

GEAR TECHNOLOGY

The cover features a large, detailed image of a gear on the left side. In the center, a metrology probe is shown measuring a surface. In the background, a computer monitor displays several line graphs. The overall theme is industrial gear manufacturing and metrology.

The Journal of Gear Manufacturing

IMTS 98 SHOW ISSUE

September/October 1998

**WHO'S WHO AT IMTS
THE KEYS TO ISO 6336-1
THE BASICS OF GEAR METROLOGY
DESIGNING RELIABILITY INTO INDUSTRIAL GEAR DRIVES**

THE GEAR INDUSTRY'S INFORMATION SOURCE

INTRODUCING THE REVOL

GP 130



REVOLUTIONARY NEW GP SERIES

Get a head start on the new millennium.

The gear-making machines of the next century will be built much faster and more economically, for quick delivery and faster ROI. Hobbers, shapers and grinders alike will share common components and readily available spare parts to greatly simplify maintenance and reduce costly downtime.

Luckily you won't have to wait until then to buy one.

Introducing the GP Series: a new line of gear hobbers, shapers and grinders that share a "common platform" and use standard modules to greatly simplify the traditional processes of machine design, assembly, and maintenance. They're designed to take advantage of the latest tool technologies available – wet or dry. It's what the gear-making industries around the world have been waiting for.

See the GP Series for the first time at IMTS '98. And get a head start on the 21st Century.



A common platform . . .



equipped for hobbing . . .



shaping . . .



. . . or grinding

Gleason PFAUTER HURTH WORLDWIDE SALES

1351 Windsor Rd., Loves Park, IL 61111 USA
Phone: 815/282-3000 Fax: 815/282-3075 Web site: www.pfauter.com E-Mail: sales@pfauter.com

The Gleason Works, 1000 University Ave., Rochester, NY 14607-1282 USA
P.O. Box 22970, Rochester, NY 14692-2970 USA
Phone: 716/473-1000 Fax: 716/461-4348 Web site: www.gleasoncorp.com

CIRCLE 100



IMTS 98 BOOTH NO. B1-7150
CHICAGO, SEPTEMBER 9-16, 1998

STAR PRECISION HOBS... BECAUSE NOT ALL GEARS ARE CREATED EQUAL



The only way to get top quality gears, is to machine them with precision hobs. At Star Cutter, we utilize the most advanced technology available to insure that each of our precision hobs will deliver the exact performance you need — cut after cut, day after day.

Take advantage of our experienced engineering department to design and develop the most economical hob to meet your individual special unique gear manufacturing requirements. These hobs are available with Gold Star titanium nitride, titanium carbo-nitride and other advanced Gold Star coatings.

If faster-running, quieter and more accurate gears are your objective, you can't do better than Star. Call, write or fax for more information.

ISO 9001/9002 CERTIFIED

Since 1927



STARCUT SALES, INC.
Subsidiary of Star Cutter Company

P.O. Box 376
Farmington, MI 48332-0376
248/474-8200 FAX 248/474-9518

CIRCLE 128

Precision Workholding Equals Precision Gearing *and nobody equals* **EMUGE**

A mechanical **EMUGE** workholding solution will immediately boost your part quality and productivity. Clamp on a symmetrical or irregular surface—pitch diameter clamping is our absolute specialty.

But let's get precise

- Accurate to within 20 millionth of an inch
- Perfect concentricity
- Perfect repeatability
- Part-family interchangeability
- Easy to install and maintain
- Mechanical reliability

Let's discuss an **EMUGE** precision workholding solution for you today!

EMUGE

104 Otis Street • Northborough • MA 01532 • 800 323 3013 • 508 393 1310 Fax



GEAR TECHNOLOGY

The Journal of Gear Manufacturing

EDITORIAL

Publisher & Editor-in-Chief
Michael Goldstein

Managing Editor William R. Stott

Associate Editor Charles M. Cooper

Technical Editors
Robert Errichello
Don McVittie
Robert E. Smith

ART

Art Director Jean Bartz

ADVERTISING

Advertising Manager
Patricia Flam

Advertising Coordinator
Donna Lawson

CIRCULATION

Marta Radziszewski
Brian Sessler

RANDALL PUBLISHING STAFF

President Michael Goldstein

Vice President Richard Goldstein

Controller Patrick Nash

Accounting Laura Manion

Art Consultant Marsha Goldstein

Phone: 847-437-6604
e-mail: people@geartechnology.com



VOL. 15, NO. 5

GEAR TECHNOLOGY, The Journal of Gear Manufacturing (ISSN 0743-6858) is published bimonthly by Randall Publishing, Inc., 1425 Lunt Avenue, P.O. Box 1426, Elk Grove Village, IL 60007, (847) 437-6604. Cover price \$5.00 U.S. Periodical postage paid at Arlington Heights, IL, and at additional mailing office. Randall Publishing makes every effort to ensure that the processes described in GEAR TECHNOLOGY conform to sound engineering practice. Neither the authors nor the publisher can be held responsible for injuries sustained while following the procedures described. Postmaster: Send address changes to GEAR TECHNOLOGY, The Journal of Gear Manufacturing, 1425 Lunt Avenue, P.O. Box 1426, Elk Grove Village, IL, 60007. ©Contents copyrighted by RANDALL PUBLISHING, INC., 1998. Articles appearing in GEAR TECHNOLOGY may not be reproduced in whole or in part without the express permission of the publisher or the author. Contents of ads are subject to Publisher's approval.

The most for your money.

Introducing the PC-based Höfler ZP Series Gear Measuring Centers from Klingelberg.

Measuring technology for the millennium—affordable today!

A new level of accuracy.

3-axis measuring with a full 3-D probing system—4 millionths resolution.

Versatile.

The ZP range can handle gears and non-gear parts—even camshafts and crankshafts—up to 40" long and up to 40" diameter. Easy 3-side loading and unloading. Ask our competition to do that.

Short measuring cycles.

Time-saving standard measuring cycles and instant evaluation help you breeze through inspections. Menu-driven operation, instant response.

And, of course, the ZP Series saves floorspace.

The ZP Series. From the Höfler family of CNC gear inspection systems.

The package our competition hoped we would never offer.

Call for a quote today from

Liebherr Gear Technology Co.

1465 Woodland Drive
Saline, MI 48176-1259

Tel. 734 429 7225

Fax 734 429 2294



KLINGELBERG

A Sigma Pool partner.

