capabilities, though, we definitely get their attention.



"When a customer gives us their first order, it's usually because they're impressed by our capabilities, our quality, and our competitive prices. But it's the second order that's most telling," says Allen. "That second order speaks volumes, because it tells us that the customer has confidence in us that's based on hard data. Once we're given an opportunity, any concern the customer may have had about the tools coming from a far away place is eliminated. And today, no place is that far away, really. I talk to Youn Yong Chun," who is the founder's son, and the company's vice president of sales, "almost every day, and our design drawings are transmitted electronically so that quotes are done within hours of the inquiry. And when a customer recognizes the value of global sourcing, they can also compete on global terms."

Although Dragon's success stories are many, one in particular stands out in Allen's mind. "We're selling hobs to a U.S. auto manufacturer, and our hobs ran as good as any that they've ever used. The parts produced were well within the tolerance band. In the past, this company had re-sharpened and re-coated its hobs after a set number of parts had been manufactured, but we decided to try something different," he says. "We decided to skip that process for a cycle, and we ran the hobs double the amount of parts per sharpening—something that hasn't been done with much success before."

Upon magnification of the hob tooth, it was determined that the wear incurred was no greater than what the former hobs had shown after a single cycle. "Does that mean our hobs always last twice as long as another manufacturer's? No, not necessarily," says Allen. "But it does speak to a level of higher performance, and that's where you'll find the true value in a tool."

From the start, Dragon's main objective has been that quality simply cannot be compromised, and the company has built—and continues building—its reputation based on that initiative. "Dragon makes a tremendous investment in the tools and technologies it utilizes to manufacture the best product it possibly can," says Allen. "Not all of our customers realize what's going on behind the scenes to make sure the tools they purchase are of such a high quality, but the closer people look at us, the more they realize that they're getting a superior product. And the word is really getting out!"

For more information on Dragon Precision Tools, go to [www.dragon.co.kr]. To contact the Greg Allen Company, call (440) 331-0038, or send e-mail to sales@gallenco.com. The company's Web site is [www.gallenco.com].

IS IN-HOUSE HOB SHARPENING AN ADVANTAGE, OR JUST DOLLARS UP THE DUST COLLECTOR?

READ ON TO LEARN MORE.

METHODS OF HOB MAINTENANCE

by Greg Allen

Deciding on the benefits of in-house hob sharpening depends on a number of factors that gear manufacturers are faced with when determining the allocation of resources to indirect labor dollars. A well-run hob sharpening facility can be a significant advantage to a gear manufacturer. However, as overhead costs are constantly under the microscope in lean manufacturing environments, the trend to outsource hob sharpening has been on the rise. Perishable tooling costs as a line item stand out on a financial statement in many gear-manufacturing plants. Hobs and their maintenance typically are a substantial part of that number. Gear manufacturers spend considerable time and effort in the procurement of hobs that are best suited for an application. But the dollars invested on quality gear hobs can be squandered with the first sharpening. A class AA finisher can be transformed to a class D rougher by poor sharpening practices. Without proper inspection procedures and controls, that same hob will produce gears that reflect the quality of a class D roughing hob. Shop managers who may not be paying attention to their hob sharpening department could be missing an opportunity for significant cost savings.

In many gear shops, I find that the tool sharpening departments are not on the same level as the gear manufacturing departments, in terms of the vintage and condition of the equipment. Like any machine tool, old does not mean bad, as long as it is maintained. There are many pre-CNC machines in use and in the marketplace that are capable of sharpening class AA hobs. Care must be taken to insure index plates are in tolerance, in addition to the standard wear areas on any grinder. Some vintage machines still operating today were not equipped for wet grinding. These machines were built when HSS M2 was the staple grade. Dry grinding is not recommended for today's high-speed steel grades. If you have one of these machines, consider upgrading or modifying it to accommodate coolant.

The high-speed steel grades available today, bridge materials and carbide grades for hobs, demand more out of the hob sharpening machine and require skilled operators. Today's CNC hob sharpeners are designed to grind these materials efficiently and as accurately as any hob manufacturer. Non-CNC machines are capable of achieving these standards as well, coupled with a well-maintained machine and a skilled operator. If you sharpen hobs in-house, you also need to inspect the hobs after sharpening. The dimensions to be qualified include the following:

- Spacing between adjacent and non-adjacent flutes (index)
- Cutting faces radial to cutting depth (rake)
- Flute lead, straight and helical
- RMS finish of cutting face
- Micro burr, for hobs to be coated (edge preparation)

The dimensional tolerances are based on the class of hob being sharpened and are available from the supplier, or from AGMA. Adherence to the sharpening tolerance has a direct effect on the tools' performance and the quality of your gear. Hobs are designed to generate a given profile throughout the life of the tool. Deviating from the hob sharpening tolerances will effect one or several features on the generated gear tooth. Hobs should be inspected before and after hob sharpening. The pre-sharpening inspection should include a measurement of the amount of wear to be sharpened. This may seem quite fundamental; however, I have witnessed a number of sharpening departments where it is acceptable to sharpen an excessive set amount of stock off, regardless of how much is required to be removed. This practice likely wastes valuable tool life and is good for the hob manufacturing business! It does not take much time for an experienced operator to predetermine the amount of hob wear to be removed—a keen eye aided with magnification may be all that is necessary.

During the sharpening process, care must be taken to take the correct amount of stock off with an adequate number of passes to sharpen the hob fully without generating excessive heat. As with any cutting tool sharpening, excessive heat can cause burrs, edge burn, reduction in Rc, hardness, and cracks, which can diminish or eliminate a tool's life. The grind ability of HSS has increased by the use of PM materials over wrought steels. However, the high performance grades and coatings have somewhat offset that advantage. The correct grinding wheel needs to be determined based on the material being sharpened. An abrasive specialist should be consulted if your present wheels have not been upgraded along with your current hob raw material.

Relatively inexpensive inspection equipment is available to check all of the aforementioned dimensional features to qualify the hob once sharpened. Manual inspection bench gages are configured to verify lead, index, and rake angle. Many CNC gear-checking machines have hob-inspection software packages to accomplish this inspection as well.

Another factor is coatings. Many hob users have found it advantageous to re-coat hobs with each sharpening. Since this practice has increased, much has been learned, and more questions are being raised about the nuances of sharpening and re-coating. The better the ground finish of a cutting tool, the more performance can be expected out of the coating. This is true on the re-sharpened face as well, and care should be taken to duplicate the finish as closely as possible to the hob's original finish. Sharpened hobs have a micro-burr on the periphery of the hob teeth. Correct adaptation of a grinding wheel to the hob material can reduce the burr. The mass of the micro-burr varies, but whatever the mass, it needs to be removed prior to coating. This procedure of edge preparation is also known as "edge prep." Edge preparation is done by a variety of methods, which include wire brush, vapor honing, glass bead blast and/or elbow grease. Failure to "edge prep" prior to coating results in the coating of the micro-burr, and when engaged in the work piece the flimsy coated burr will break off, exposing the substrate material. The result is pre-mature tool wear, due to the exposed area.

In order to gain the advantage of re-coating it has been determined that certain PVD coatings need to be stripped prior to applying a new coating layer. However, depending on the coating type, it may not be necessary to strip every time between sharpening and re-coats. Care should be taken when stripping bridge materials, since the process has been known to degrade the substrate material.

The benefits of tool coatings are well known. In addition, re-coating between sharpening can be just as beneficial. However, the end user should be aware of additional process requirements impacting sharpening, edge preparation, and stripping of the cutting tool. When ascertaining the effectiveness of your hob sharpening facility, consider the following:

- Is your sharpening equipment capable of maintaining the required quality level?

- Are your tooling and grinding wheels up to date with today's hob materials?
- Do the sharpening personnel possess the required skills?
- Can you verify the quality level you can produce?
- Is the amount of tool wear documented?
- Is the amount of stock removal predetermined?
- Do you re-coat? If so, do you edge prep?
- What is your sharpening facility really costing?
- Are your re-sharpened tools performing as good as new?

A good way of assessing your hob-sharpening capability is to send one out to a hob-sharpening facility for analysis after sharpening. Many firms have made an analysis of their capabilities and determined a cost effective alternative is to outsource hob sharpening, which includes much more than sharpening. It is really outsourcing tool management, which can monitor, prolong, and manage tool life. Companies dedicated to hob sharpening typically put as much expertise and dedication into hob sharpening as their customers put into manufacturing gears. A relationship with an outside sharpener requires clear communication channels, rapid turnaround, and uncompromising quality. A qualified commercial hob sharpener, or your in-house tool room, should be able to answer "yes" to all of the questions listed above.

Hobs and hob maintenance are major items in perishable tooling costs for gear manufacturers. The higher the cost, the more opportunity one has to implement cost savings. A critical review of your hob-sharpening facility may uncover a significant cost-savings opportunity. Whether you improve your in-house capability or look to the outside, your bottom-line will look a lot better for it.

ABOUT THE AUTHOR:

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BladeRunner 3F

by Hartmuth Müller, Ph.D.
and Hastings Wyman III

The new three-face grinding blade design for dry cutting spiral bevel gears guarantees higher process capability, shorter handling sequences, and longer part runs.

In the past five years, dry-cutting technology has steadily moved to dominate production of automotive hypoid gearsets in the United States, while a parallel trend has occurred in Europe. The significant difference between wet cutting with high-speed steel and carbide cutting is higher productivity, better quality, increased ecological friendliness, and lower total cost of production.

A simple substitution of a high-speed steel blade with carbide will show the same shape of the flank, but the potential of dry cutting using carbide blades is not used. A protective coating of the carbide blades is mandatory. Normally, the protective coating consists of a Titan-Aluminum-Nitride-base and prevents thermal penetration into the outer layer of the carbide. This coating is critical to the dry-cutting process: without it, the underlying K-grade carbide substrate wears after only a few pieces.

Blade Geometry: An Introduction

Besides coating the blades, the cutting process itself needs to be taken into account. When chips are created, two technological angles are important: the rake angle, and the relief angle. In figure 1 the influence of the rake angle can be seen.

The arrow in this figure indicates the actual cutting direction. The angle between this direction and the front side of the blade is the rake angle. The higher the rake angle, the less the chips are bent. The smaller the rake angle, the chips are more bent, and more thermal energy is inducted into the blade. The obvious fact is very important: after every pass through the gap, the chips need to leave the cutter head. If there is enough space between following blades, the shape of the chips is not very important.

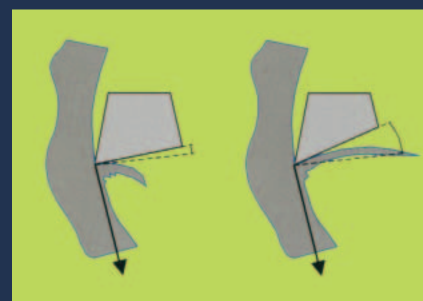


Figure 1 — Rake angle and shape of the chips

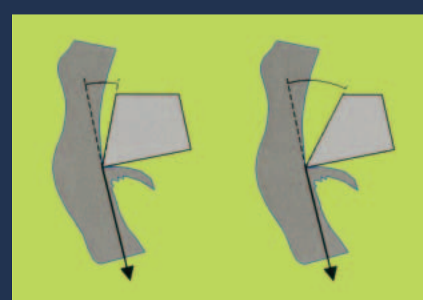


Figure 2 — Different relief angles

In the case of a cutter head with a high number of blades, the room in between is limited. If single chips do not fall down, they will be scratched through the next gap, damaging the cutting edge of this blade. If the cutting edge loses its sharpness, more thermal energy is induced, which decreases the tool life. The other technological angle is the relief angle, shown in figure 2.

Compared to the rake angle, the relief angle doesn't effect the shape of the chips. But it can be seen that the thermal energy induced into the cutting edge is better transported to the center of the blade when the relief angle is small. If the relief angle is too small, the relief side will slide on the flank of the gear. If the relief angle is high, we have a locally high temperature on the cutting edge. Depending on the shape of the gear's flank, a minimal angle between rake face and relief side can be calculated.

The relief angle is not allowed to be smaller than this minimum. Because of thermal aspects, the tool life is very sensitive to the relief angle. Another effect is based on a chemical aspect. Since there is an affinity between carbide and steel, the surface of the carbide is attacked and changes its chemical characteristics during the cutting process.


Two-face grinding blade

In the case of a high relief angle, the contact zone is small, and the carbide is not much attacked. But now the temperature flow into the blade is limited. Using a small relief angle will transport the heat away from the cutting edge faster, but the contact zone of the carbide blade and the gear flank is bigger, attacking the carbide material to a greater degree.


Three-face grinding blade

Besides affinity, another physical effect is important. The more peaked the cutting edge, the less friction we have when making chips. This can only be achieved by increasing the sum of face angle and relief angle. But this advantage has the side effect of reducing the blade rigidity and of a slower transportation of thermal energy from the cutting edge into the carbide blade. There are several effects in the cutting process influenced by the technological geometry of the blade. Since the geometry of the gear is only given by the shape of cutting edge and not by the technological geometry of the blade, it is mandatory to optimize the rake and relief planes of the carbide blade.

Two-Face Grinding and Three-Face Grinding Blades

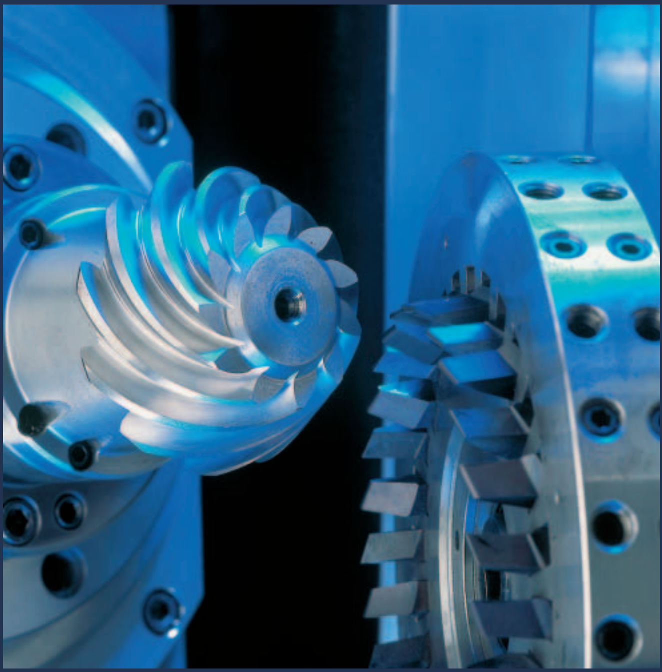
The geometry of a 2F blade and a 3F blade initially appears quite similar. Both have a front rake face, a cutting (pressure angle) flank, and a clearance (non-cutting side) flank. But in a 2F blade, the entire front rake face is pre-ground into the shaft of the blade during the blade blank manufacture. Typically TiAlN-based coating is applied, commercially available from several sources. After blade manufacture, the cutting profile (cutting and clearance sides) is ground into the precoated blade blank on a suitable precision blade-grinding machine, such as the Oerlikon B24 or B10. But the front rake face is never reground or recoated after blade blank manufacturing. While the pre-ground front rake face initially provides a simplification of the blade resharpening process, it does so at great cost once the carbide sticks are used in production.