SIGMA  POOL

 **IMTS 98**
CHICAGO, SEPTEMBER 9-16, 1998
BOOTH 7170

The Unparalleled Resource for Innovative Gearing Technology

LIEBHERR

**LORENZ
ETTLINGEN**

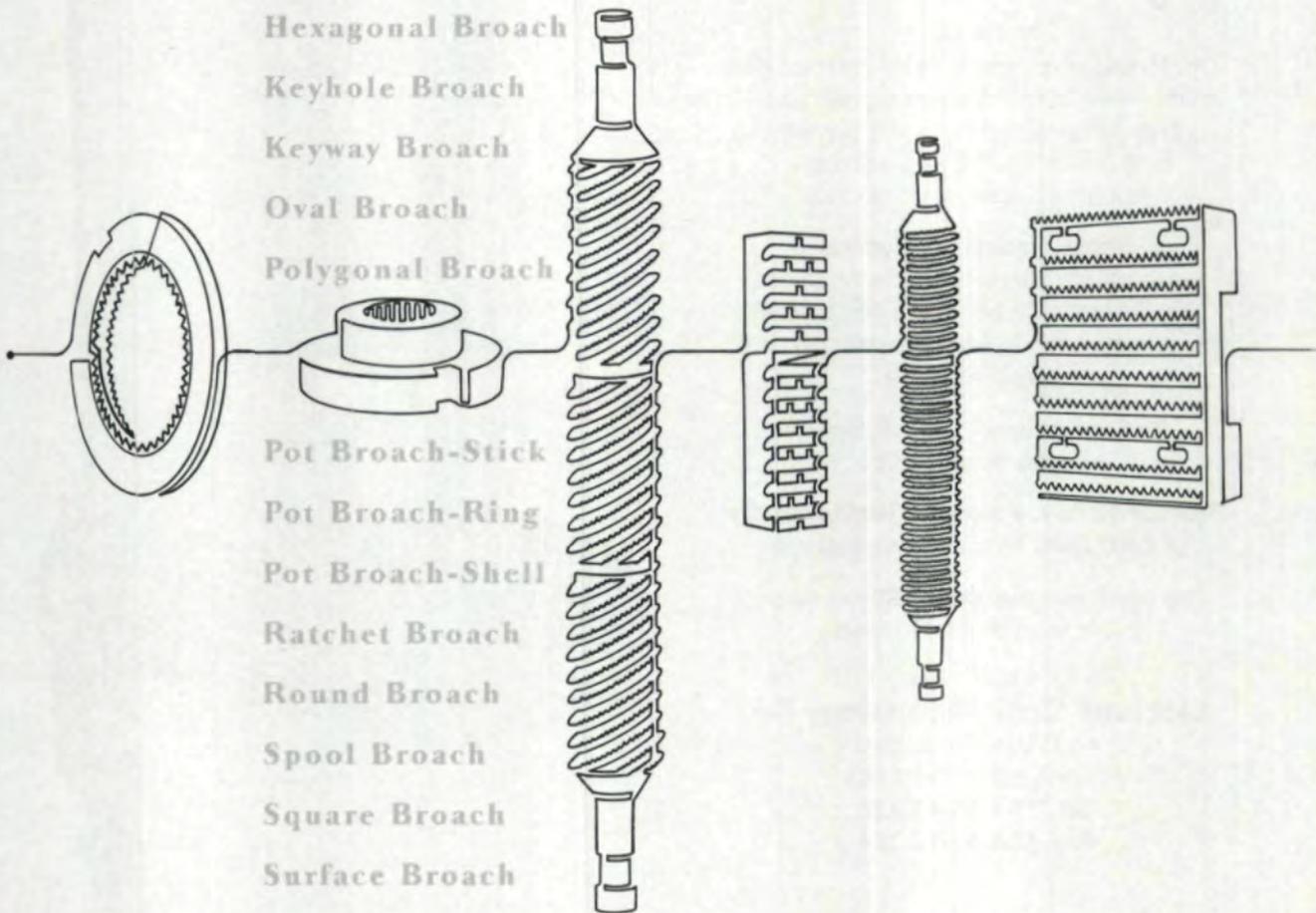

KLINGELBERG

DERLIKON
GEAR
TECHNOLOGY

Blind Spline Broach
 Christmas Tree Form Broach
 Flattened Round Broach
 Helical Gear Broach
 Helical Involute Spline Broach

WE HAVE ONE GREAT LINE OF BROACH TOOLS.

Helical Rifle Broach
 Internal Gear Broach
 Hexagonal Broach
 Keyhole Broach
 Keyway Broach
 Oval Broach
 Polygonal Broach



Pot Broach-Stick
 Pot Broach-Ring
 Pot Broach-Shell
 Ratchet Broach
 Round Broach
 Spool Broach
 Square Broach
 Surface Broach
 Oil Groove Broach
 Offset Wrench Broach
 Round Surface Broach
 Serration-Involute Broach
 Serration-Straight Broach
 Spline-Involute Broach
 Spline-Straight Sided Broach

**Let us Line You Up...
 to Improve Your Bottom Line**

Picking the right tool out of the line-up can be a challenge. Let the experts at National Broach & Machine Co. help you select the perfect broach for your application.

Visit Us
IMTS 98
 September 9-16
 Booth No.
 B1-7490



National Broach & Machine Co. • 17500 Twenty-Three Mile Road • Macomb, Michigan 48044-1103 • 810-263-0100 • Fax 810-263-4571

LOOKING AROUND THE CORNER

Listen carefully these days and you'll hear a faint rumbling among the economic masses. It's probably nothing to worry about. It'll most likely go away. It's only the naysayers and skeptics who predict that the end is near. They've been doing so for almost all eight years of our current economic boom, and they've been wrong so far.

As a matter of fact, most of today's statistics and news clippings on the U.S. economy seem to point toward more good times ahead. "We enjoy impressive growth, low inflation and unemployment, and unprecedented wealth creation," says *U.S. News and World Report*. "The U.S. continues to manufacture almost twice as much wealth as any other country," says *Industry Week*. The good news crosses my desk every day.

But an uncanny feeling persists that there's a monster hiding around the corner, that good times can't last forever. It's just a feeling, but it hints that Alan Greenspan's perpetual motion machine is doomed to run out of momentum just like every contraption ever invented by a backyard mechanic chasing a dream.

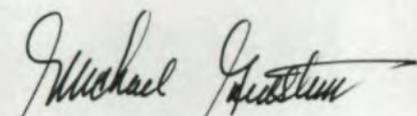
While factories are still cranking out goods, and consumers are still buying them, economic headlines lately have been raising some eyebrows. Economic turmoil in the Far East. Hmm. Atomic weapons being tested. Hmm. Russia raising interest rates to 150%. Hmm. Stock market "corrections" of 100-200 points in a day. Hmm. Big companies announcing layoffs. Hmm.

Other than the fact that these are tough times for prognosticators, what does all of this mean? I don't claim to have all the answers. Each business owner must make his own decisions. But it would be prudent, at the very least, to have a contingency plan in place. Weighing your options now may mean the difference between weathering the storm or becoming tomorrow's driftwood.

We usually look to IMTS for ideas about how we can make our manufacturing operations more efficient, more productive and more profitable. Certainly now—when business is still good—is a good time to consider these things. This year, show organizers are promising even more exhibits taking up even more floor space than ever before.

But this year, I'll be looking at more than the technology. I'll be looking at IMTS itself as a bellwether of industry confidence in the future of manufacturing demand. I'll be looking at attendance levels and reports of machine tool orders that come out after the show.

These reports should give us an idea whether the monster is really around the corner or whether he is merely the result of an overactive imagination.



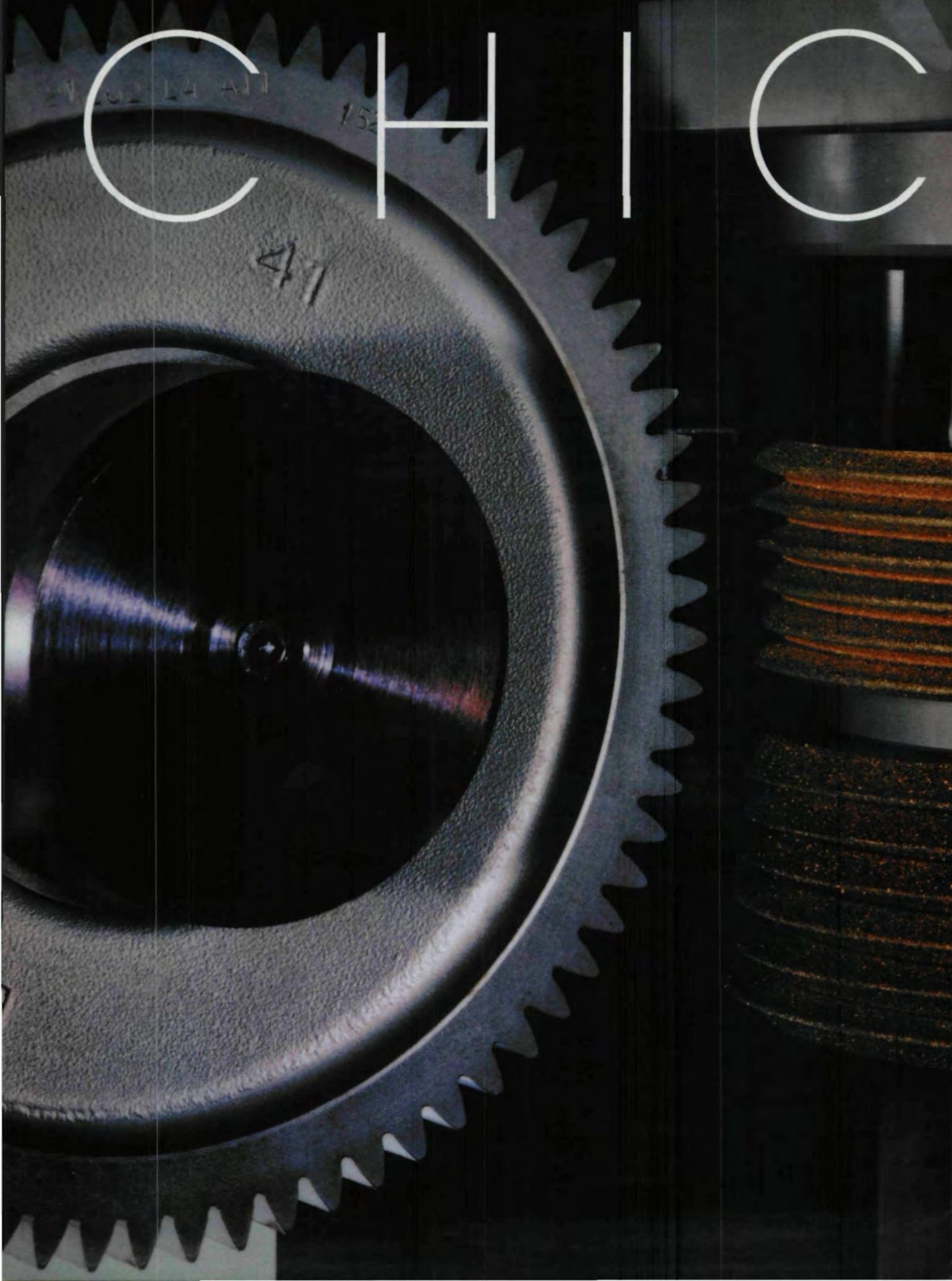
Michael Goldstein,
Publisher & Editor-in-Chief

While factories are still cranking out goods, and consumers are still buying them, economic headlines lately have been raising some eyebrows. Economic turmoil in the Far East. Hmm. Atomic weapons being tested. Hmm. Russia raising interest rates to 150%. Hmm. Stock market "corrections" of 100-200 points in a day. Hmm. Big companies announcing layoffs. Hmm.

N E R



CHIC



A G O



IMTS 98

CHICAGO, SEPTEMBER 9-16, 1998

The best just got better!

We're introducing our revolutionary KAPP KX1 Gear Center and our new line of NILES ZP Profile Grinders. Of course they come with our famous KAPP CBN grinding wheels and our complete process package which ensures reliability and satisfaction.

Stop by and see us at McCormick place. We'll be in the North Building, Booth No. B1-6981. See you in Chicago!



NILES
BERLIN

PHONE 011 49 30/92 797-0
FAX 011 49 30/92 797-103

U.S.-REPRESENTATIVE:
KAPP SALES AND SERVICE LP.
2870 WILDERNESS PLACE
BOULDER, CO 80301

PHONE 303-938-9737

FAX 303-447-1131

CIRCLE 145

KAPP
COBURG

PHONE 011 49 95 61/8 66-0
FAX 011 49 95 61/8 66-103

Pfauter-Maag Cutting Tools now brings you the best in bevel gear tools

Pfauter-Maag Cutting Tools now offers more than just cylindrical gear-cutting tools. We are now responsible for the North American sales and service of the fast-growing line of Gleason bevel gear-cutting blades and heads. Even better, many of these products will be manufactured at Pfauter-Maag's ultra-modern

production facility in Loves Park, IL, helping raise quality and responsiveness to unprecedented new levels.

Bevel gear-cutting blades and heads are the latest addition to the

Pfauter-Maag line of hobs, shaper cutters, shaving cutters, form cutters, CBN grinding wheels, thin film coatings, heat treat services, and resharpener services.

Pfauter-Maag Cutting Tools CORPORATION

1351 Windsor Road
Loves Park, IL 61111 USA
Web Site: <http://www.pmct.com>

Phone: 815-877-8900
Fax: 815-877-0264
E-Mail: Sales@pmct.com

 **IMTS 98**
CHICAGO, SEPTEMBER 9-16, 1998

BOOTH NO. B1-7150

CIRCLE 168



Proudly Announcing . . .

ISO
9001
Registered

Sponsors Predict Biggest IMTS Ever

On 1927 the first precursor of IMTS was held in Cleveland. Back then, lasers, robots and computer controls were just science fiction. At IMTS 98 they will fill nearly every last corner of the recently expanded McCormick Place.

Sponsors expect IMTS 98 to break records. Already it's the biggest IMTS in terms of exhibit space (1.4 million square feet) and exhibitors (more than 1,400). And if registration continues at its current pace, we could also see new highs for attendance and sales made at the show.

The following are just some of the companies that might be of interest to gear manufacturers.

IMTS 98 BASICS

The International Manufacturing
Technology Show

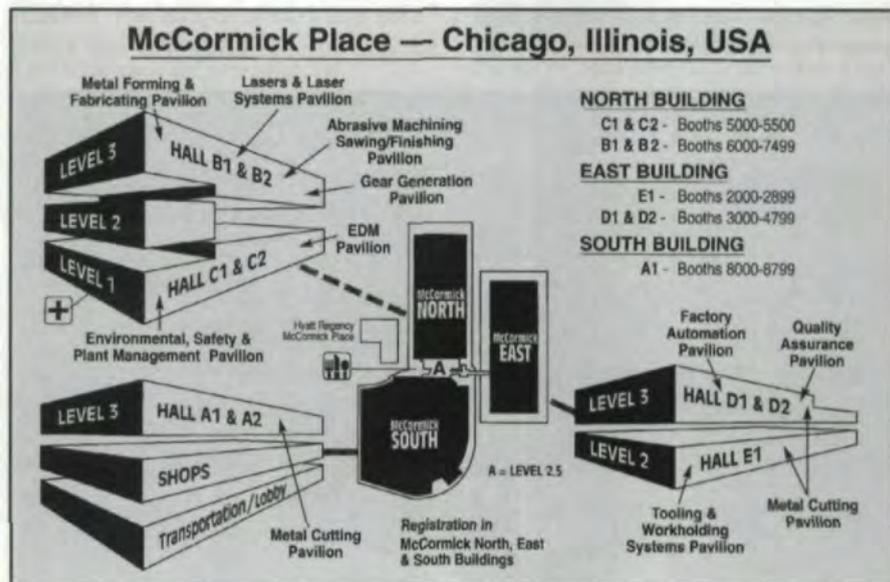
September 9-16, 1998

McCormick Place, Chicago, IL

Registration: (800) 322-IMTS

Additional information:

www.imts.org



GUIDE TO THE BOOTHS

A.G. Davis/AA Gage (Booth E1-2332) will have on display their line of Hydra-grip hydraulic expansion arbors and chucks for gear grinding, hobbing, shaping, honing and other manufacturing operations. They will also show their line of face gear couplings.