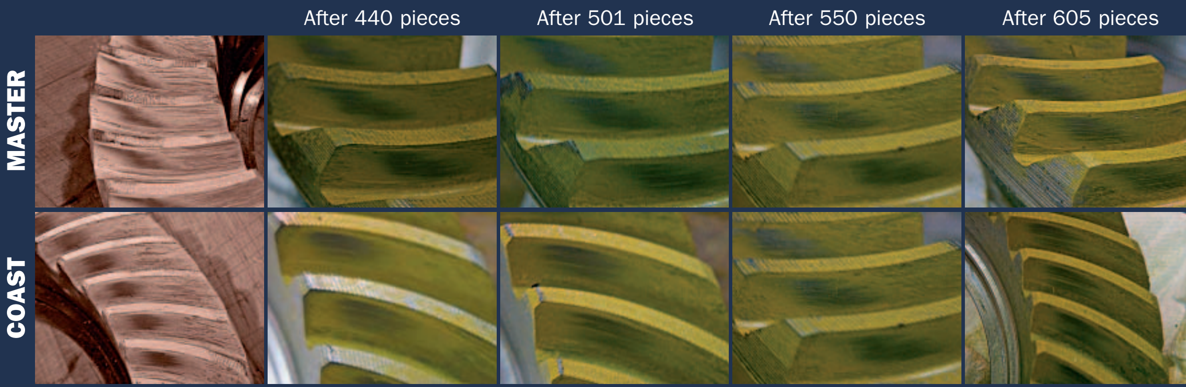
A 3F blade design requires only an uncoated rectangular carbide stick to be delivered for initial profiling. This greatly eases the manufacturing requirements of blade suppliers, as they no longer need to hold the very tight tolerances required when pregrinding the front rake face into the stick. A simple uncoated rectangular carbide stick, which is much simpler to manufacture, is all that is needed for the blade blank.

But what does this mean for profiling and subsequent resharpening of 3F blades once they are in production? They must be reground on all three faces at every resharpening, and recoated afterwards.

Additional coating costs are incurred, and carbide blade supplies must be large enough to allow for "blade float" while the blades are out-of-house being recoated. These clear disadvantages initially stunted the acceptance of 3F blade technology in the United States.

However, these drawbacks allow for a few extremely critical opportunities when designing with 3F blades. The independent control that we have over the front rake





face means that we can tune this angle to optimize the cutting performance. With 2F blades, the front rake angle is 12.00 degrees. Whether an outside blade or an inside blade, carbide or HSS, soft material or hard material, the front rake angle is always 12.00 degrees. Clearly this is not an optimal choice in every case. 3F blade geometry allows us to define this front rake angle as the cutting conditions demand for consistent tool life, surface finish, and part quality—from lot to lot, ratio to ratio, and job to job.

Since we regrind this front rake face, however, we are forced to recoat the blade after every resharpening. Here, what appears at first to be a severe drawback to the 3F approach is actually one of its greatest strengths: not only is the front rake face recoated, but also the cutting and the clearance flanks. With a fully coated blade, the cutting results improve dramatically. The inert TiAlN coating on the relief surfaces inhibits the tremendous flank wear, which is a key weakness of a 2F blade design. Surface finish improves, and blade "run-in" becomes trivial, with no need for additional edge preparation equipment.

Contact pattern, tooth topography, and size remain constant, with almost no change during the entire run of the cutterhead. And tool life, as a rule of thumb, doubles.

continued on page 30 >>

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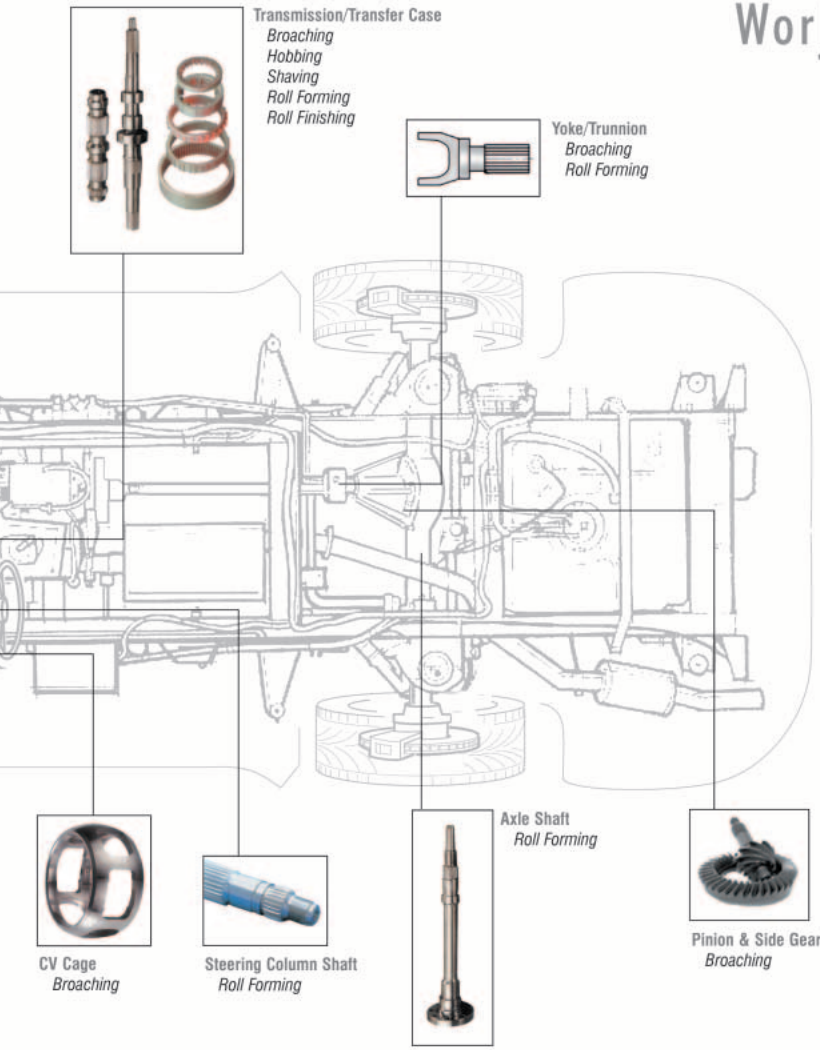
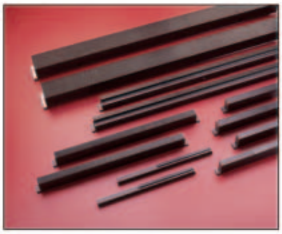


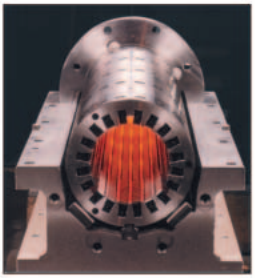
Hob & Shaper Cutters

Surface Broaches



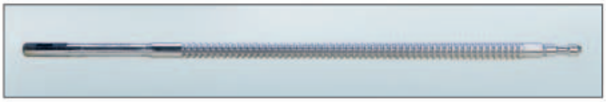
Roll Form Racks

Shave Cutters



Pot Broach Tools

Helical Broaches



Spline Broaches

<< continued from page 27

Technology Applied: Awesome Cutting Results

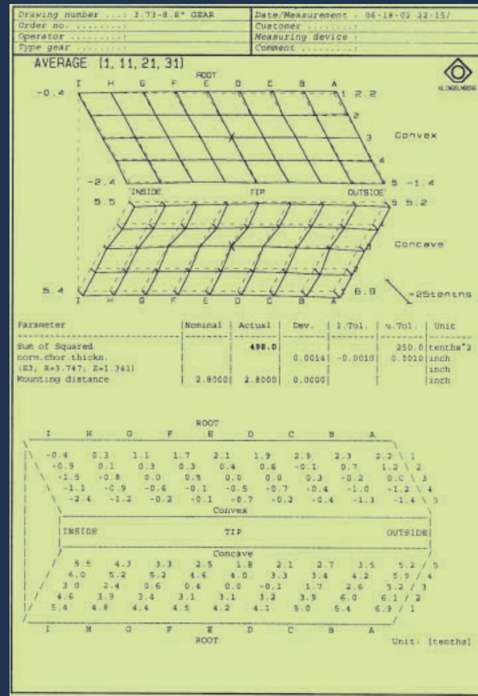
Based on this analysis, technical experts at the Klingelnberg-Oerlikon group proposed an interesting experiment: could 3F blade technology also satisfy the process requirements of U.S. automotive axle producers?

With all of this information in hand, Klingelnberg-Oerlikon—together with a tier-one U.S. axle supplier—developed a 3F blade design to duplicate a high-volume production job currently cut with a 2F carbide blade system. After a preliminary trial using a single blade group, we placed a full cutterhead with 3F technology into production. The results were even better than expected.

The job selected for this experiment was a 225mm ring gear with 41 teeth. This job has high production numbers and is representative of the modern face-hobbed designs in use throughout the U.S. axle industry.

Typical tool life for this job with 2F blade design is 250 parts per cutterhead, on average, with some heads running as many as 300 pieces, and others as few as 180 pieces. The primary reason for pulling 2F cutterheads in normal production is a loss of blade pressure angle on the inside blade, causing the drive side contact pattern to "dive," moving low toward the root of the ring gear. This condition is difficult to correct when the parts are lapped and, as such, must be monitored closely.

The 3F trial proceeded using a 17/88 Spiron cutterhead with a full set of optimized 3F blades, trued on a CS200 CNC cutter setting machine. The strong and stiff Spiron head construction allows us to true the assembled Spiron head radially without losing axial runout accuracy. The cutting parameters used were exactly the same as is normally used for 2F cutterheads, with identical feeds and speeds. Supplier personnel were in charge



The typical 2F blade geometry currently in production shows tremendous pattern degradation in as little as 50 pieces. After more than 600 pieces, the 3F process showed no pattern degradation whatsoever.

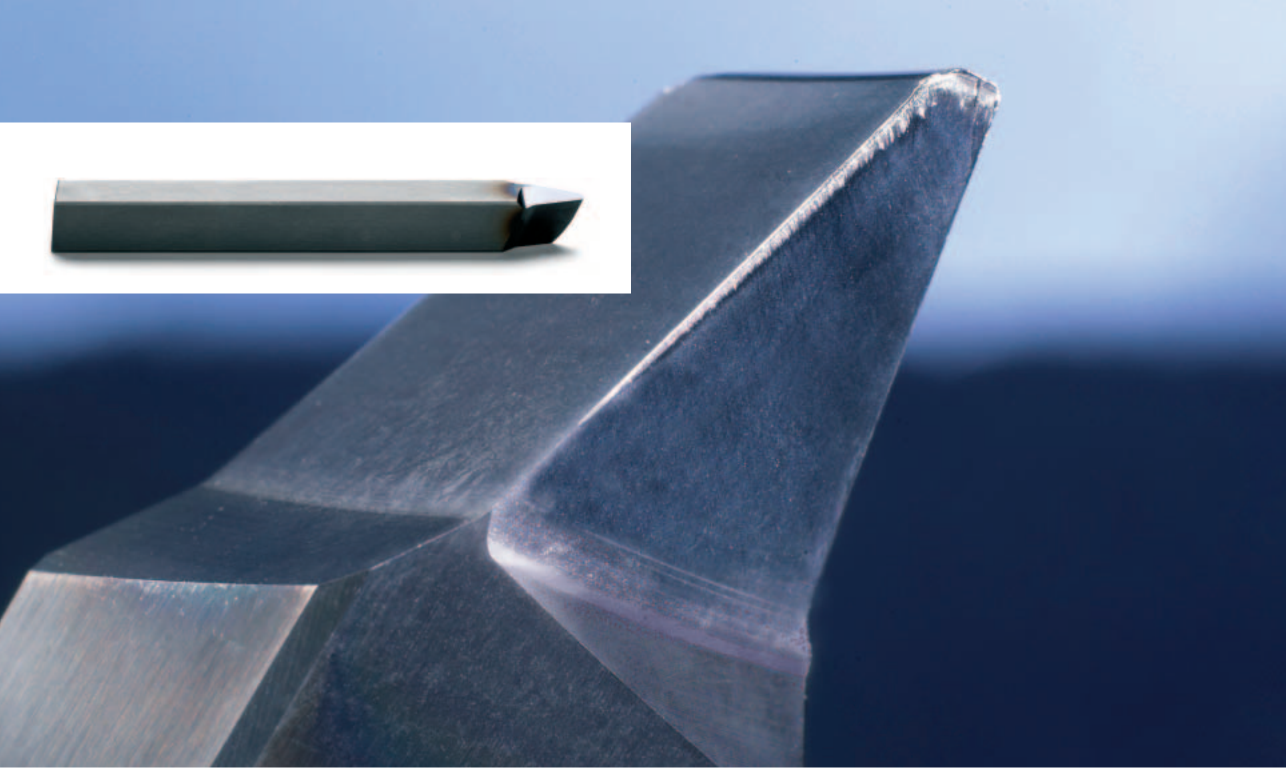
of all normal production activities during the 3F run—mounting the cutterhead, loading and unloading parts, and inspecting the finished pieces.

Klingelnberg-Oerlikon personnel were present for data collection and record keeping. We cut 605 pieces. We pulled the cutter for deteriorating coast side surface finish. We input KOMET corrections only once, to zero the machine after piece #1. The initial correction achieved a sum of the errors squared of less than 100. This shows the excellent ability of 3F blade design to emulate in-production jobs currently cut with 2F blades.

600 Pieces—No Degradation

The results of the painted and rolled parts go hand in hand with the sum of errors squared results, if not going a step further to highlight the robustness of the 3F process. All pieces rolled matched identically with the soft roll master. The typical 2F blade geometry currently in production shows tremendous pattern degradation in as little as 50 pieces. After more than 600 pieces, the 3F process showed no pattern degradation whatsoever.

Blade wear was predictable and even. The outside blade and the inside blade had equal wear: a condition almost unheard of when cutting with 2F blades. Again, this is due to the ability to independently optimize the front rake faces of both the inside and outside blades with a 3F design.



The flanks of the 3F blades were barely worn, showing only smooth, even wear. The bulk of the wear was concentrated on the blade tips. 3F blades need only 0.4 mm of grinding stock removal during resharpening, which is less than half of what 2F blades require. This keeps 3F resharpening cycle times even with 2F blades, despite the addition of a third face to grind. And, over their lifetime, each set of 3F blades will produce more than four times the number of gears as a set of 2F blades.

Conclusion: 3F Blades

3F blade design can emulate tooth topographies and contact patterns of gears currently in production with 2F blade geometry. The improved quality and reduced variation of parts produced with 3F blades positively impacts downstream operations, ensuring faster and more-consistent lapping results. The additional degrees of freedom that 3F blade design provides allow optimization of the inside and the outside blades independently for even tool wear, consistent results, and a robust process. 3F cutter designs guarantee the user with longer part runs with higher process capability.