Bourn & Koch Machine Tool Co. (Booth C2-5473), will exhibit the model 400H 5-axis gear hobber. The unit at the show will be an extended bed version with an optional sliding operator guard. The machine is capable of producing AGMA quality 10 on parts with diameter up to 400 mm. The machine features a hob slide that can accommodate up to 6" X 7" hobs and is CNC controlled to allow programming cycles for crowning, tapered root spline hobbing and the shifting between different hobs or cutters on one arbor. Bourn & Koch is a manufacturer of OEM gear hobbers, gear shapers, specialty gear machines, dial machining centers, extrusion milling machines, specialty machines, turning centers, machining centers, grinders, boring machines and more.

Emuge Corporation (Booth E1-2352) is a premier manufacturer of quality workholding and electronic control systems for gear manufacture. Emuge will feature a precision clamping product line that includes arbors, chucks, diaphragm chucks, spindles, draw bars and machine operation measuring systems configured to accomplish a broad range of turning, grinding, hobbing, milling, drilling, lapping, balancing, inspection and assembly operations. Emuge's mechanical, hydraulic and mechanical/hydraulic systems achieve an excellent runout accuracy—typically .00008 to .0002—and are renowned for reliability, functionality, clamping element interchangeability and ease of maintenance. Custom application services are offered. Emuge's Web site at www.emugecorp.com outlines details.

Euro-Tech Corporation (Booth E1-2530) will show the Franco line of gages and workholding devices, Mytec hydraulic expansion arbors and chucks and the Euro-Tech Power Block III toolholder. Franco's product range includes extremely long-wear go/no go gages,

bevel gear testing gages, completely automatic spline and cluster shaft inspection systems and a full range of clamping arbors, chucks and nests for inspection and machining applications. Mytec rupture-proof arbors and chucks are ideally suited to precision applications. Mytec arbors and chucks provide normal runouts under .00012" for grinding, hobbing, shaving, shaping and inspection of gears. The Euro-Tech Power Block III

mounts directly to your bench or work table to make tool changes easy and risk-free. Vertical and horizontal axes allow access to the bottom of the toolholder. Either axis may be outfitted with like or different receptacles to accommodate any standard or custom toolholder tapers, including HSK.

Gleason Pfauter Hurth (Booth B1-7150) will exhibit several new products for gear manufacturing. The new Power

Dry Cutting process for bevel and hypoid gears will be demonstrated on the new Gleason 175HC Power Dry Cutting machine. The 175HC will demonstrate face milling and face hobbing on bevel gears. Gleason will also premier the new 600HTL Hypoid Turbo Lapping machine for hard finishing bevel and hypoid gears. The turbo lapping process (ultra high speed) is possible due to Gleason advances in machine dynamics and compound application technology. Gleason-Pfauter will exhibit for the first time the new (16") P400G profile grinder with integrated gear measuring and integrated CNC wheel dressing. Gleason-Hurth will demonstrate the capabilities of the ZH125 CNC spheric honing machine for hard finishing cylindrical gears using an internal abrasive honing tool. The machine will be shown with automation. Gleason and Pfauter will also exhibit, for the first time, a new joint engineering and manufacturing cooperation in machine design with a new gear manufacturing machine to be unveiled at IMTS.

Gold Star Coatings (Booth E1-2701), a subsidiary of Star Cutter Co., will feature thin film coatings used to either improve tool life on cutting tools and dies or improve wear life on parts.

H.B. Carbide Co. (Booth E1-2700) a subsidiary of Star Cutter Co., will feature its line of carbide pre-forms used to manufacture finished tools and wear parts.

Holroyd (Booth B2-6516) will show, for the first time anywhere in the world, the TG150E thread grinder. This is a 'sister' version of the TG350E launched two years ago as the first in a planned new generation of machines. The TG150E has been specifically designed for grinding smaller components, with profiles up to 70 mm wide and less than 300 mm in diameter (the TG350E has a maximum 350 mm capacity and 110 mm profile width). An important feature of the new machine is integrated 3D component profile measurement with automatic machine compensation to all axes. Also on display will be a range of worm gears, screw compressor rotors and other helical products manufactured by Holroyd's subcontract facility.

MMT... Products for Manufacturing

Since 1961 Mitsui Machine Technology has represented a number of Japan's top manufacturing companies in markets throughout North America. We import only the highest quality products for distribution through a network of qualified machine tool dealers.

You get the latest in manufacturing technology from a local source with full factory support for all parts and services from MMT. At Mitsui Machine Technology we're helping you grow - Profitably.

IKEGAI

Over 50 standard models—turning machines, mill-turn machines, machining centers, gear hob and grinding machines, boring and milling machines and internal/external grinders—a machine tool for virtually all requirements.

- Universal and chucker CNC turning including mill-turn from 8" to 24" chuck (up to 120" center distance). Heavy duty CNC machines, swing-over bed to 98" and center distance to 314". CNC VTL with 49 3/8" table and mill-turn capability.
- Vertical and horizontal machining centers and HBMs. Verticals feature exclusive U-axis. Horizontal has 10,000 RPM with No. 50 taper and 24" pallets. HBM tables from 37.3" x 41.3" to 98.4" square and W-axis control of 4.3" to 5.1" diameter spindles.
- CNC internal/external grinders with X and Z axis full scale closed loop control. Hob sharpening, (4) axis CNC and CBN wheel capability.
- High speed CNC gear hobbing from 3.9" to 15.7". Capable of dry cutting with carbide hob.



OM

Vertical CNC turning, boring and milling for small to large part needs since 1920.

- Table size from 16" to 26 feet.
- Automation with ATC and table changers.
- Horsepower ranges from 15 to 160.



HOWA

Compact high production CNC horizontal and vertical machining centers.

- Milling to high performance drilling and tapping capability.
- Speed ranges from 8,000 to 20,000 rpm.
- ATC up to 24 tools and automatic pallet changer available.



GRAPHIC PRODUCTS

New advanced CAM-Tool for broad spectrum of surface processing functions.

- CAD/CAM.
- Data conversion and modeling.
- 3D shapes to 3-axis shapes.



Mitsui Machine Technology, Inc.

100 High Grove Boulevard, Glendale Heights IL 60139-2279
Phone: (630) 924-8800 • Fax: (630) 924-8879

126-09SR1

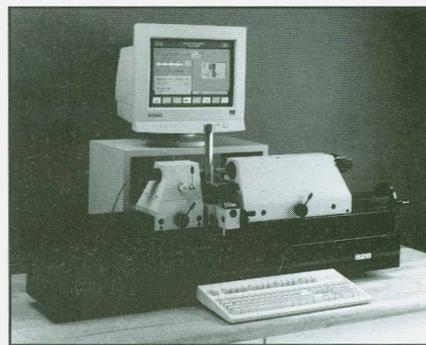
Kapp Sales & Service L.P. (Booth B1-6981) represents the Kapp and Niles product lines of internal and external grinding machines featuring stock dividing, on-board measuring, dressable wheels and CBN wheels for the manufacture of internal and external spur and helical gears, ball screw tracks, worms, compressor rotors, rotary pistons (root type), pump spindles (IMO type), pump rotors (gerotor type), vane pump rotors, constant velocity tracks (CVT and the like) and more.