Another strong manufacturing benefit is the elimination or reduction of the sources of variation in the cutting process. Because every active face of the blade is accurately resharpened, variation in the blade blanks themselves is monitored and controlled before every cutterhead goes ″out on the floor.″ Loosely controlled processes, such as edge preparation, are rendered unnecessary. And the full coating of the entire active portion of the blade reduces the impact of slight variations present in blade grinding (wheel wear, surface finish, etc.). All of this translates into more-stable, more-predictable, and more-efficient production of bevel and hypoid gears.

In the future, new designs can be developed using the KIMoS hypoid gear calculation program that is tailored to take full advantage of the capabilities of the 3F system. For example, Spiron cutterheads are available in both a 17/76 and a 19/88 construction.

These increased numbers of blade groups translate to higher cutting efficiency, and shorter cycle times. And contact pattern shape and inclination—also known as "bias"—which is so critical to the lapping development and noise behavior of a gearset, can be more completely controlled when designing with a 3F blade ″from scratch.″

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Depending on the type of tooling, a **SINGLE FACE DRIVER** may replace several solid ring drivers. Read on to learn more.

the fundamentals of face driving

by Mitchell Kirby

Ever-increasing demands on manufacturers to improve productivity and quality have led to the need for faster and more accurate machine techniques. Face driving arose to help meet these demands. Originally developed in Europe, it has become increasingly popular in the United States in the last decade.

With chucks and grinding dogs the part must be released after the first operation, reversed, and re-chucked before subsequent operations can be performed. Traditional machining requires multiple operations and multiple setups, increasing both costs and cycle times. Work in process accumulates as parts are queued waiting for subsequent operations.

Unlike a chuck or grinding dog, a face driver grips and turns the work piece by locating only on the face of the part. The face driver's center point centers the part establishing the axis of rotation, while the drive pins penetrate the face of the work piece. Since the part is machined between centers, radial runout is largely eliminated, resulting in a higher quality part at a reduced cost. Basically, face driving allows the complete turning or grinding of the entire outside diameter of a work piece in a single operation. Higher part quality is achieved while reducing queue times and work in process inventories.

How a Face Driver Works

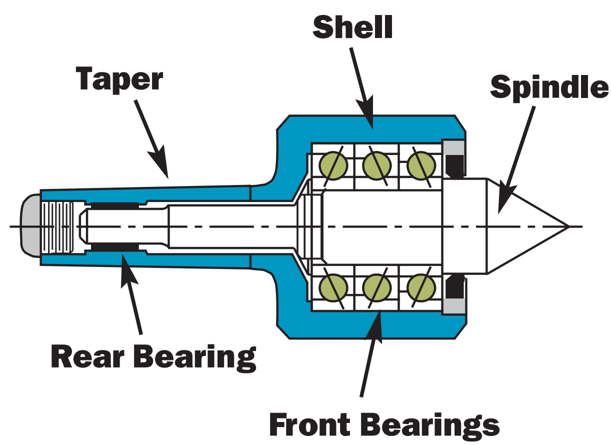
A face driver has two main components, the drive head and the mounting mechanism. The drive head contains a compensating medium; drive pins and a spring loaded center point. The most common mountings are Morse Taper shank mounts, chuck mounts, or flange mounts. Custom mountings are readily available to fit a variety of special applications.

Face driving is a simple, two-step operation; centering followed by clamping. Under tailstock pressure the work piece engages the center point, locating the part and providing a consistent axis of rotation. As the tailstock continues to drive the work piece against the center point, the axial pressure forces the spring-loaded center point back into the drive head until the drive pins engage the face of the work piece. Each pin individually compensates for any irregularities in the face until all of the pins are fully engaged. Under the increasing axial load, the drive pins penetrate the work piece, completing the clamping operation, while the center point maintains the axis of rotation. The compensating medium in the face driver assures equal penetration of the drive pins despite surface imperfections or variations in the squareness of the face.

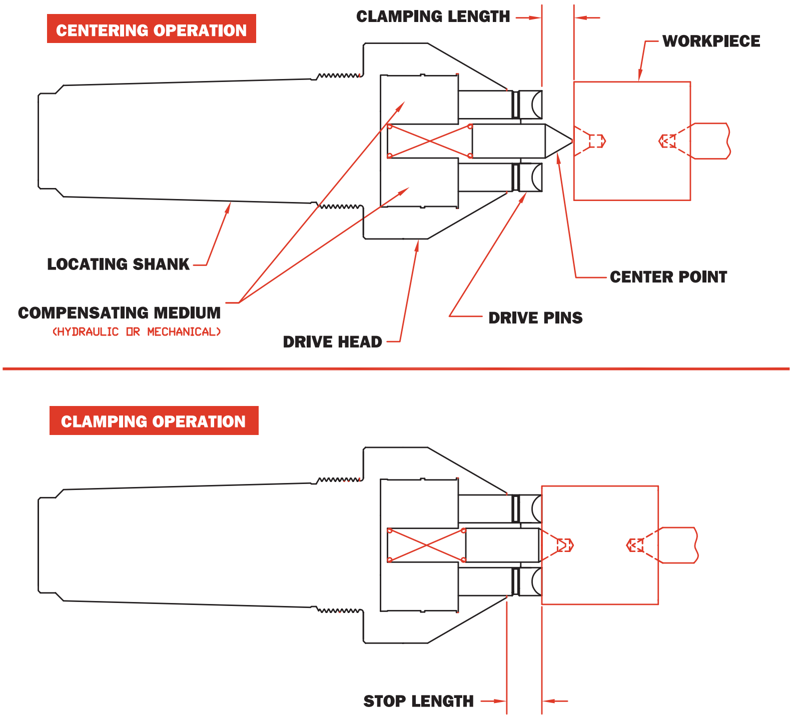
Face Driver Designs and Mounting Methods

The compensating medium distinguishes the two predominate designs of face drivers. Hydraulic designs are generally less accurate than mechanical designs and require some disassembly to change drive pins and center points. Sitting behind every drive pin is a sealed piston assembly that prevents hydraulic fluid leakage. The oil cavities behind the pistons interconnect to a common fluid reservoir. Because the pressure equalization of each drive pin is directly influenced by the hydraulic fluid, each pin "floats" in conjunction with the other pins. The drive pins "react" to accommodate irregular work pieces to a greater degree than that of mechanical designs. However, higher tailstock pressures may be required to drive the work piece when compared to mechanical drivers.

Mechanical face drivers have quick-change center points and drive pins. Both pins and points can be removed from the drive head with moderate pressure without disturbing the accuracy of the driver. Changing from one pin style to another can be accomplished in under a minute. The drive pins in mechanical face drivers sit on a series of male and



female convex and concave washers. The male inner washer is split into segments that move independently against the concave surface of the female washer. Pressure from the drive pins forces the split segments to slide down the concave surface of the female washer until the segments lock around the center point. This locking feature provides a similar effect to that of a collet chuck. The locking center point feature enhances dimensional accuracy and repeatability to a greater degree than that found in hydraulic designs. Since



FACE DRIVING ALLOWS THE COMPLETE TURNING OR GRINDING OF THE ENTIRE OUTSIDE DIAMETER OF A WORK PIECE IN A SINGLE OPERATION, SO HIGHER PART QUALITY IS ACHIEVED WHILE REDUCING QUEUE TIMES AND WORK IN PROCESS INVENTORIES.

the center point and the drive pins both support the work piece, tailstock pressure requirements can be reduced in comparison to hydraulic drivers. This not only saves wear and tear on the machine spindle bearings, but allows mechanical drivers to be used in applications where tailstock pressures are limited.

Morse Taper shank mounts are used when machine spindles will accept a taper shank. They have the benefit of easy changeovers without requiring any tools. Chuck mounts require special soft jaws and grip directly on the drive head or the mounting flange of the face driver. This configuration is not as accurate as taper shank or flange mounts, but does not require the removal of the chuck from the machine spindle. Flange mount face drivers are bolted to a spindle adapter plate, which in turn bolts directly to the machine spindle nose. This mounting is the most rigid and is usually required when holding tighter tolerances. Spindle adapter plates are available for most standard machine spindles. During setup, the driver is "dialed in" on the adapter plate with stirring screws until all runout from the machine spindle has been eliminated.

The Riten Face Driver product line consists of seven hydraulic and 10 mechanical designs. This wide range of models offers a large degree of versatility for large parts such as large rolls, motor shafts, and crankshafts: for small parts such as valve stems, ball studs and automatic transmissions shafts; and for rough castings and forgings such as automotive axles and gears. As a general rule, hydraulic drivers are used for larger shafts and forgings, aggressive roughing applications, and applications where accuracies of .0015 -.0020 inches are acceptable. Mechanical designs are frequently used for smaller parts, families of similar parts where quick-changeovers are important, and applications where accuracies of .0004 - .0008 inches are required. Face drivers are used in many between center operations such as hobbing, milling, shaping, grinding, gear cutting, spline milling, facing, and turning.

The gear industry is somewhat unique in that solid ring face drivers or driving disks are used extensively in hobbing applications. Most of the standard tooling supplied by Liebherr, Gleason, and Pfauter consists of this type of driving mechanism. Standard face drivers can be used in many hobbing and gear cutting applications without difficulty. Depending on the type of tooling, a single face driver may replace several solid ring drivers. As with any new process, customers should consult the factory to determine the best choice of face driver for a given application.

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animated CAD Solutions for G3AR M3CHAN1SM dES1GN

Embracing new technologies helps place engineers at the center of the gear-design process.

by Sandor J. Baranyi

Two-dimensional and 3D CAD programs have continually lessened the role of the engineer in the actual process of designing gears, gear mechanisms, and mechanisms in general. This unilateral phenomenon can be corrected by using ACADS to increase the designer's interactivity and creativity in that process.

Countless examples of this have been available since April 2003, with the arrival of ACADS as a mechanical design engineering tool.

Gearing and Gearing Profile Types

There are three basic types of contemporary gear profile types:

- involute
- trochoid (cycloid)
- curve-linear

ACADS is suitable to all three profile types, of which the involute is the dominant and best-known to most gear designers. Consequently, it is not necessary to elaborate on the involute in this paragraph of the article.

Trochoidal (cycloidal) gears have enjoyed a slow but persistently increasing use in various industries in the past few decades. This tendency is expected to continue in the future, especially in connection with emerging industries and involving both large and small physical size applications, such as gear drives for wind farms for renewable power generation, for instance. Certain obvious advantages of trochoidal gearing will be apparent to the reader by reviewing the sample examples provided in this article. For further information on the subject of trochoidal and cycloidal gearing, the reader is urged to review Reference 1, which is cited at the end of the article.

Certain curve-linear functions have been used to approximate involute and trochoidal gear tooth profiles, especially for slow moving and large gear drive applications. Readers with interests in these realms of gear design should also review Reference 1 (see sidebar References, page 42).

Sample Examples on ACADS

Illustrative examples on using ACADS appear in the following sections, which include:

- speed reducers
- indexers
- geared four-bar linkage mechanisms

A limitless number of other specific application areas for ACADS will be found by gear and gear mechanism designers, some of which have been listed in the summary.

Speed Reducers

Consider the layouts (CAD plots) in Figure 1 that will help us create corresponding ACADS animations for the respective epitrochoidal speed reducer, as a most simple and introductory example on ACADS.

The single-line left plot (or "single frame," which is a term borrowed from the movies) serves as a zero position and time reference for the beginning and the end of a motion cycle involving one full turn of the gear as an input or driving member, and a corresponding half revolution of the four-roller follower wheel as an output or driven member of the reducer. The internal-mesh type engagement of the input and output members causes the members to rotate in the same direction, as it is implied by the positive value of the ratio R=2 in this case.

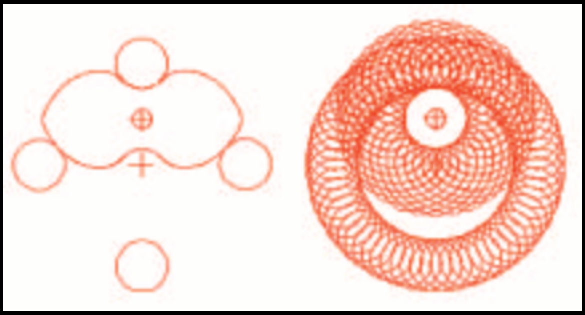

Figure 1 — Two-tooth partially conjugate prolate epitrochoid spur gear reducer of parallel input/output shafts for ratio R=2:1.

Figure 2 — Photograph of epitrochoidal spur gears such as shown in Figure 1 for R=2:1 speed ratio.

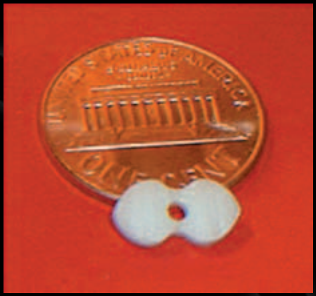

Figure 3 — Miniature version of the gears shown in Figure 2. Reduced in size to a scale of 1:16 (6.25 percent) approximately, this gear was precision cut in acetal, an engineering thermoplastic.

As in all sample examples in this paper, we assume uniform motion at constant speed for the input member, the gear in Figure 1. In this example we have used 16 frames per motion cycle. The resulting 16-frame composite plot is shown on the right side in Figure 1. The opening (zero reference) frame plot, and the composite plot in Figure 1 constitute the static ACADS images, typically and dominantly the product of a design engineering effort. To the trained eyes of designers, static ACADS images are important counterparts to actual ACADS animation. A set of CAD files for the corresponding static ACADS images we refer to as an "ACADS folder," in PC parlance.

Creating an actual ACADS animated image of our reducer is an easy task for someone with Web-design skills and working tools, using the ACADS folder referred to in the previous paragraph.

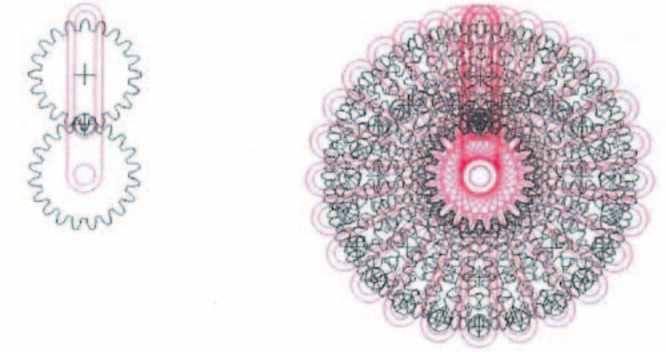

Figure 4 — Full-turn epicycloid (cardioid) indexer using two identical involute spur gears.

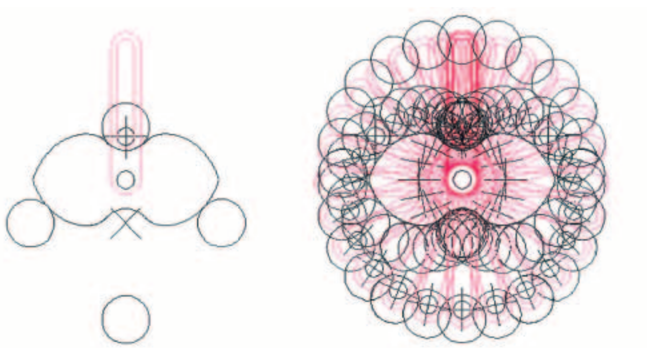

Figure 6 — Full-turn cardioid indexer using two-tooth prolate epitrochoidal spur gearing elements of internal gear mesh type we have discussed in connection with Figure 1. The crank pin is fixed onto the roller follower wheel, with its center at a radius from the wheel center to satisfy both the prolate epitrochoid gear profile and the cardioid traced by the crank pin center, for a common center distance with the wheel, as a "congruity criterion" for proper design.

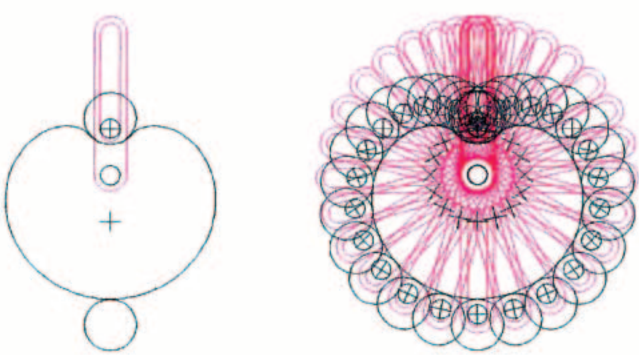

Figure 7 — Full-turn cardioid indexer using a one-lobe prolate epitrochoidal gear as a sun, in constant engagement with the corresponding two rollers of a follower wheel used as a planet. The crank pin is secured onto the planet so that the center distance between the planet center and the crank pin center satisfies the congruity criterion for the one-lobe epitrochoid and the cardioid.

The animated ACADS image cited in Figure 1 for this example can be viewed using an Internet browser such as the Microsoft Internet Explorer or the Netscape Communicator, for instance. Browsers are downloadable from the Internet free of charge.

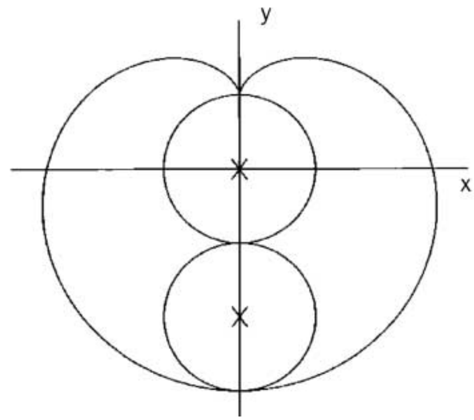

Figure 5 — Illustration of cardioid that is traced by the crank pin centers in Figures 4, 6, and 7.

For best viewing of high speed ACADS animations, however, the reader is urged to experiment with the specific browsers used, because animation smoothness can be affected considerably. We note that ACADS animations presented in this article have been created using the Fireworks animation software by Macro Media for cost-effectiveness of creating both the static ACADS folder by the design engineer, and the animated image file by the Web designer in cooperation with each other.

Higher quality ACADS animations are available at significantly higher cost, using MM's more-sophisticated Flash rather than the Fireworks software.

HTM files on ACADS animation can be saved in individual GIF files for high quality playback on a PC using various viewers and players, such as the Windows Picture and Fax Viewer, or Quick Time Player, for instance, for slide show presentations at upper management meetings on important projects and programs, and for many other uses.

Gear design engineering work in conjunction with this article was done using Trogetec's wEZGearplot CAD package for Windows and the respective software products for involute and trochoid (cycloid) gear design.

Please note that hands-on seminars on ACADS will be held at the Riverton Holiday Inn in Riverton, Wyoming, beginning in May 2004. On-site classes are available as needed.

The two-tooth trochoidal spur gears shown in the photograph of Figure 2 were released in June 2003. The approximately 4"x2"x3/16" (102 mm x 51 mm x 4.8 mm) overall size gears, precision laser-cut in 1008/1010 HRP&O stock for a bench-top automatic assembly setup, engage with 1" (25.4 mm) outside diameter rollers on 4" diameter bolt circle of a four-roller follower wheel in an internal-mesh style. These same gears are also offered as cost-effective off-the-shelf parts for experimenting by proactive engineers with an interest in the new gear design. Cost effective, custom-made versions of the gears in larger or miniature sizes are offered in virtually any material.

Full-turn Epicycloid Indexers

Gear drives of this type using external involute spur gears are discussed in connection with Figure 4.

In reference to the single frame plot in the figure, this drive employs two identical size involute gears held in a constant center distance engagement by means of a link (link not shown). The link serves as a driver or input member. One of the gears is used as a fixed sun gear of which the centerline is coaxial with that of the link and a slider crank (shown in red) with a pin. The pin is secured to the second gear so that its center coincides with the pitch circle of the gear.

The planet gear center is indicated by a "+" symbol. The single frame plot in Figure 4 represents the "dwell," or "rest" position of the drive at which the output member comes to rest for an instant while the input member keeps moving. The centers of the gears and the link are positioned along the centerline of the slider crank, and the pin center is at a common tangent point of the pitch circles of the gears.

The curve traced by the crank pin center is a one-cusp or one-lobe epicycloid, most often referred to as a "cardioid" in mathematics and kinetics, owing to its unique shape (Figure 5.) The circle with center at the origin represents the pitch circle of the sun gear in Figure 4, and the other circle represents the p.c. of the planet gear, that rolls around the former without slipping. A point on the rolling p.c. traces a cardioid as shown.

We note here that, in practical gear design engineering, it is often the creation of a design chart for a given

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mechanism that is our ultimate aim. Toward that end, however, the road is through the organized and structured process of ACADS, while the actual animated image and composite plot results themselves may be of little importance. In contrast to this, animated images of complex mechanisms can greatly simplify our grasping or describing the operation principle of the mechanism. A good example for this is provided by the analysis of three-gear drives, which we will consider in the next paragraph.

It is important to consider that the motion characteristics of both epicycloidal and hypocycloidal indexers of large number of stations (cusps or lobes) approach that of the cycloidal motion. For cycloidal motion the output displacement, velocity, acceleration, and pulse factors are respectively as, s*=1, v*=2, a*=6.283, and p*=39.48 (see References 1-3). In comparison with these, the values for cardioid motion per sample example of Figure 11 are s*=1, v*=1.333, a*=8.400, and p*=229.0

For a set of traditional epicycloidal and hypocycloidal drive designs, please refer to Reference 4.

Geared Four-Bar Linkage Mechanisms

These mechanisms became widely known as three-gear drives, or 3GD, in the 1960s (Figure 13).

A set of equations for calculating dwell point conditions for 3GDs is offered by Reference 4.

Note that, typically, the process of creating the animated ACADS image and the ACADS folder made it possible to obtain the output displacement S versus the rotation of the eccentric gear as input displacement (or, s vs. t/T) in Figure 15. Successive differentiations of

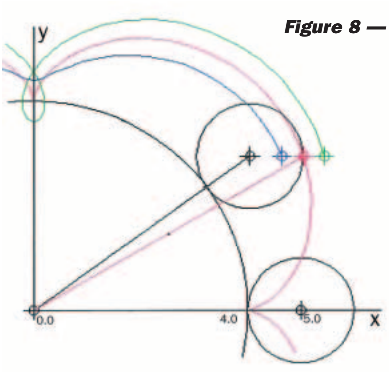

Figure 8 — Example on describing a four-lobe epicycloid, prolate, and looped epicycloid for E=1, and Q=1, 0.6 and 1.4, respectively, (see Reference 1.) The x, y tracing points and the center point of the rolling circle describe the three output displacement values corresponding to the input angle displacement of 36 degrees. For the epicycloid shown in red, the output displacement is arctan (2.93891/5.04508)=30.2221 degrees where both the input and output displacements are measured from the x-axis as zero reference. The complete curves are shown in Figure 9

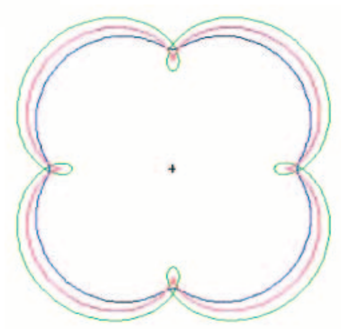

Figure 9 — Full curve plots of the four-lobe epicycloid and epitrochoids described in Figure 8.

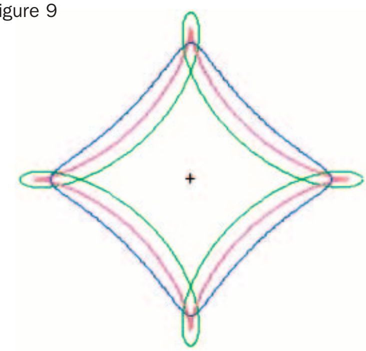

Figure 10 — Hypo-cycloidal and hypo-trochoidal counterparts of the curves shown in Figure 9.

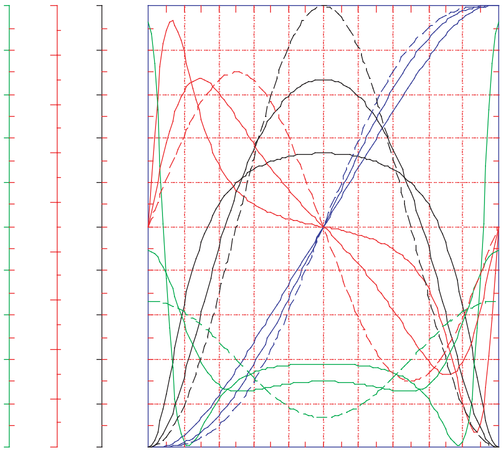

Figure 11 — Design chart for rigid epicycloid indexers, where L and T designate output displacement lift and cycle period, respectively. The term rigid simply implies that compliance effects are negligible for a given mechanism. Sample Example: A rack-pinion mechanism and a cardioid indexer comprise a linear motion drive for T=1 sec and L=10" (25.4 cm). Find maximum values of V, A and P.

Solution:

Vmax=1.333*L/T=13.33 ips (33.86 cm/sec);

Amax=8.40*L/(T^2)=84.0 in/sec^2 (213.4 cm/sec^2);

and,

Pmax=229.0*L/(T^3)=2290 in/sec^3 (5817 cm/sec^3)

S with respect to time was done numerically, to obtain the v, a, and p vs. t/T curves in Figure 15.

Finally, considering the animated ACADS image per Figure 3, the seemingly reversals of the large gear motions are actually optical illusions, similar to the rotation of the wheels of a speeding car.

Summary

Uniform input motion (constant speed), and rigid system conditions have been assumed as simplifying rather than limiting factors throughout the introductory presentation of the ACADS above. System compliance and/or non-uniform input displacement conditions in a given drive system application would make the mechanical design effort more complex (see References 2-3). However, the corresponding ACADS portion of the overall design effort would remain relatively small.

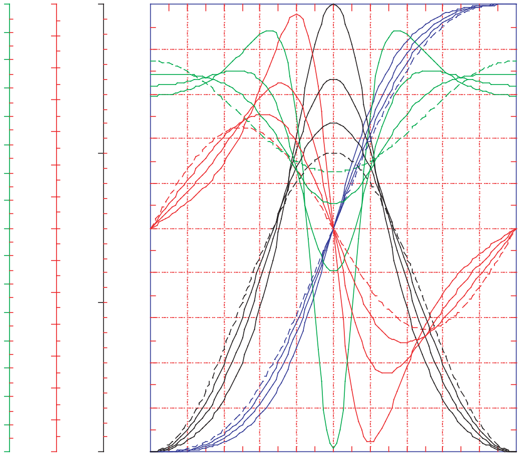

Figure 12 — Design chart for rigid hypo-cycloidal indexers.

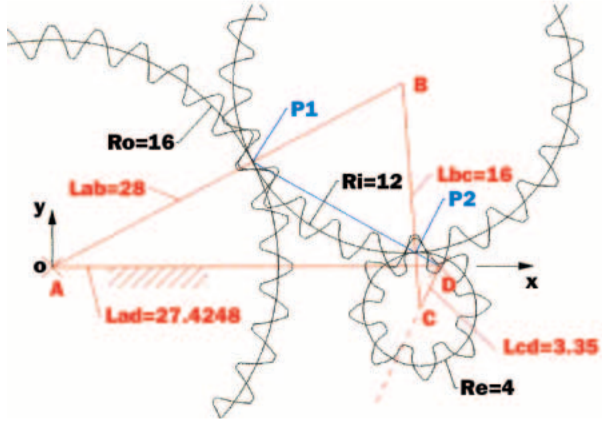

Figure 13 — Description of a 3GD setup shown at dwell position designated by the dash line in red as an extension of the eccentric (input) at dwell.

Similarly, ACADS proved to be a powerful practical design engineering tool for handling the design of composite and aggregate mechanisms obtained by coupling several component mechanisms serially or in parallel. This is not to say, however, that ACADS is not just as important in simplifying certain existing designs in the continual quest of new and improved mechanical drive products involving gears, cams, power screws, and linkages, etc.

In reference to gear design—and special gear designs in particular—at the component level, ACADS has been found useful in the following situations:

- determining contact ratio

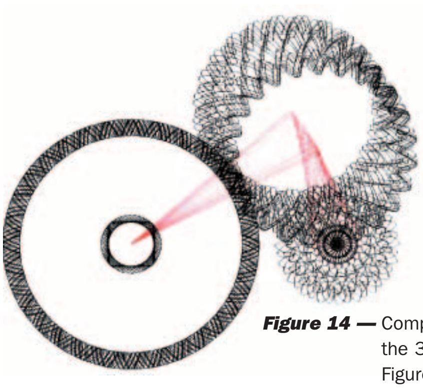

***Figure 14* —** Composite plot for the 3GD example per Figure 13.

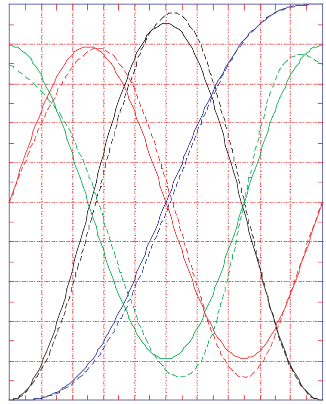

***Figure 15* —** Motion characteristics of the 3GD system per Figure 13, for negligible compliance effects in the drive. This design chart of the 3GD is considered to be an unprecedented result, thanks to ACADS.