Koepfer America, L.L.C. (Booth B1-6961) will display a new high-speed, eight axis gear hobbing machine with computer controlled flexible automation. The Koepfer Model 160 is designed for shaft, pinion and gear work up to 60 mm and 2.36" diameter. The machine includes eight axes of CNC control, including tailstock and gantry loading arm positions to reduce setup time and improve overall efficiency. A unique slant bed design provides ideal chip flow and allows the user the choice of wet or dry hobbing. High spindle speeds (cutter up to 5,000 rpm and work spindle up to 1,000) allow optimum use of coated carbide cutting tools even when hobbing parts of small diameters or low numbers of teeth. The automation allows loading of a part in two seconds.

M&M Precision Systems Corporation (Booth B1-7149) will feature metrology systems for parallel axis and spiral bevel gears, gear cutting tools, thread gages and turbine blades. 3515 and 200 Series CNC inspection systems for gear manufacturing process control, running a full complement of inspection software, will be networked to a remote workstation with M&M's GearNet™ software. M&M will highlight multiple probe technology with demonstrations of ID, 3D and laser probe scanning. New LMS laser measuring systems will showcase non-contact scanning for thread gages and turbine blades. The GRS-2 double flank gear roller system and durable ODM-8 dimension over pins gage will also be shown.

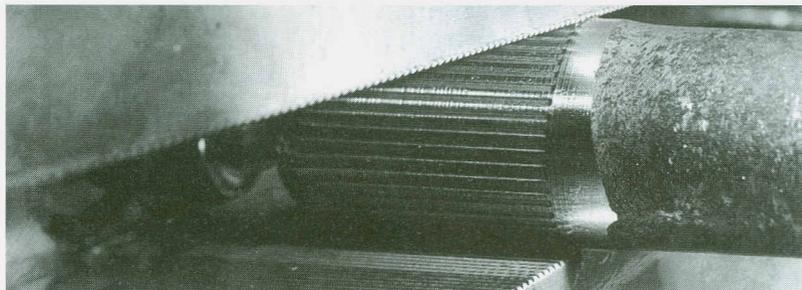
Mahr Corporation (Booth D2-4437) will present metrology products for measuring gears as well as surface texture, form and length on a variety of parts. The

Extramess 2000 is a new analog/digital inductive comparator accurate to .000012". The M1 and M2 are the first of a new series of surface texture measurement instruments designed for the shop floor. The Optimar 100 is a new bench-top calibration system for dial indicators, dial comparators, dial test indicators, incremental probes and LVDTs. A staff of applications engineers and technical specialists will be on hand to discuss the new products.



The 828 PC calibration center from Mahr Corp.

3 REASONS TO USE COLONIAL SPLINE RACKS



- 1** Proprietary design, engineering and manufacturing.
- 2** Involute splines, helical splines, tapered splines, threads.
- 3** Production spline rolling supported by SPC.

If you're going by the numbers, Colonial Tool Group has all the reasons you need to have us be your spline rolling service supplier. We're a leading designer and manufacturer of high quality precision spline rolling racks, with extensive prototype capability. And if you need pre-production or production spline rolling services... we do that too!

Call, write, FAX or E-mail us off our Web Site.

COLONIAL TOOL GROUP INC.

1691 Walker Road, Windsor, Ontario, Canada N8W 3P1
 519-253-2461 • FAX 519-253-5911 • www.colonialtool.com
 In the U.S.A. 5505 Concord Ave., Detroit, MI • 313-965-8680

From the desk of Fred Young, President, Forest City Gear

Noise, Misalignment, Banding, Transmission Error, Harmonic Resonance, Binding, Roughness

These are a few frequently occurring problems with gears. Are you losing business to competitors because of noise and poor efficiency? Forest City Gear has resolved these problems for many diverse companies with our high accuracy cut gears.

CROWN HOBBING

We have pioneered *fine pitch crown hobbing* (putting a radius on the flank of the tooth along the longitudinal axis) which has dramatically reduced noise especially in helical applications and compensated for various misalignment scenarios. Almost single-handedly we introduced this concept to the American power tool industry and many small motor manufacturers.

CARBIDE REHOBBING

We reduced gear error by *carbide rehobbing* gears after they have been heat treated to 60Rc. Only a few gear producers utilize this advanced technology. Precise index accuracy for x-ray positioning equipment, telescopes, printing presses, copiers, plotters & printers— these are a few applications assisted by Forest City Gear.

ANALYTICAL GEAR INSPECTION

Few people have the *inspection capability* to investigate and monitor profile error as does FCG. Our analytical gear checkers verify lead and profile error to ten millionths of an inch. You may already be one of about eighty **gear manufacturers** assisted by FCG to produce quieter, more accurate gears. Accuracy of profile is determined by the quality of the hobs, *hob re-sharpening* (another of our services) and mounting on the gear machine. Problems here effect transmission error and noise. Lead error and crossed bearing cause premature failure and contribute to excess backlash as well as noise variation.

STATE-OF-THE-ART MACHINERY

Gear cutting equipment at Forest City Gear is offered for resale after three to five years, to be replaced by more efficient *state-of-the-art new machinery*. Index error, another bugaboo contributing to roughness, is common to gear producers using obsolete gear equipment with very worn master index gear and transmission components. Accumulated spacing error can occur during heat treatment or from multistart hobs as well as from badly worn gear equipment. This non-adjacent index error excites transmission errors, banding and harmonics. Finally all of these problems are additive to plain old runout or eccentricity which can be caused by bad gear blanks, inadequate and inaccurate work fixturing as well as worn master drive worm gears and cutter spindles in the gear machines. These conditions, unfortunately, are all too common in the American Gear industry and overseas.

LET US HELP

Our ability to measure these attributes and determine their causes has allowed us to help countless people in the power transmission and motion industry through the years. We would like an opportunity to confirm the accuracy (or inaccuracy) of your gears, which we offer as a service, and provide you opportunity to improve your products. We look forward to hearing from you.

Sincerely,

Frederic M. Young

Fred Young



FOREST CITY GEAR



Still Not Sure? We Are!

We offer World Class Gear Quality

- **Crown Hobbing** for noise reduction and misalignment compensation.
- **Hard Hobbing** with carbide hobs after heat treat as a substitute for gear grinding.
- **CNC hobbing** and shaping alignment programs for varying teeth and pitches.
- **Hobbing 2 tooth & greater helical pinions.**
- **High helix worms and camshafts.**
- **Precision analytical gear inspection.**
- **Hob sharpening.**

**Come visit us to see
a Mini Gear Show — we
welcome our competitors!**

*The Most Modern Fine and Medium
Pitch Gear Job Shop in the World!*



FOREST CITY GEAR

11715 Main Street, P.O. Box 80
Roscoe, Illinois 61073-0080
815-623-2168 • Fax 815-623-6620

Check us out on the Web at www.fcgear.com

CIRCLE 138



Now closer than ever... Shave tools made in Oak Park, MI!



SU OAK PARK, MI



SAMPUTENSILI



For detailed information
please contact:
COME VISIT US AT IMTS BOOTH #B2-6657



SU America, Inc.
8775 Capital Ave. • Oak Park, MI 48237
Ph: 248/548-7177 Fax: 248/548-4443
E-mail: usas@concentric.net
www.samputensili.com

Mitsubishi Machine Tools (Booth A1-8242) will demonstrate its line of gear hobbers, shapers, shavers and grinders. Mitsubishi's gear shapers and hobbers have sophisticated cutting mechanisms for high productivity shaping and hobbing of gears up to one meter in diameter. Their gear shavers can handle gears up to 450 mm diameter.

Mitsui Machine Technology Inc. (Booth A1-8733) represents Ikegai Corporation with their full line of CNC machining centers, including gear hobbing, boring, milling, turning, grinding and combination machines. MMT also will show the O-M Ltd. line of vertical CNC lathes and the Howa Machinery Co. line of vertical and horizontal CNC machining centers.

National Broach (Booth B1-7490) introduces three new gear machines at IMTS 98. The NBV 5-8 is a low-cost, small part broaching machine with a low table height and transfer height, eliminating the need for pits and platforms and improving user accessibility. The Red Ring Shavemaster 400 combines advanced software, rigid design and kinematics to enable higher quality, greater efficiency and more complex parts than ever before. The CLP-35 CNC gear checker can inspect profile, lead and pitch of gears, hobs, shave cutters and worm gears. All assemblies on the CLP-35 are hand scraped for absolute static accuracy. In addition to the new machines, visitors will see demonstrations of broaches, shave cutters, hobs, hones, roll form racks and master gears.

Pfauter-Maag Cutting Tools (Booth B1-7150) is a world leader in the manufacturing of hobs, shaper cutters, shaving cutters, form cutters, CBN grinding wheels, thin film coating, bevel gear tools and heat treat service. Their products are sold throughout the United States, Mexico, Canada, Asia, Europe and South America. Pfauter-Maag features tools made of premium high speed steel as well as carbide.

Radyne (Booth C2-5364) will exhibit its Power Integrated Solid State Induction Heating systems—the Power Integrated ScanMaster, incorporating a 250 kW/10kHz IGBT solid state induction power source and Windows-based PC con-

trol. The scanner drive uses an AC brushless servo motor, providing some of the fastest scan speeds with the highest degree of positioning accuracy in the industry. Also featured will be the Dual Position Power Integrated Pop-Up Fixture with its integral 160 kW/30kHz IGBT solid state induction power source. This design incorporates three positions, allowing one position to load, a second to heat, and a third to quench. In addition, Radyne will provide a

hands-on demonstration of its Apex QA Quality Assurance Monitoring System. Finally, a pre-show press release suggests that "a few other surprises may be awaiting you at the Radyne booth."

Reishauer Corporation (Booth B1-7164) is demonstrating the RZ820, the biggest machine in the Reishauer product line. It is capable of efficiently grinding large, heavy duty gears to a very high quality level. This machine replaces all previ-

3 REASONS TO USE COLONIAL BROACHES



1 Precision round broaching tools with diameters as small as 1-in.



2 Big solid broaches up to 105-in. long and 12-in. diameter.



3 Helical broaches for transmission running gears.

If you're going by the numbers, Colonial Tool Group has all the reasons you need to have us be your broaching tool supplier. We've become one of North America's leading designers and manufacturers of high quality precision involute spur and helical broaches... big and small. And if you need broaching machines... we design and build those too!
Call, write, FAX or E-mail us off our Web Site.

COLONIAL TOOL GROUP INC.

1691 Walker Road, Windsor, Ontario, Canada N8W 3P1
 519-253-2461 • FAX 519-253-5911 • www.colonialtool.com
 In the U.S.A. 5505 Concord Ave., Detroit, MI • 313-965-8680

ous ZB, RZ701 and RZ801 machines. The RZ820 has improved software for increased productivity and improved positioning accuracy of the shift axis, which greatly reduces idle times. Hydraulic tailstock and on-machine fine balancing of the grinding wheel are two new features that enhance throughput.

Richardon (Booth B1-7164) will display the R200 CNC high production hobbers. The Richardon machine comes with

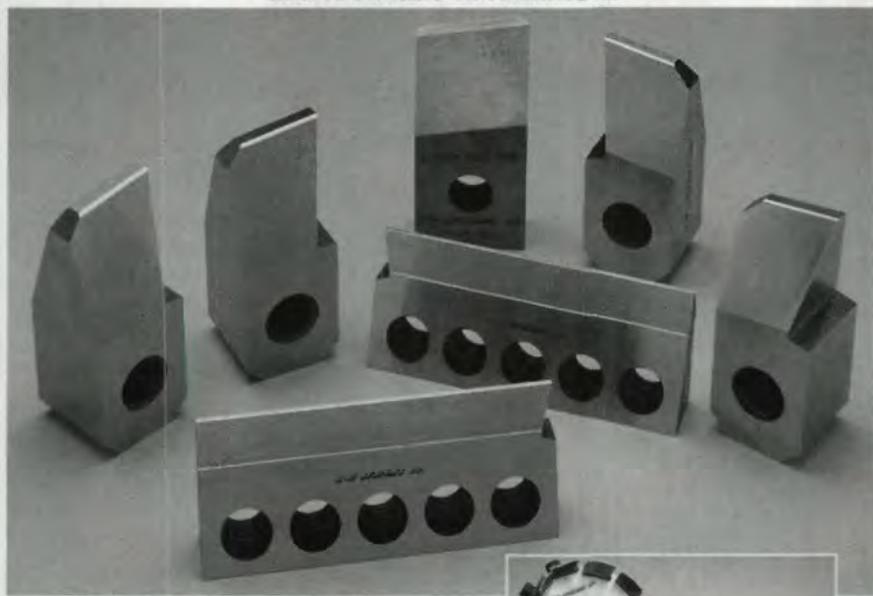
a modern 6-axis control coupled with the mechanical stiffness of all cast iron and all vee way construction. It has been configured to handle high helical jobs (-45° to +60°) that are difficult to cut on competitive machines. As standard the R200 CNC can be used to mill or hob gears, and its compact design is intended to please equipment engineers.

S.L. Munson & Company (Booth B2-6555) will be displaying products

from Dr. Kaiser Precision Diamond Products Company and DWH Super Abrasives. They will display a complete line of rotary diamond dressers for all gear dressing applications; a new single- and double-side dresser design including an integral rotary root relieving tool for Reishauer SPA and Fässler DSA system dressing units; wear parts produced with polycrystalline diamond surfaces lapped to extremely close tolerances; CNC pro-

NEW! NOW YOU HAVE ANOTHER CHOICE...

and it's made in AMERICA!



A/W Systems Co. announces that it is now a manufacturing source of spiral gear roughing and finishing cutters and bodies.

We also can manufacture *new* spiral cutter bodies in diameters of 5" through 12" at present.

A/W can also supply roughing and finishing cutters, hardware and replacement parts for most 5"-12" diameter bodies.

Whether it's service or manufacturing, consider us as an alternative source for replacement parts and hardware as well as bodies and cutters.

You'll be in for a pleasant surprise.

NEW! Straight Bevel Cutters.



Royal Oak, Michigan 48067
Tel: (248) 544-3852 • Fax: (248) 544-3922

THE PAVILIONS

IMTS 98 features three new pavilions this year, bringing the total to 10 shows within the show. Below is a list of the pavilions and their locations in the McCormick Place complex.

Abrasive Machining/ Sawing/Finishing	B1 & B2	North
EDM	C1 & C2	North
Environmental Safety & Plant Management	C1 & C2	North
Factory Automation	D1 & D2	East
Gear Generation	B1 & B2	North
Lasers & Laser Systems	B1 & B2	North
Metal Cutting	A1, D2 & E1	S & E
Metal Forming & Fabricating	B1 & B2	North
Quality Assurance	D1 & D2	East
Tooling & Workholding Systems	E1	East

IMTS FUN FACTS

33 football fields of exhibit space



50 million pounds of equipment



11.8 miles of carpeting



\$550 million worth of metalworking
equipment on display

filing dressers; and rotary diamond dressers for plunge form applications. DWH products include examples of vitrified CBN and vitrified diamond wheels for precision grinding applications.