- avoidance of profile undercutting
- avoidance of fouling
- gearmesh efficiency
- proving studies of various types
- convex/concave profile enveloping for external helical gearmesh
- convex/concave profile enveloping for internal helical gearmesh
- skewed profiles
- other applications

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FELLOWS Model #10-4/10-2, All Parts Available **REF#106**
Tilt Tables for 10-2/10-4, Qty 2 **REF#106**

GEAR HOBBERS/CUTTERS CNC

BARBER-COLMAN #6-10, 2 Axis, CNC, 6" Dia, 10" Face, New '96 **REF#107**
G&E #120H, CNC, Gasher/Hobber, Twin Stanchion, 1/2 DP, 42" Face, '94 **REF#107**
G&E #60S-2, CNC, Miller/Gasher, 1 DP, 72" Dia, 38" Vert Travel, 60 HP, '80 **REF#107**
GLEASON PHOENIX #125GH, 6-Axis CNC, 4.92" Diam., 7.8 DP, Late Model **REF#107**
LIEBHERR #L-1202, 6-Axis, CNC, 49" Dia, 24" Face, 1.2 DP, '78 **REF#107**
LIEBHERR #LC-152, 6-Axis, CNC, Hobber, 6" Dia, 5 DP, 10" Face **REF#107**
LIEBHERR #LC-183, CNC, Full 6-Axis, 8" Dia, 10" Face, 8 DP, New '88 **REF#107**
LIEBHERR #LC-252, CNC, Full 6-Axis, 10" Dia, 10" Face, 4 DP, New '96 **REF#107**
LIEBHERR #LC-255, CNC, Full 6-Axis, 10" Dia, 10" Face, 4 DP, New '87 **REF#107**
LIEBHERR #LC-502, CNC, Full 6-Axis, 20" Dia, 16" Face, 2 DP, New '87 **REF#107**
MITSUBISHI #GB-25, 6-Axis, 10" Dia, 10" Face, 4 DP, New '91 **REF#107**
MITSUBISHI #GA-40, 5-Axis, 16" Dia, 11" Face, New '86 **REF#107**
MITSUBISHI #GB-100, 6-Axis, 40" Dia, 20" Face, 2 DP, New '96 **REF#107**
PFAUTER #P-125H, 6-Axis, 5" Dia, 16" Face, Yr '88 **REF#107**
PFAUTER #P-250H, 12-Axis, 32" Dia, 3" Face, Yr '81 **REF#107**
PFAUTER #P-250H, 6-Axis, 11.81" Dia, Fanuc O Control, New '85 **REF#107**
PFAUTER #PE-300, 6-Axis, 12" Dia, A/B 8600 Control, New '87 **REF#107**
PFAUTER #PE-150, 6-Axis, CNC, 6" Dia, 5 DP, 6" Face, Fanuc 18MI Control, New '80's **REF#107**
SYKES #H160, 4-Axis, CNC, Hobber, 6" Dia, Skip Feed & Crowning, Etc, New '93 **REF#107**
TOS #OFA-31, 6-Axis, CNC, Hobber, 12.6" Max Dia, New Machine **REF#107**
TOS #OFA-75, 6 Axis, Hobber, 32" Max Dia, 18" Face, New Machine **REF#107**
TOS #OFA-100, 6 Axis, Hobber, 39" Max Dia, 24" Face, New Machine **REF#107**
BORAS Helical Gear Hobber **REF#101**
TOS OFA-32, CNC 6, Hobbing Machine **REF#104**
TOS OFA-75, CNC 6, Hobbing Machine **REF#104**
TOS OFA-100, CNC 6, Hobbing Machine **REF#104**
PFAUTER #PE-150, (6" Dia), 6-Axis CNC, New '86 **REF#105**
LIEBHERR #LC-152 (6"/8" Dia), 7-Axis CNC w/Automation, New '88 **REF#105**
PFAUTER #PE-750, (30" Dia), 6-Axis CNC Universal, New '00 **REF#105**
LIEBHERR #L-902, (36" Dia), 3-Axis CNC Universal **REF#105**
LIEBHERR #L-1801, (72" Dia), 6-Axis CNC Universal **REF#105**
G&E #96H (100" Dia.) .75 DP, CNC Universal **REF#105**
BARBER-COLMAN 6-10, S/N 5437, '90 2-Axis CNC Sgl Thrd **REF#108**

GEAR HOBBERS/CUTTERS

BARBER-COLMAN #14-15, 14" Dia, 15" Face, Dual & 4-Start Worms, (Several) **REF#107**
BARBER-COLMAN #14-30, 14" Axis, 30" Dia, 3.5 DP, '67 **REF#107**
BARBER-COLMAN #16-16, Multi-Cycle, Dual Thrd Worm, Downfd, Auto Hob Shift, 50's-78's **REF#107**
BARBER-COLMAN #16-36, Special Riser, 24" Dia, C-Frame Style, 4 1/8" Bore, Ext Overarm, '68 **REF#107**
BARBER-COLMAN #16-56, 16" Dia, 56" Face, Diff, Dbl Thread Worm, '68 **REF#107**
BARBER-COLMAN #22-15, 22" Dia, 14" Face, Diff, Dbl Thread Worm, Auto Hob Shift, '56 **REF#107**
BARBER-COLMAN #3 (6-10), Sgl Start Precision Worm, Screw Type Ctr **REF#107**
BARBER-COLMAN #6-10, Triple Thread Comm Worm, Downfeed 90 Deg Head **REF#107**
BARBER-COLMAN #6-16, 6 Start Worm, Downfeed, Hyd Clamping, Mag Loading, '72 **REF#107**
DAVID BROWN #MT-60, 60" Dia, 1.5 DP Diff, Infeed, Tailstock, New '60 **REF#107**
G&E #16H, Univ Head, Hob Shift, Excellent Condition, '62, Reb '80's **REF#107**
G&E #24H, Univ Head, Infeed, Tailstock, Diff, Good Condition, '50's **REF#107**
G&E #36HWD, Diff, Excellent Condition, New '40's **REF#107**
G&E #48HWD, Diff, Excellent Condition, New '50's **REF#107**
G&E #60S, Sgl Index Machine, 72" Dia, 16" Face, 9" Cutter, Under Power, Nice! **REF#107**
G&E #72H, 72" Dia, 1.5 DP, 24" Face, Diff, Infeed **REF#107**
G&E #84/96H, High Stanchion, Diff, Infeed, Excellent Condition, In Plant **REF#107**
G&E #96HWD, 1 DP, 66" Face, 125" Max Dia, Ext Col, New '48 **REF#107**
HAMAI #120, 4.8" Dia, 4" Face, 12 DP, '70 **REF#107**
HURTH #WF-280, 11" Dia, 10" Face, 4 DP, '85 **REF#107**
KOEPFER #135, Horiz Loader, 3" Dia, 3" Face, 25 DP, '60 **REF#107**
LIEBHERR #L-252, 9.84" Dia, 4.2 DP, 5.7" Hob Dia **REF#107**
LIEBHERR #L-301, 12" Dia, 9' Face, 4 DP, '74 **REF#107**
LIEBHERR #L-400, 16" Dia, 10' Face, 3 DP, High Helix, Crowning, '68 **REF#107**
LIEBHERR #L-401, 16" Dia, 8' Face, 3 DP, '70's **REF#107**
LIEBHERR #L-1200, 2 DP, 49" Dia, 22" Face, Hyd Tailstock, Nice, In Plant, New '75 **REF#107**
LIEBHERR #L-402, 16" Cap, 2-Cut Cycle, Crowning, Chip Conveyor, New '77 **REF#107**
LIEBHERR #L-652, 25" Dia Cap, 19.7" Face, 2 DP, Well-Equipped **REF#107**
LIEBHERR #L-900 Duty, 35" Dia, 2.5 DP, Diff, Infeed, '61 **REF#107**
LIEBHERR #L-901, 35" Dia, 2.5 DP, 2-Cut Cycle, Univ Hob Head **REF#107**
LIEBHERR #L-902, 36" Dia, 25" Face, 2 DP, Crowning, Clamping, New '78 **REF#107**
MODUL #ZFWZ, 400/4 **REF#107**
WMW-Modul #ZFWZ 250/3,10" Dia, 10" Face, 4 DP, New '77 **REF#107**
RPM #AD-616, 6" Dia, 16" Face, 16 DP, (3) Thread, Bayonette Ctr, New **REF#107**
OVERTON #HD-400, 15.7" Max Dia, 3 DP, 2 Cut Cycle, Crowning, Diff, Tang, '80 **REF#107**
PFAUTER #P-251 & P-253, 10" Dia, 9" Face, 4 DP, '83 **REF#107**
PFAUTER #P-403 & #P-400, 16" Dia, 3 DP, 2-Cut Cycles, Change Gears, '83 **REF#107**
PFAUTER #P-630 & 630, 24" Cap, 2-Cut Cycle, Crowning, '60-'70 **REF#107**
PFAUTER #P-900, 2 DP, 36" Dia, 15" Face, Universal Head, Tailstock, New '60 **REF#107**
PFAUTER #RS-00, 10" Dia, 8 DP, 7" Face, Univ/Tang, Head, New '60's **REF#107**
PFAUTER #RS-1, 29" Dia, 3 DP, 12" Face w/Tang Head, New '50's **REF#107**
SCHIESS #RF 40/60S-90, 360" Dia, 90" Face, 1 DP, '74, "RARE" **REF#107**
TOS #OFA32A, Auto, New, 12"x10", Yr '86 **REF#100**
TOS #OFA71A, Auto, 29"x18", Yr '91 & '88 **REF#100**
TOS #FO16, 63"x22", Set-ups, Sgl Index **REF#100**
TOS FO-10, 1000mm, Yr '66, Reb '89 **REF#104**
TOS OFA-16A, Gear Hobbing Machine, Yr '85, Reb '00 **REF#104**
TOS OFA-32A, Gear Hobbing Machine, Yr '89 **REF#104**
TOS OFA-71A, Gear Hobbing Machine, Yr '84 **REF#104**
TOS OFA-32A, Gear Hobbing Machine, Yr '86 **REF#104**
TOS OFA-71A, Gear Hobbing Machine, Yr '87 **REF#104**
TOS OFA-16B, Gear Hobbing Machine **REF#104**
TOS OFA-32R, Gear Hobbing Machine **REF#104**
TOS OFA-75, Gear Hobbing Machine **REF#104**
LIEBHERR #ET-1202, (48" Dia), 4-Axis CNC Ext Miller/Gasher **REF#105**
G&E #60S2, (60" Dia), 3-Axis CNC, Spur/Bevel **REF#105**
G&E #60S, 72" (Dia), Yr '52/'64 **REF#105**
MIKRON #A21/2, (1-9/16" Dia), 26 DP, Hopper Feed **REF#105**
BARBER-COLMAN #2-1/2-4, (2.5" Dia),4" Face, Var Speed Drive **REF#105**
BARBER-COLMAN #3, (5" Dia), 10" Axial Travel, With or w/o Diff **REF#105**
BARBER-COLMAN #6-16, (6"Dia), 3-Thread, Turret Tailstock, Yr '63 **REF#105**
BARBER-COLMAN #Type D, (14" Dia), 15" Axial Travel, 3.5 DP, Diff **REF#105**
BARBER-COLMAN #14-15, (14" Dia), Hobshift, 6-Thrd Index **REF#105**
BARBER-COLMAN #16-36, (16" Dia), Multicycle, 2-Thrd Index, Reb **REF#105**
BARBER-COLMAN #16-36, (16" Dia), Differential, 2-Thrd Index, 36" Axial Travel **REF#105**
BARBER-COLMAN #16-56, (16" Dia), Hobshift, Dbl Thread Index, Recon **REF#105**
CLEVELAND #1883, (7" Dia), w/Ext Hgt Tailstock **REF#105**
LEES-BRADNER #7HD, (8" Dia), 4 DP, Auto Hobshift **REF#105**
CLEVELAND #1886, (8" Dia), 4 DP, Sine Bar Att **REF#105**
PFAUTER #RS00S, (8"/10" Dia), 6 DP, Diff **REF#105**
LIEBHERR #L-200, (10" Dia), Hvy-Duty Hi-Speed, Yr '79 **REF#105**
LIEBHERR #L-252, (10" Dia), Crowning, Spur only **REF#105**
LIEBHERR #L-301, (12" Dia), 2-Cut, Crowning **REF#105**
CLEVELAND #CR-300, (12" Dia), Crowning, 2-Cut, New **REF#105**
KASHI FUJI #KS-14, (14" Dia), Crowning, Auto Cycle, 4 DP **REF#105**
PFAUTER # P-400 (16" Dia) Vertical Universal, High Tailstock **REF#105**
PFAUTER #P-400H (20" Dia x 160" Face) Horiz, Crowning, 2-Cut, Sgl Index, '76 **REF#105**
PFAUTER #P-403, (18" Dia), 2-Cut, Full Mach Encl, New '81 **REF#105**
PFAUTER #P-630, (24" Dia), Diff, Infeed, New '67 **REF#105**
LIEBHERR #L-652, (24" Dia), Diff, Infeed, Crowning, 2-Cut, Yr '76 **REF#105**
BARBER-COLMAN #25-30, (25" Dia), 30" Face Width, 2.5 DP **REF#105**

PGM-STAEHELY #SH-651, (25.5" Dia), Univ Hobhd, Yr '82 **REF#105**
LIEBHERR #L-901 (36" Dia), Crowning, Auto-2-Cut, Diff, Yr '74 **REF#105**
G&E #48HWD, (48" Dia), Worm Driven Hobhead **REF#105**
G&E #48HWD, (48" Dia), Worm Driven Hobhead, Yr '72 **REF#105**
LIEBHERR #L-1500, (60" Dia), Sgl-Index, Diff, Yr '68 **REF#105**
G&E #72HWD, (72" Dia), 1.25 DP, Diff, Infeed, Sgl-Index **REF#105**
G&E #96H (100" Dia.), 1 DP, Crowning, New '72 **REF#105**
MODUL ZSTZ-2000/3 (100" Dia) Universal Hd, Milling Hd, 49" Face, 1 DP, New '76 **REF#105**
SCHIESS #RF-30E, (125"/196" Dia), Hvy Duty w/Gashing Hd **REF#105**
BARBER-COLMAN 2 1/2 -4, S/N 119, '62 Hi-Production Spur Gear **REF#108**
BARBER-COLMAN 3HM, S/N 797, '26 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 878, '28 Completely Recon in '99 **REF#108**
BARBER-COLMAN 3HM, S/N 1088, '31 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 1152, '34 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 1158, '35 Prec Triple Thrd w/Down Feed & 90 Deg Hd **REF#108**
BARBER-COLMAN 3HM, S/N 1178, '35 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 1676, '41 Sgl Thrd Precision **REF#108**
BARBER-COLMAN 3HM, S/N 1976, '41 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 2058, '42 Triple Thrd, Reasonably Priced **REF#108**
BARBER-COLMAN 3HM, S/N 2139, '42 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 2241, '42 Triple Thrd Prec, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 2451, '42 Triple Thrd w/90 Deg Hob Head **REF#108**
BARBER-COLMAN 3HM, S/N 2648, '43 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 2823, '45 Triple Thrd w/Differential **REF#108**
BARBER-COLMAN 3HM, S/N 2840, '43 Triple Thrd w/Downfeed **REF#108**
BARBER-COLMAN 3HM, S/N 2982, '44 Triple Thrd, Gone Through **REF#108**
BARBER-COLMAN 3HM, S/N 3002R, '44 Prec Triple Thrd, Fact Reb **REF#108**
BARBER-COLMAN 6-10, S/N 3414R, '47 Prec Triple Thrd, Fact Reb **REF#108**
BARBER-COLMAN 3HM, S/N 3431, '47 Prec Triple Thrd, Fact Reb **REF#108**
BARBER-COLMAN 3HM, S/N 3492, '52 Sgl Thrd Prec, 90 Deg Att Avail **REF#108**
BARBER-COLMAN 3HM, S/N 3837R, '52 Prec Triple Thrd, Fact Reb **REF#108**
BARBER-COLMAN 6-10 SYKES, Triple Thrd w/Lever Operated Collet Assy **REF#108**
BARBER-COLMAN 6-10 B&C Ltd, S/N 8079, Triple Thrd **REF#108**
BARBER-COLMAN 6-10, S/N 4573, '57 Triple Thrd **REF#108**
BARBER-COLMAN 6-10, S/N 4626, '57 Triple Thrd 3" Hob Slide **REF#108**
BARBER-COLMAN 6-10, S/N 4659R, '56 Triple Thrd Adj Ctr Assy **REF#108**
BARBER-COLMAN 6-10, S/N 4664R, '57 Triple Thrd **REF#108**
BARBER-COLMAN 6-10, S/N 4665, '57 Fine Pitch Prec Triple Thrd **REF#108**
BARBER-COLMAN 6-10, S/N 4701, '58 Triple Thrd w/Power Down Feed **REF#108**
BARBER-COLMAN 6-10 M/C, S/N 4754, '59 Triple Thrd w/MC Conversion **REF#108**
BARBER-COLMAN 6-10 M/C, S/N 4755, '59 Triple Thrd w/MC Conversion **REF#108**
BARBER-COLMAN 6-10 Multicycle, S/N 4778R87, '60 ('87 Rebuild), Sgl Thrd Hi-Spd **REF#108**
BARBER-COLMAN 6-10, S/N 4813, '60 Triple Thrd, 800 RPM **REF#108**
BARBER-COLMAN 6-10 M/C, S/N 4913, '63 Triple Thrd w/90 Deg Hob Slide **REF#108**
BARBER-COLMAN 6-10, S/N 4941, '63 Triple Thrd **REF#108**
BARBER-COLMAN 6-10 Multicycle, S/N 5055, '66 Triple Thrd, 800 RPM **REF#108**
BARBER-COLMAN 6-10, S/N 5066, '66 Triple Thrd, 800 RPM **REF#108**
BARBER-COLMAN 6-10, S/N 5141, '67 Triple Thrd w/Prec Hob Shift **REF#108**
BARBER-COLMAN 6-10 Multicycle, S/N 5148, '68 Triple Thrd, 800 RPM **REF#108**
BARBER-COLMAN 6-10 Multicycle, S/N 5259, '75 Triple Thrd w/Auto Hob Shift **REF#108**
BARBER-COLMAN 6-10 M/C, S/N 5330, '75 Sgl Thrd Prec **REF#108**
BARBER-COLMAN 6-10, S/N 5351, '77 Triple Thrd w/3" Hob Slide, 800 RPM **REF#108**
BARBER-COLMAN 6-10, S/N 5353, '77 Triple Thrd w/3" Hob Slide, 800 RPM **REF#108**
BARBER-COLMAN 6-10, S/N 5394, '81 Fine Pitch Triple Thrd w/Dwell & Hob Rev **REF#108**
BARBER-COLMAN 6-10 M/C, S/N 5432, '87 Sgl Thread Prec **REF#108**
BARBER-COLMAN 6-16 Auto, S/N 5044, '66 Auto Loader **REF#108**
BARBER-COLMAN 6-16 Auto, S/N 5045, '66 Auto Loader **REF#108**
BARBER-COLMAN 6-16 M/C, S/N 5121, '68 Triple Thrd, 800 RPM **REF#108**
BARBER-COLMAN 6-16 M/C, S/N 5238, '70 Triple Thrd, Recon '02 **REF#108**
BARBER-COLMAN 6-10 Auto, S/N 5245, '70 Auto Loader **REF#108**
BARBER-COLMAN 6-10, S/N 5407, '82 Auto w/PLC Control **REF#108**
BARBER-COLMAN DHM, S/N 105, '42 Double Thrd **REF#108**
BARBER-COLMAN DHM, S/N 129, '42 Sgl Thrd **REF#108**
BARBER-COLMAN 14-15, S/N 336R, '49 Dbl Thrd, Fact Reb **REF#108**
BARBER-COLMAN 14-15, S/N 537R, '51 Dbl Thrd, Fact Reb **REF#108**
BARBER-COLMAN 14-15, S/N 635R, '53 Dbl Thrd, Fact Reb **REF#108**
BARBER-COLMAN 14-15, S/N 741, '55 Sgl Thrd **REF#108**
BARBER-COLMAN 14-15, S/N 745, '55 Dbl Thrd w/Dwell **REF#108**
BARBER-COLMAN 14-15, S/N 793, '56 Dbl Thrd w/Hyd Tailctr **REF#108**
BARBER-COLMAN 14-15 Dual Fd, S/N 926, '62 Dbl Thrd **REF#108**
BARBER-COLMAN 14-15 Dual Fd, S/N 938, '62 Dbl Thrd, Comp Recon **REF#108**
BARBER-COLMAN 14-15, S/N 957, '63 Dbl Thrd **REF#108**
BARBER-COLMAN 14-15, S/N 1033, '65 **REF#108**
BARBER-COLMAN 14-15, S/N 1055, '65 Dbl Thrd w/New Hyd Sys **REF#108**
BARBER-COLMAN 14-15, S/N 1068, '65 **REF#108**
BARBER-COLMAN 14-15, S/N 1114, '66 Dbl Thrd **REF#108**
BARBER-COLMAN 14-15, S/N 1131, '66 Dbl Thrd w/Hyd Tailctr **REF#108**
BARBER-COLMAN 14-15, S/N 1162, '66 Dbl Thrd **REF#108**
BARBER-COLMAN 14-15 Dual Fd, S/N 1169, '66 Dbl Thrd w/Hyd Live Ctr **REF#108**
BARBER-COLMAN 14-15 Dual Fd, S/N 1261, '67 Dbl Thrd w/Hyd Live Ctr **REF#108**
BARBER-COLMAN 14-15 Dbl Cut, S/N 1278, '68 Dbl Thrd w/4-1/8" Bore **REF#108**
BARBER-COLMAN 14-15, S/N 1383, '72 Sgl Thrd w/Hyd Live Ctr **REF#108**
BARBER-COLMAN 14-15 Dual Fd, S/N 1438, '75 Dbl Thrd **REF#108**
BARBER-COLMAN 14-30 Dual Fd, S/N 1371, '71 4-Thrd w/Sizing Cycle **REF#108**
BARBER-COLMAN 22-15, S/N 923, '62 Dbl Thrd **REF#108**
BARBER-COLMAN 16-11, S/N 148, '45 Dbl Thrd w/Hollow Wk Clamp Cylinder **REF#108**
BARBER-COLMAN 16-11, S/N 184, '50 Dbl Thrd w/Vert DRO **REF#108**
BARBER-COLMAN AHM, S/N 1896, '42 Sgl Thrd w/3 Jaw Chuck **REF#108**
BARBER-COLMAN AHM, S/N 2133, '44 Sgl Thrd **REF#108**
BARBER-COLMAN AHM, S/N 2448, '46 Dbl Thrd w/Cam Down Fd **REF#108**
BARBER-COLMAN 16-16, S/N 2745, '51 Sgl Thrd w/90 Deg Hd **REF#108**
BARBER-COLMAN 16-16, S/N 3169, '53 Sgl Thrd **REF#108**
BARBER-COLMAN 16-16, S/N 3171, '53 Dbl Thrd, Spanish Nameplates **REF#108**
BARBER-COLMAN 16-16, S/N 3409, '56 Sgl Thrd **REF#108**
BARBER-COLMAN 16-16, S/N 3572, '58 Sgl Thrd **REF#108**
BARBER-COLMAN 16-16, S/N 3580, '59 Dbl Thrd w/Diff & Auto Hobshift **REF#108**
BARBER-COLMAN 16-16 Multicycle, S/N 3682R, '59 Dbl Thrd, Air Operated w/Diff **REF#108**
BARBER-COLMAN 16-16 Multicycle, S/N 3641, '60 Dbl Thrd w/Diff **REF#108**
BARBER-COLMAN 16-16, S/N 3660, '57 Sgl Thrd **REF#108**
BARBER-COLMAN 16-16 Multicycle, S/N 3718, '61 Dbl Thrd w/Auto Hob Shift **REF#108**
BARBER-COLMAN 16-16, S/N 4061R, '66 **REF#108**
BARBER-COLMAN 16-16, S/N 4111, Dbl Thrd, "C" Style End Brace **REF#108**
BARBER-COLMAN 16-16, S/N 4136, Dbl Thrd, "C" Style End Brace w/Diff **REF#108**
BARBER-COLMAN 16-16 Multicycle, S/N 4170, Dbl Thrd w/Jump Cut Cycle "C" Style **REF#108**
BARBER-COLMAN 16-16, S/N 4175R, '67 4-Thrd, "C" Style End Brace **REF#108**
BARBER-COLMAN 16-16, S/N 4176R, '67 4-Thrd, "C" Style End Brace **REF#108**
BARBER-COLMAN 16-16, S/N 4182R, '67 4-Thrd, "C" Style End Brace **REF#108**
BARBER-COLMAN 16-16, S/N 4257, '68 4-Thrd w/Workclamp Cyl "C" Style **REF#108**
BARBER-COLMAN 16-16, S/N 4259, '68 **REF#108**
BARBER-COLMAN 16-16, S/N 4473, '73 4-Thrd w/Workclamp Cyl "C" Style **REF#108**
BARBER-COLMAN 16-16 Multicycle, S/N 4520, '75 Dbl Thrd w/Gooseneck Slide **REF#108**
BARBER-COLMAN 16-16 Multicycle, S/N 4631, '79 "C" Style End Brace, 4W Adj Ctr **REF#108**
BARBER-COLMAN AHM (36"), S/N 572, '39 Dbl Thrd **REF#108**
BARBER-COLMAN AHM (36"), S/N 1152, '42 Dbl Thrd **REF#108**
BARBER-COLMAN 16-36, S/N 3613, '59 Sgl Thrd **REF#108**
BARBER-COLMAN 16-36, S/N 4090, '66 Dbl Thrd, "C" Style End Brace **REF#108**
BARBER-COLMAN 16-36 Multicycle, S/N 4232, '68 Dbl Thrd "C" Style End Brace w/Diff **REF#108**
BARBER-COLMAN 16-56, S/N 3136R84, '53 (Reb '84), Dbl Thrd **REF#108**
BARBER-COLMAN 10-20, S/N 6700045890, '76 Dbl Thrd w/2 Cut Cycle **REF#108**
BARBER-COLMAN SHM (1 1/2), S/N 719 **REF#108**
BARBER-COLMAN SHM (1 1/2), S/N 824 **REF#108**
BARBER-COLMAN SHM (1 1/2), S/N 825 **REF#108**

GEAR PINION HOBBERS & SPLINE MILLERS

LEES BRADNER #SH, 8" Dia, 54" Face, 4 DP, '50 **REF#107**
LEES BRADNER #HH, 15" Dia, 59" Face, 2.5 DP, '77 **REF#107**
HURTH #KF-32A, 15" Dia, 59" Face, '67 **REF#107**
BARBER-COLMAN #11"x48", 11" Dia, 48" Face, 2 DP, '68 **REF#107**
NEWARK Horiz Pinion Hob, 18" Dia, 112" Face, 5 DP **REF#107**
WANDERER #GF32N, 13" Dia, 200" Face, 200" CC, 3" DP, '80 **REF#107**

GEAR HOB & CUTTER SHARPENERS (incl CNC)

ARTER #A-12, 12" Rotary Surface Grinder for Sharpening Sharper Cutters **REF#107**
BARBER-COLMAN #10-12, Dry Machine, Dust Collector, Manual Dresser, '40's **REF#107**
BARBER-COLMAN #4-4, 4" Dia, 4" Long, '51 **REF#107**
BARBER-COLMAN #6-5 & #4-4, All machines will grind straight & spiral gash **REF#107**
HEALD #22 Rotary, 13" Dia, 12" Chuck **REF#107**
KAPP #AS204GT, 10" Dia, Wet Grinding, CBN Wheels, New '82 **REF#107**
KAPP #AS-305T, 12" Dia, Straight & Spiral Gash, CBN Wheels, Lots of Tooling **REF#107**
KLING #SNC-30, CNC, 12" Dia, 18" Length, CBN or Std Wheels w/Hob Checker, '83 **REF#107**
KLING #AGW-30A, 11" Dia, 16" Part Length, Straight & Spiral Gash, '62 **REF#107**
UTMA #LC-35-NC4, 4-Axis, NC Hob & Cutter Sharpener, 10" Dia x 10" Length **REF#107**
STAR #2VHS-EZ, 6" Max Hob, Coolant Filtration System, New '73 **REF#107**
MAAG #WS, 2 Rack Cutter Sharpener **REF#100**
KLING #GW20, Hob Sharpener/Grinder, Very Nice, Complete Machine **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#105**
BARBER-COLMAN #2 1/2-2, (2.5" Dia) Straight Flute Hobs **REF#105**
BARBER-COLMAN #3-4/4, Index Plates **REF#105**
BARBER-COLMAN #6-5, (6" Dia, 5" Face), Yr '57-'70 **REF#105**
MIKRON #A62, (6" Dia), Auto Dressing, Coolant **REF#105**
KLINGELNBERG #AGW-230, (10" Dia), Index Plates **REF#105**
KLINGELNBERG #SNC-30, (12" Dia), CNC Hob Sharp, New '84 **REF#105**
KLINGELNBERG #ZS-231, Wheelhd for AGW-232, 230, 231, 301, 421 **REF#105**
FELLOWS #6SB, (6" Dia), Helical, 50° Helix Angle **REF#105**
MAAG #WS/3, Rack-Type **REF#105**
GLEASON #2JST, (6" Dia), Straight Bevel Coniflex **REF#105**
GLEASON #13A, (18" Dia), Bevel **REF#105**
KLINGELBERG Index Plates and Arbors **REF#105**
BARBER-COLMAN 2 1/2 -2, S/N 3, '64 Wet Manual Feed **REF#108**
BARBER-COLMAN 2 1/2 -2, S/N 16, '66 Wet w/Auto Feed **REF#108**
BARBER-COLMAN 6-5, S/N 47R, '53 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 51R, '53 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 110R, '55 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 157, '56 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 264, '62 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 265, '62 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 296, '63 Wet **REF#108**
BARBER-COLMAN 6-5, S/N 392, '66 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 396, '66 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 424, '69 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 6-5, S/N 433, '69 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 4HS, S/N 332, '51 Dry w/Mist System **REF#108**
BARBER-COLMAN 4HS, S/N 381, '52 Dry **REF#108**
BARBER-COLMAN 10-12, S/N 520R82, Wet w/Auto Dress & Sparkout, Fact Reb '82 **REF#108**
BARBER-COLMAN 10-12, S/N 598, '65 Wet w/Auto Dress & Sparkout **REF#108**
BARBER-COLMAN 10-12, S/N 643R83, Wet w/Auto Dress, PC Control, Fact Reb '83 **REF#108**