Schunk Inc. (Booth E1-2471) manufactures and sells a wide range of tooling products, including hydraulic chucks, hydraulic arbors, lathe chucks, chuck jaws, FUNDO—a new hydraulic dowel pin, and TRIBOS—a revolutionary new tool-holding system. Schunk also manufactures grippers for factory automation.

Sigma Pool (Booth B1-7170) will present three new machines, including the Liebherr-Emag hobbing machine, a Klingelnberg-Hoefler crank-shaft/cam-shaft inspection machine and an Oerlikon bevel gear tester. Also at the booth will be the Sigma Pool's full line of bevel gear generators, plunge shaving machines, shaping machines and the latest in dry cutting technology.

Star Cutter Co. (Booth B1-7182) will display Elk Rapids Engineering CNC sharpening machines as well as its full line of cutting tools, including hobs, milling cutters, pressure coolant & non-pressure coolant drills & reamers, solid carbide tooling and PCD tooling.

SU America (Booth B2-6657) will feature a CNC gear grinding machine, which the company says is accurate, flexible and affordable. It is a form grinder that can use ceramic and/or conventional grinding wheels. It can grind internal gears as well as externals and splines, and it has the latest-generation numerical controls. SU's entire line of gear cutting tools, including carbide hobs, will also be on display.

Sunnen Products Company (Booth B1-7303) will introduce the new MVH modular vertical honing system incorporating a menu driven industrial PC control. The machine comes in two modules to take advantage of either of Sunnen's honing tool systems. The single stroke honing module incorporates rigid, single-pass plated diamond tooling. The Krossgrinding™ module uses plated diamond in-process expansion tooling for

extremely precise roundness and straightness and control of bore size and finish. The Krossgrinding™ system also produces an oil-bearing crosshatch pattern. The two basic modules can also be combined for rough and precision honing in one unit. ⚙

Tell Us What You Think . . .
If you found this article of interest and/or useful, please circle 200.



DR. KAISER
precision through diamond

for Gear Dressing Applications

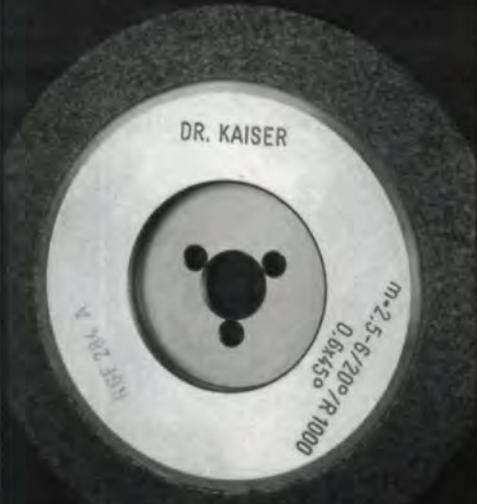
*We will design, build and guarantee from your gear summary charts gear dressers for **Reishauer SPA** and **Fassler DSA Systems** Direct-Plated or Sintered-Bond Single- or Double-Sided Dressers.*

We also produce gear dressers for

- Gleason CNC & Phoenix
- Niles
- Okamoto
- Liebherr
- Csepel
- Normac
- GII Solutions
- Hoglund
- Höfler

We offer our customers

- Highest Accuracy
- Competitive Prices
- Fastest Delivery
- Relap & Replating Service



Call or fax us your gear dresser requirements.
You will quickly discover what leading U.S. gear producers have learned.
Dr. Kaiser gear dressers are the best value available.

Imported by
S.L. Munson & Company

1517 Gregg St., Columbia, SC 29201
1-800-775-1390 • 1-803-252-3211
Fax 1-803-929-0507



Modular Vertical Honing System (MVH) from Sunnen Products Company.

SEE US AT IMTS BOOTH #B2-6555

CIRCLE 123



Cut & Dry.

Mitsubishi presents the world's first dry hob cutting system – the *SuperDry* GN Series.

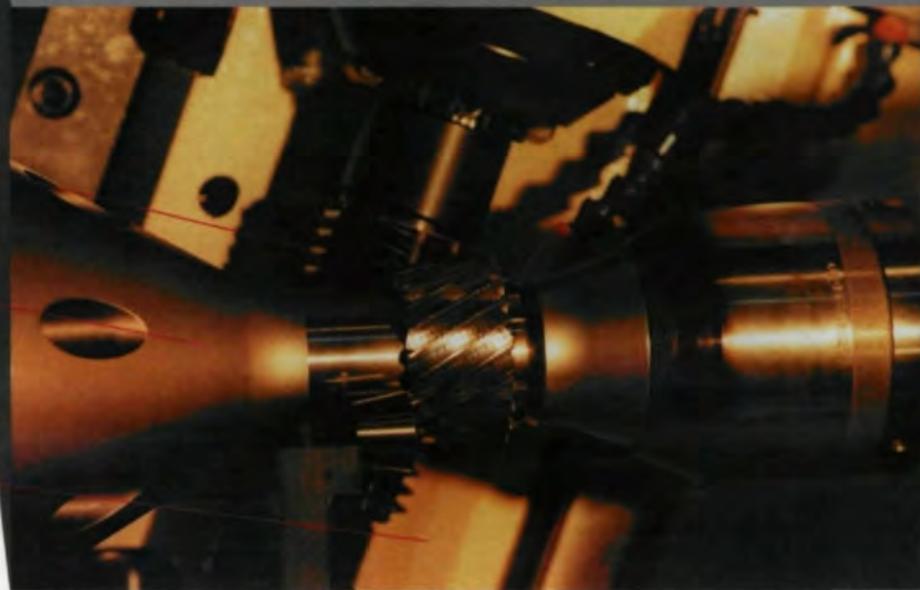
The Mitsubishi team of engineers has successfully developed a totally revolutionary hobbing process that eliminates the need for cutting fluids and the hassle of disposing them. Here are the facts:

- 1) The *SuperDry* GN Series provides a cutting speed *twice* that of conventional hobbers.
 - 2) Faster cycle times mean less capital investment and reduced labor hours ultimately leading to at least a 40 percent decrease in production costs.
 - 3) Our *SuperDry* hob is made of MACH 7 HSS material with a proprietary coating that dissipates heat and reduces tool wear resulting in an extended tool life of *five times* that over traditional wet cutting.
- In short, Mitsubishi's dry hobbing process is safe, clean, and clearly, cut and dry.

Mitsubishi revolutionary "SuperDry" HSS hob cutter design.

A hardened ground helical gear drive table permits highly accurate indexing.

With an innovative horizontal machining method, chips simply drop beneath the workpiece into the conveyor and out of the machine – without the flushing action, or mess, of coolant.



For more information on the new *SuperDry* GN Series dry hobbers and the entire family of our gear machines, contact Mitsubishi today.

 **MITSUBISHI
MACHINE TOOLS**

MHI Machine Tool U.S.A., Inc.
907 W. Irving Park Road • Itasca, IL 60143-2023
Phone: (630) 860-4222 • Fax: (630) 860-4233
<http://www.mhi-mmt.com>

CIRCLE 109

See us at IMTS '98 Booth A1-8242

Mitsubishi introduces revolutionary dry hobber that reduces gear cutting costs by up to 40%

Kenji Ueno

Itasca, IL – MHI Machine Tool U.S.A., Inc. has announced the introduction of the *SuperDry* – a revolutionary dry hobber system for gear cutting. The new system was featured in the company's booth #A1-8242 at IMTS '98.