GEAR LAPPERS

GLEASON #503, (10.5" Dia), Hypoid, 90-Degree **REF#105**

GEAR SHAPERS CNC

FELLOWS #10-2 & 10-4, 1 to 4-Axis, CNC, 10" Dia, 2"-4" Face, 4 DP, Reb '03 **REF#107**
FELLOWS 20-4, 4-Axis, 20" Int/Ext Dia, 4" Face, New '70/'03 **REF#107**
FELLOWS 100" CNC Gear Shaper, 12" Stroke, Retrofitted In '98 **REF#107**
FELLOWS 50-8, 6-Axis, 51.18" Int/Ext Dia, 8" Face, New '86 **REF#107**
FELLOWS FS-630-200, 6 Axis, 24" Dia, 8" Face, 3 DP, '95 **REF#107**
LIEBH/LORENZ #WSC-1202, CNC, Shaper, 48" Dia, 12" Face, 3 DP, '90 **REF#107**
LORENZ #LS-180, 4-Axis, CNC, 7" Max OD Ext, 11" Max ID, 2" Stroke, New Controls '03, New '87 **REF#107**

MITSUBISHI #SC15, CNC, 5-Axis, 5.9"/2.4" Ext/Int Dia, 6.35 DP, Fanuc OMB Control, New '93 **REF#107**
FARREL-SYKES #2A Herringbone Gear Shaper **REF#101**
FELLOWS Type 6 Gear Shapers **REF#101**
TOS OHA-32, CNC 5, Shaping Machine **REF#104**
TOS OHA-16, CNC 5, Shaping Machine **REF#104**
TOS OHA-50, CNC 5, Shaping Machine **REF#104**
LORENZ #MCS-40, (20" Dia), 6" Face, 6 Axis Ret w/Warr, New '90 **REF#105**
LIEBHERR #WS-501, (20" Dia), 5" Face, 5 Axis SIEMENS 840D, New '89/'03 **REF#105**
FELLOWS #50-8, (51" Dia), Sgl Axis NC, 3 Axis PLC, New '76 **REF#105**
MAAG CNC Retrofit Pkgs for Both Crank-Type & Screw Type Machines **REF#105**
FELLOWS #10-4/10-2, Qty 150 **REF#106**
HYDROSTROKE #50-8, Qty 2 **REF#106**
HYDROSTROKE #20-8, Qty 5 **REF#106**
HYDROSTROKE #FS630-125, Qty 1 **REF#106**
HYDROSTROKE #FS400-90, Qty 2 **REF#106**
FELLOWS #20-4, Qty 6 **REF#106**
FELLOWS #48-8Z, Qty 1 **REF#106**
36" Shapers, 14" Throat Risers, 53" of Swing, Qty 3 **REF#106**

GEAR SHAPERS

BARBER-COLMAN #HD-200, 3 DP, 2.75" Stroke, Exc Cond, New '84 **REF#107**
FELLOWS #10-2, 10" Dia, 4" Face, 4 DP, '82 **REF#107**
FELLOWS #10-4, 10" Dia, 4" Face, 4 DP, '96 **REF#107**
FELLOWS #120-8, 8" Stroke, Spur Guide, Reb '88, New Electrics, Dig Readout **REF#107**
FELLOWS #18-5, 18" Dia, 5" Face, 3 DP, '74 **REF#107**
FELLOWS #200, 8" Stroke, 200" Dia Spur, Exc Cond, 1 DP, Reb '88 **REF#107**
FELLOWS #20-4, 20" Dia, 4" Face, 4 DP, '75 **REF#107**
FELLOWS #3-3 & #3-1, 3" Max Dia, 1" Face, Pinion Support, High Precision, New '60's **REF#107**
FELLOWS #36-6, 36" Dia, 6" Face, 3 DP, '51-'55 **REF#107**
FELLOWS #36-6, 36" Dia, 6" Face, 3 DP, '68 **REF#107**
FELLOWS #36-8, 36" Dia, 8" Face, 3 DP, '53 **REF#107**
FELLOWS #4AGS, 6" Dia, 2" Face, 4 DP, '68 **REF#107**
FELLOWS #4GS, 6" Dia, 2" Face, 6 DP, 2" Riser, New '61 **REF#107**
FELLOWS #50-8 Hydrostroke, 50" Dia, 8" Face **REF#107**
FELLOWS #50-12 Hydrostroke, 50" Dia, 12" Face **REF#107**
FELLOWS #6, 16" Dia, 3" Face, 3 DP, '70's **REF#107**
FELLOWS #61, #6A, #61A, #645A, From 18"-35" Dia, 0-12" Risers, Sev Avail **REF#107**
FELLOWS #612A, 18" Dia, 5" Face, 3 DP, '40's **REF#107**
FELLOWS #615A, 18" Dia, 5" Face, 3 DP, '40's-'60's **REF#107**
FELLOWS #645A, 18" Dia, 5" Face, 3 DP, '50 **REF#107**
FELLOWS #71, 7" Dia, 1.5" Face, 6 DP, '50's **REF#107**
FELLOWS #712, 7" Dia, 1.5" Face, 6 DP, '48 **REF#107**
FELLOWS #7125 & #7125A, 7" Dia, 1.5" Face, 6 DP, '50's **REF#107**
FELLOWS #7125A, #7, #7A, #715, 7" Dia, 1 1/2-2" Stroke, Different Risers **REF#107**
FELLOWS #72, 7" Dia, 1.5" Face, 6 DP, '48 **REF#107**
FELLOWS #725, 7" Dia, 1.5" Face, 6 DP, '50's **REF#107**
FELLOWS #75, 7" Dia, 1.5" Face, 6 DP, '50's **REF#107**
FELLOWS #75A, 7" Dia, 1.5" Face, 6 DP, '50's **REF#107**
FELLOWS #8AGS, Vert Shaper, 8" Dia, 2" Face, 6-7 DP **REF#107**
FELLOWS #Horiz Z Shaper, 6" Stroke, 17" Bore in Table, New '50's **REF#107**
MAAG #SH-100K, Disc Control, 47" Dia, 12" Face, 1.7 DP, '60's **REF#107**
MAAG #SH-180/300, Ext Generating/Int Gashing Heads, New '60's **REF#107**
MAAG #SH-350/500, 200" Dia, 21" Face, .75 DP, New Cutter Head Installed 85, '60's **REF#107**
MAAG #SH-450/500, 200" Dia, 27.5" Face, Crowning, Exc Cond, '76 **REF#107**
MICHIGAN #18106, 10" Dia, 4.5" Face, 5 DP **REF#107**
TOS #OHA-50A, 20" Dia, 5" Face, 3.1 DP, '85 **REF#107**
TOS #OHA50A, Auto, 20" x 5", Yr '86 Low Hours **REF#100**
MAAG #SH100, w/JV100 **REF#100**
MAAG #SH75C, Sub Table, Steady, Nice **REF#100**
MAAG #SH45 w/Tail Stock & Tooling **REF#100**
FELLOWS #6 Gear Shaper **REF#102**
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-16BA, Shaping Machine **REF#104**
TOS OHA-32B, Shaping Machine **REF#104**
TOS OHA50B, Shaping Machine **REF#104**
MAAG SH75K, Shaping Machine, Yr '66, Reb '00 **REF#104**
MAAG SH180/300, Yr '60, Reb '00 **REF#104**
MAAG SH100, Shaping Machine, Yr '63, Reb '00 **REF#104**
MAAG SH75K, Shaping Machine, Yr '66, Reb '00 **REF#104**
FELLOWS #3, (3" Dia), Fine Pitch, w/Change Gears **REF#105**
FELLOWS #725, (7" Dia), 1.5" Face **REF#105**
FELLOWS #8AGS, (8" Dia), 2" Face **REF#105**
FELLOWS #10-2, (10" Dia), 2" Face **REF#105**
FELLOWS #10-4, (10" Dia) 4"Face **REF#105**
MICHIGAN #18106, (14" Dia), "Shear Speed" **REF#105**
FELLOWS #36-6 (36" Dia) Cutter-Elevating, 6" Riser, New '69/'70 **REF#105**
FELLOWS #50-8, (51" Dia), "Hydrostroke", 8" Face **REF#105**
MAAG #SH-180/300K (118" Dia), 17" face, DS-Swivel Hd **REF#105**
MAAG #SH-250/300, (121.3" Dia), 26" Face Width, New '76 **REF#105**
MAAG #SH-450 (170" Dia), 26" Face, Swivel Tool Holder, '76 **REF#105**

BARBER-COLMAN Model 10, '73 Three Cut Machine **REF#108**
FELLOWS 645A, S/N 20683 **REF#108**
FELLOWS 7125, S/N 23090, '42 Face Cutting Atc **REF#108**
FELLOWS 645A3, S/N 20716, '41 **REF#108**
FELLOWS 7125A, S/N 27805, '50 **REF#108**
FELLOWS 6A, S/N 20212, '41 **REF#108**
FELLOWS 7125, S/N 33904 **REF#108**
FELLOWS 3.2 S/N 32251 **REF#108**
FELLOWS 645A, S/N 33506 **REF#108**

GEAR DEBURRING/CHAMFERING/POINTING

CROSS #75 Gear Tooth Chamferer, 10" Max Dia, 10" Face, New '52 **REF#107**
HURTH #SRS400, Gear Shaver, Grinder & Sharpener, 1.57" Dia **REF#107**
HURTH #ZK-5, Twin Spindle Chamfering & Deburring Mach, Good Condition **REF#107**
HURTH #ZK-7, Twin Spindle Chamfering & Deburring Mach, New '82 **REF#107**
NAT BROACH RED RING, #GCU-12, 9" Cutter Shaver, 8" Max Dia, New '82 **REF#107**
RED RING #GCU-12, 9" Cutter Head, w/Crowning, New '91 **REF#107**
RED RING #GCX-24", 3"-24" Pitch Dia Crowning, Tailstock, Taper Attachment, '74 **REF#107**
RED RING #GCY-12, Gear Shaver, 12" Dia, 6" Stroke, Crowning, '68 **REF#107**
RED RING #GYC-18, Gear Honing Machine, 18" Dia, 6" Stroke, '64 **REF#107**
RED RING/NAT BROACH #GF-300, 7-Axis CNC Gear Finisher, 12" Dia Cap, '90 **REF#107**
REDIN # 6, 6" Dia, 3" Face, .33 to 14 RPM, 4" Int **REF#107**
REDIN #18, 28" Dia, 2,3,4 Spindle, Deburrer/Chamfer, NEW '90's-'00, (8) Machines **REF#107**
SAMPUTENSILI #SCT-3, Chamf/Deburrer, 14" Dia, 5" Face, New '82 **REF#107**
CROSS #75, (10" Dia) **REF#105**
CROSS #65, (10" Dia), 9" Face, 4 DP **REF#105**
REDIN #24 (28" Dia) CNC Twin Spindle Deburring Mach, Yr '90 **REF#105**

GEAR HONERS

FASSLER #K-400, Int Gear Honer, 12.6" Dia, 12" Stroke, NUM 1080 Control, New '95 **REF#107**

GEAR SHAVERS

RED RING Shaver 12" **REF#101**
RED RING #GCY-12, (12" Dia), 9" Cutter-Head **REF#105**
RED RING #GCU-18, (18" Dia), Crowning **REF#105**
RED RING #GCJ-36/60, (60" Dia), 12" Cutter-Head **REF#105**

GEAR GENERATORS, STRAIGHT BEVEL

GLEASON #12, 12" Cone, 3.5 Face, '50's **REF#107**
GLEASON #14, Coniflex, Str Bevel Generator, 12" Max Cone Dist, 3.5" Face **REF#107**
GLEASON #104, Coniflex, Str Bevel Generator, 4.5" Max Cone Dist, 1.375" Face **REF#107**
GLEASON #114, Coniflex, Str Bevel Generator, 7" Max Cone Dist, 2.5" Face **REF#107**
GLEASON #24A, Coniflex, 1.5 DP, 6" Face, 6" Work Spindle Bore **REF#107**
GLEASON #37, 26" Cone, 10" Face **REF#107**
GLEASON #54, 38" Cone, 17" Face **REF#107**
MIKRON #120.1 & 132.02, 1.6" Dia, 25 DP, 50's-60's **REF#107**
GLEASON #3", (4.45" Dia), 2-Tool w/Segments & Gears **REF#105**
GLEASON #710, (10" Dia), Coniflex **REF#105**
GLEASON #14 (24"dia) Coniflex w/gauges, gears **REF#105**
GLEASON #114, (16" Dia), Coniflex **REF#105**
OERLIKON #K4A, (63" Dia), Templates, Full Gears, .7 DP **REF#105**

GEAR GENERATORS, SPIRAL BEVEL (HYPOID)

CNC 116 Gear Generator or Hypoid Rougher w/Fanuc 161-MA Control **REF#102**
GLEASON #641 (G-PLETE) (16" Dia), CNC Retrofit '03 **REF#105**
GLEASON Index Plates for 11 & 22 Hypoid Rougher & Finisher **REF#105**

GEAR GENERATORS, HERRINGBONE

SYKES #1A, 12" Dia, 30˚ Guide & Spur Guide **REF#107**
FARREL-SYKES #5B, 61" Dia, 18" Face, 2 DP **REF#107**
FARREL-SYKES #10A, 120" Dia, 24" Face, 1-1/4 DP, 18" Hole Thru Spindle, 30 Deg Guides **REF#107**
FARREL-SYKES #2A Herringbone Gear Shaper **REF#101**
FARREL-SYKES #3C, (37" Dia), 8" Face, 30" LH/RH Guides **REF#105**

GEAR GRINDERS CNC

OERLIKON/OPAL #50, CNC, Form Grinder, 20.5" Dia, 24.8" Face, New '98 **REF#107**
REISHAUER #RZ-301S, CNC, 12" Dia, 4 DP, DIN 5 Grinding Quality, New '89 **REF#107**
NILES #10L, CNC, 39.4" Dia, 12 DP, AB PLC 2 Control, New '88 **REF#107**
HOFLER #H-1253, 10-Axis, CNC, 59" Dia, 28" Face, 1 DP, '96 **REF#107**
MITSUBISHI #ZG-400, 5-Axis, CNC, 15.75" Dia, 3.175 DP **REF#107**
MITSUBISHI #ZG-1000, 5-Axis, CNC, 39.37" Dia, 1.41 DP **REF#107**
GLEASON #120 Curvic Grinder **REF#102**
HOFLER Supra 1253 CNC, Yr '96, Reb '00 **REF#104**
REISHAUER #RZ-301AS, (13" Dia), Production CNC, New '92 **REF#105**
KAPP #VAS-531, (20" Dia), CNC Spur/Helical, New '91 **REF#105**
REISHAUER RZ801S (30"dia) CNC w/AM-dresser & SPA unit, New '96 **REF#105**

KLINGELNBERG-WIENER #W-800 (31.5" Dia.), CNC Spiral Bevel, 1.4 DP, New '90/'03 **REF#105**
GLEASON # 130, (36" Max Dia), CNC Curvic Cplg, Comp Reb **REF#105**

GEAR GRINDERS

OKAMATO # SHG-360H, 15" Dia, 8" Face, 5 DP, '80's **REF#107**
PFAUTER #PE-1200G, 47" Dia, New '95 **REF#107**
REISHAUER ZA, 13" Dia, 6" Face, Straight & Helix **REF#107**
REISHAUER #OZA, 11.8" Dia, 6.7" Face, 5 DP, '69 **REF#107**
REISHAUER #RZ-300E, 12" Dia, 5 DP, '86 **REF#107**
REISHAUER #RZ-301S/AS, 13" Dia, 7" Face, '90's **REF#107**
REISHAUER #AZA & #AZA-K, 11" Diam, 3 DP, 7" Face, Exc Cond, '77-'89 **REF#107**
REISHAUER #ZB, 27.5" Max Dia, 11" Face, Good Cond, New '70 **REF#107**
HOFLER #H-500, 20" Dia, 7" Face, 2 DP, '79 **REF#107**
HOFLER #H-630, 25" Dia, 9" Face, 1.5 DP, '80 **REF#107**
RED RING #SF-500, Int/Ext, 26" Dia, 30" Face, 2 DP, '88 **REF#107**
MAAG #SD-36-X, 14.2" Dia, 2.1 Max DP, Like New!! '89 **REF#107**
NILES #10L, 39.4" Dia, 12 DP, AB PLC 2 Control, New '88 **REF#107**
MAAG 72" Gear Grinder **REF#101**
MAAG 32" Gear Grinder **REF#101**
STANKO 24" Gear Grinder, New **REF#101**
NILES 800 Millimeter Gear Grinder **REF#101**
GLEASON #120 Curvic Grinder **REF#102**
NILES ZSTZ 10, Yr '79 **REF#104**
REISHAUER ZB, Yr '67, Reb '00 **REF#104**
MAAG #HSS-30A, (11.8" Dia), Spur **REF#105**
REISHAUER #AZA-K, (12" Dia), SPA Diamond Disc, New '79 **REF#105**
MAAG # SD-32X, (12.6" Dia), 9.8" Face, T&R **REF#105**
OKAMOTO #SHG-360, (14" Dia), FAESSLER "DSA" Diamond Disc **REF#105**
HOFLER #H-500, (20" Dia), Spur/Helical, Crowning T&R, New '80 **REF#105**
HOFLER #H-630/800 (30" Dia) Spur/Helical, Crowning, New '80 **REF#105**
HOFLER #H-1000E (40" Dia), Spur/Helical, Crowning, New '88 **REF#105**
MICHIGAN #MHGGI-FA, (40" Dia) x 24" Face, Spur/Hel/Int/Ext **REF#105**
REISHAUER #DS, Diamond Lapping Machine **REF#105**

GEAR RACK MILLERS/SHAPERS

FELLOWS #3X36 Rack Shaper, 3" Face, 36" Length, 4 DP, Good Cond, New '60 **REF#107**
FELLOWS #61A, Gear Shaper w/48" Rack Att, 8" Riser, Exc Cond, Reb '90's **REF#107**
MIKRON #134, Shaper, 1.1" Face, 14.4" Length, 16-20 DP **REF#107**
SYKES VR-72, Vert Rack Shaper, 72" Cut Length, 4DP, 4" Stroke, '60's **REF#107**
SYKES VR-72B, Vert Rack Shaper, 72" Cut Length, 4DP, 4" Stroke, '70 **REF#107**
SYKES 1800R, Vert Rack Shaper, 72" Cut Length, 4DP, 4" Stroke, '80 **REF#107**
SYKES Machine Package Price Also Available, CALL TODAY **REF#107**

GEAR THREAD & WORM, MILLERS/GRINDERS

EXCELLO #39A, 9.5" Dia, 5" Length, '60's **REF#107**
HANSON-WHITNEY, 10" x 24" Univ Thread Mill **REF#107**
HECKERT #ZFWVG, 10" Dia, 49" Length, '99 **REF#107**
HECKERT #ZFWG, 250 X 2000, 19.6" Over Bed, 19.6" 78.7" Hob Length, Reb '01 **REF#107**
J&L 12x45, 12" Dia, 45" Length **REF#107**
LEES BRADNER #HT, 12"x 36" Horiz Thread Miller, 12" Dia, 36"Length **REF#107**
LEES BRADNER #LT, 9" x 54" Thread Miller, 2-3/4" Hole, Steady Rest, '40's **REF#107**
LEES BRADNER #HT, 12" x 102" Thread Miller, 6" Hole, Steady Rests, '40's **REF#107**
PRATT & WHITNEY #6x20, #4.5 x 36, 6" Dia, 20" Length, '48 **REF#107**
REISHAUER #UL-900, 9" Dia, 18" Grinding Length, '80's **REF#107**
REISHAUER #US, 10" Dia, 36" Grinding Length, 46" Bet Ctrs, New '80 **REF#107**
WANDERER #31L x 3000, 8" Dia, 120" Length, '60's **REF#107**
WANDERER #31Lx3000, 120" Centres **REF#100**

GEAR TESTERS/CHECKERS (incl CNC)

Please Check Our Website to View the Gear Testers & Recorders In Our Inventory **REF#107**
GLEASON 13 Hypoid Tester (2) **REF#102**
TOS IMZ-50, Gear Tester **REF#104**
GLEASON #15, (15" Dia), Blank Checking Device **REF#105**
GLEASON #D-15S, Spiral Bevel Cutter Inspection Device **REF#105**
FELLOWS #4RL, (4" Dia), Comp Roll Checker **REF#105**
FELLOWS #12M, (12" Dia), Involute **REF#105**
HOFLER #EFR-401, (15.75" Dia), Lead & Involute **REF#105**
ILLINOIS #3412B-2C, (12" Dia), Involute **REF#105**
ILLINOIS #3424B-3C, (24" Dia), Involute **REF#105**
ILLINOIS #3712A-2C, (12" Dia), Tooth Space Comp **REF#105**
ILLINOIS #3806, (6" Dia), 24"cc **REF#105**
GLEASON #519 (36"dia.) Universal Angular Bevel Tester **REF#105**
ILLINOIS #524, (36" Dia), Involute Profile Checker **REF#105**
MAAG #DAS-1, Composite **REF#105**
MAAG #TML, Hand-Held Pitch Tester, 50–3 DP **REF#105**
RED RING #GRH, (10.375" Max cc) **REF#105**
PARKSON #30, Worm & Worm Wheel Att **REF#105**
KLING #PFSU-2500, (100" Dia), Lead/Inv/Spacing, w/Warranty **REF#105**

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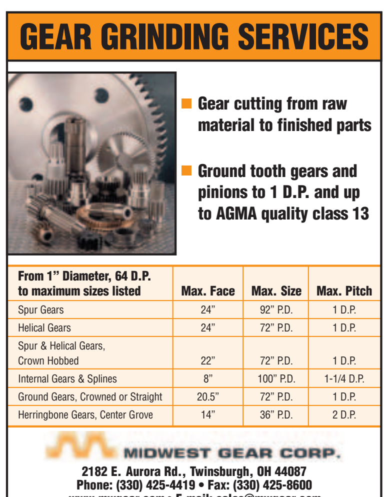

From 1" Diameter, 64 D.P. to maximum sizes listed	Max. Face	Max. Size	Max. Pitch
Spur Gears	24"	92" P.D.	1 D.P.
Helical Gears	24"	72" P.D.	1 D.P.
Spur & Helical Gears, Crown Hobbed	22"	72" P.D.	1 D.P.
Internal Gears & Splines	8"	100" P.D.	1-1/4 D.P.
Ground Gears, Crowned or Straight	20.5"	72" P.D.	1 D.P.
Herringbone Gears, Center Grove	14"	36" P.D.	2 D.P.

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He has traveled extensively throughout the world, providing broach and rack users with engineering, manufacturing, and troubleshooting support.

Petrimoulx can be contacted at (704) 547-0614. The company's Web site is [www.nachi.com].

LeCount Attends China Gear Show in Shanghai

Chip Brettell, president of LeCount and Marshall Krumpe, marketing and sales consultant, recently visited the China Gear Show 2003 in Shanghai, China.

LeCount—which is located in White River Junction, Vermont—manufactures high-quality expanding mandrels and hydraulic workholding tooling, and currently sells its products in the United States, Europe, Latin America, India, and Japan. The company attended the show to investigate the China Gear market for new sales opportunities.

"What a great experience, both professionally and personally," says Brettell. "The people we encountered were gracious and welcoming, and the business opportunities are overwhelming."

Prior to its departure, LeCount made contact with three Vermont groups who provide export assistance to Vermont companies. Susan Murray, of the U.S. Commercial Service, Curtis Picard and Chris Barbieri of the Vermont Chamber of Commerce, and Bill Zuccareno of the Vermont World Trade Office offered timely advice and assistance.

Upon arrival in Shanghai, James Golsen—the commercial officer at the American Consulate—conveyed that VIP treatment was being provided by the China Gear Manufacturers Association, including a private introduction to key members of their association, a place on the podium during the ribbon-cutting ceremonies, and an invitation to make an informational presentation on LeCount and its products at a special meeting of the entire association membership.

"It was a bit overwhelming being asked to speak in front of such an influential group with little preparation, as well as getting comfortable with using a translator," says Krumpe. "But it was a unique opportunity to put LeCount in front of such a large group of prospects."

The Chinese Gear Show, which was held at the Everbright Exhibition Center in the center of Shanghai last December, was extremely well attended. Brettell says that it was an excellent opportunity to analyze the market opportunities for LeCount expanding mandrels, as well as a chance to meet customers and colleagues, such as Gleason Sales (China) and Siber Hegner China.

For more information contact Marshall Krumpe at (802) 296-2200, or via e-mail at marshall@lecount.com. The company's Web site is [www.lecount.com].

Curtiss-Wright Acquires Evesham Coatings

The Curtiss-Wright Corporation has announced the acquisition of selected assets of a coatings business based in Evesham, United Kingdom, for approximately 3.4 million pounds sterling from Morgan Advanced Ceramics Ltd, a subsidiary of Morgan Crucible Plc. Evesham will operate as part of the E/M Coatings business unit of the Metal Treatment segment of Curtiss-Wright Corporation.

Evesham manufactures and applies an extensive range of solid film lubricant (SFL) coatings which provide lubrication, corrosion resistance, and enhanced engineering performance. These coatings are applied under the trade names of Everlube, Ever-Slik, Lube-Lok, Lubri-Bond, Flurene, and Perma-Slik to steel, titanium, and aluminum substrates. With 2003 sales of approximately 2.6 million pounds, Evesham has a diverse base of approximately 300 customers in automotive (50 percent), oil exploration (15 percent), and general industrial (35 percent) markets. Evesham has 53 employees, and its state-of-the-art 32,000 square-foot facility has ISO 9001 quality certification.

Evesham is a sister facility to the six North American E/M Coatings Service facilities that were acquired by Curtiss-Wright in 2003. E/M Coatings constitutes the largest provider of SFL coatings in North America. The coatings are used in a broad range of products and industries whenever conventional wet lubricants provide insufficient protection due to high temperatures, extreme loads, corrosion, wear, chemical corrosion, or other adverse operating conditions.

"The Evesham acquisition is an integral piece of the E/M Coatings business we acquired in 2003 as part of our strategic objective to grow and diversify our metal treatment services," says Martin R. Benante, chairman and CEO of Curtiss-Wright. "Evesham will provide a premier coatings facility which will generate customer and product synergies with our other European metal treatment facilities."

For more information contact Alexandra Magnuson at (973) 597-4734. Visit the company's Web sites at [www.curtisswright.com] and [www.metalimprovement.com].

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Q&A

Our Conversations with Industry Leaders

with Robert L. Handwerk

Founder and President, RLH & Associates, LLC.

> **What differentiates us from the competition is that all of our people have already been successful in business management, so we're able to bring that experience to the table when we're working with our clients.**

GS: *How long has your company been in business, and what are your primary activities?*

RH: We've been in business for the past nine years, and we basically provide executive and management services to enhance employee productivity and increase profitability. Quite a bit of this includes management training, but there are a few subsets to that. For example, Raycar Gear and Machine Company is a good customer of ours, and we've done a variety of growth enhancement projects with them. We've been privileged to provide executive coaching with Dan and Joy Schwartz, who are the co-owners, and management and supervisory training for their team leaders, helping them to develop team-building and human-management skills, along with creating performance and reward systems. We do what I call "process work," helping produce employee handbooks and policy development guidelines, involving systems related to employment, payroll policies, employee benefits, progressive discipline, sexual harassment, drug use, those sorts of things. We also market Profile assessment tools, which is one of our product lines that helps companies hire, retain, and promote the right people. That's a sophisticated online service that we market across the country to help companies select—based on job fit for their individual firm—everybody from presidents to vice presidents and production managers, schedulers, and technicians. In some cases we're involved in the executive search process, and we also help with strategic planning and goal setting. In other words, we help them achieve the particular mission that they've defined.

GS: *Seems like you'd need to know a lot about a company before you begin the process.*

RH: Yes, we try and find out some of the basic things about the company, in terms of how long they've been in business and what their area of specialization is. We learn all we can about their customer base and the technology they have available, the company's history and ownership structure, and their particular needs and concerns. Most of our work comes from referrals, and they share their perception of what the potential client's challenges are, as told to them by their intimate with the firm. So we often know something about the challenges the company is facing going in. And every business or industry has its own nomenclature and way of going about doing things, so we have to get up to speed in those areas in a hurry. We work with a lot of clients who are involved in the gear industry, but we've also worked with others that are involved in metalworking, plastics, carpentry, even insurance. But that's what keeps us young, and always excited about the next project.

GS: *We've discussed how you can help your clients with their internal operations, but how about their relationship with customers?*

RH: One thing we try to emphasize is that every company has two sets of customers, internal and external. A lot of people forget about that, but a good relationship with your internal customers—your employees—will improve your dealings with external customers as well. We also point out that what you as a company may perceive as good customer service is actually based on your own internal strategy, but is that really the same thing as what your customer thinks? They may want something completely different. With some customers it's important to get things there way ahead of time, and others might be driven more by cost. I have a customer who's really impressed when his suppliers make their deliveries in bright, shiny trucks. For whatever reason, that's really important to him. So you just can't deliver everything to every customer in the same way, in the same time frame, and in the same packaging. You've got to figure out what makes them tick, and then deliver on that.

GS: *I would think that the same thing applies to your company. How do you go about delivering on your customer's particular needs?*

RH: First we do our research, as I've mentioned, and then we determine which members of our staff can best address the customer's situation. Everyone on our staff has a great deal of experience. For instance, we have one person whose expertise is in compensation and employee benefits, and another whose strength is in strategic planning and team building. We also have a life-balance coach, and another who works primarily in recruiting and skill assessments. In fact, that's one thing that helps differentiate us from the competition: all of our people have already been successful in business management, so we're able to bring that experience to the table when we're working with our clients. They want someone who can relate to their situation in a real-world sense, and that's exactly what we're able to provide.

Robert L. Handwerk has more than 25 years of experience in human resources management and human services, and he holds an M.Ed degree in guidance and counseling. He can be reached at (262) 728-9682, or via e-mail at info@rlhassociates.com. Visit the company's Web site at [www.rlhassociates.com].

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