The highly efficient Mitsubishi GN10A, GN20A and GN25A dry hobbers eliminate the cost of purchasing cutting fluids and the hassle of disposing of them – protecting the environment and enhancing safety – while reducing overall gear production costs by more than forty percent.

As a key part of its new system, a proprietary dry hob has been developed by Mitsubishi engineers. The *SuperDry* hob is a distinctive cutting tool made of MACH 7 HSS material with a proprietary coating that dissipates heat and reduces tool wear. It allows a hobbing speed of two hundred meters per minute which is two times faster than conventional machining, with tool life up to five times that of a conventional hob. The *SuperDry* machine was redesigned so that the hob operates horizontally to accommodate chip removal by allowing the chips to drop beneath the workpiece directly into the conveyor and out of the machine.

Longer tool life means users will need a smaller tool inventory, with less frequent tool changes or re-sharpening, and less overall machine downtime. Faster cycle times mean fewer machines are required – thereby reducing capital investment, labor hours, and floor space needed. The process is ideal for gears that range from automotive final drive gears and larger truck gears, to automotive pinion and sun gears.

The *SuperDry* machine also offers excellent unmanned operation capabilities, high productivity, and full FMS compatibility. The standard spindle speed is 300-3,000 rpm for the GN10A and 200-2,000 rpm for the GN20A and GN25A *SuperDry* hobbers.

The Curse of Great Potential

Over recent years, much has been said about the potential environmental and cost benefits of dry gear hobbing, but results have often been inconsistent, costly and generally disappointing. This led to a lull in the application of the technology while the industry reassessed the results of these early efforts.

Mitsubishi is convinced that environmentally friendly processes will eventually be mandated, but decided not to offer dry



Advantages of Mitsubishi *SuperDry* HSS Hobs

- Doubled productivity with high cutting speeds of (150-200m/min) – 2-times faster than standard tin-coated HSS
- Tool life up to 5-times longer than wet cutting with HSS
- Clean and safe

gear hobbing machines until a truly workable and cost-effective solution was found. With continued R&D in tooling and equipment, the company is now confident that the solution has arrived. Following is a brief recap of the developmental process.

The Mitsubishi *SuperDry* Hob

Initially, Mitsubishi was among the builders who experimented with carbide hobs. After extensive testing Mitsubishi engineers determined that the solution to dry cutting might come from a more user-friendly cutting tool. Unlike carbide, which is expensive and requires great care in sharpening and handling, a High Speed Steel (HSS) solution would be ideal if the base material and coatings could be improved enough to handle the high speeds.

Mitsubishi has now found the solution, with the combination of a new, patent-pending MACH 7 HSS base material and a new, also patent-pending *SuperDry* coating. The new *SuperDry* hob cutter operates at speeds approaching those of carbide cutters, without the high cost or chipping problems associated with carbide hobs.

The *SuperDry* Dry Hobbing Systems

Mitsubishi engineers also redesigned the machine tools to ensure an optimum fit of the hob and the cutting equipment. (The redesigned machines are fully capable of using carbide hobs, but only the HSS hob provides the optimal performance advantage.) As stated earlier, in the new machines, the hob operates horizontally to accommodate chip removal by allowing the chips to drop beneath the workpiece directly into the conveyor and out of the machine. Compared to conventional gear hobbers, chip-to-chip dead time has been greatly reduced, rapid traverse rate has doubled, and maximum hob length and hob shift length are now the longest of any gear hobber in its class.

A hardened and ground helical gear drive table permits highly accurate indexing. When used in an FMS situation, the *SuperDry* is easy to maintain with chip conveyor and simple hydraulic maintenance schedules. Various monitoring functions simplify FMS operation and ensure that hobbing is performed smoothly.

For more information on the GN10A, GN20A and GN25A *SuperDry* dry hobbers and the complete line of Mitsubishi gear production machinery, contact MHI Machine Tool U.S.A., Inc., Marketing Division, 907 W. Irving Park Rd., Itasca, IL 60143-2023 (630) 860-4222; fax (630) 860-4233.

Dr. Eng. Kenji Ueno
is Vice President,
Gear Machines and Grinders,
at Mitsubishi Machine Tool U.S.A., Inc.,
of Itasca, IL.

Designing Reliability Into Industrial Gear Drives

Peter A. Mayo

Introduction

The primary objective in designing reliable gear drives is to avoid failure. Avoiding failure is just as important for the manufacturer and designer as it is for the end user. Many aspects should be considered in order to maximize the potential reliability and performance of installed gearing.

This article is intended to provide some insight into the important elements applied to the design and production of industrial gearing and how the reliability of the gear and drive train is influenced from such measures. Fortunately these days, the gear designer and gear manufacturer have some very sophisticated tools at their disposal to achieve these goals.

There are many gear design codes in use worldwide, including AGMA & DIN standards. The long-awaited ISO standard for gears has recently been approved after more than 20 years in the making. While the gear design codes provide formulas for the determination of various parameters, these equations do not yield a unique or definitive solution.

The actual design process proceeds by the intuitive selection of parameters by the experienced

gear designer, who then applies the design code to establish compliance with certain criteria. Regardless of the standard employed, the gear design codes share the common objective of assessing the ability of the teeth to resist surface pitting and cracking when subjected to cyclic loads. The standards also provide guidelines to avoid surface damage to the active tooth flanks by scoring due to inadequate lubrication.

Tooth distress due to pitting is a manifestation of excessive contact (Hertzian) stress. Even more significant is the development of cracks in the critical tooth root fillet region when the tooth bending stress exceeds the endurance strength.

Gears may fail by other means such as wear, plastic flow, case crushing, quench cracks and corrosion, but these modes are not so readily determinate or predictable. Also, more than just the tooth design affects the reliability of the gearing. Other factors influencing reliability include lubrication, construction, the characteristics of the prime mover, bearings, application, assembly and maintenance.

Theory

The power capacity of gears is most often referred to as the gear rating. In order to understand the fundamental design criteria, a brief explanation as to the origins of the rating equations is appropriate. The following derivation should serve as an adequate introduction to the subject, but the reader should refer to Ref. 1 for more information.

For spur and helical gears, the basic equation for assessing the pitting resistance of two engaging teeth is based on the simple analogy of two cylinders of length F pressed together under load W_t , as shown in Fig. 1.

The Hertzian stress for the band of contact is given by

$$B = \sqrt{\frac{16 W_t (K_1 + K_2) R_1 R_2}{F (R_1 + R_2)}}$$

where

$$K_1 = \frac{1 - \nu_1^2}{\pi E_1}$$

$$K_2 = \frac{1 - \nu_2^2}{\pi E_2}$$

The maximum compressive stress is

$$S_c = \frac{4 W_t}{F \pi B}$$

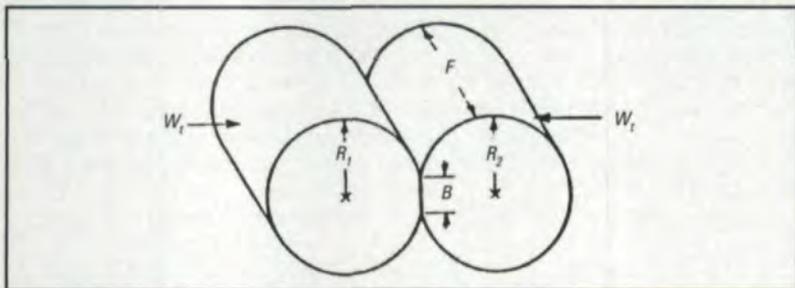


Fig. 1 — Parallel cylinders in contact and heavily loaded. Courtesy of Technomic Publishing (Ref. 1).

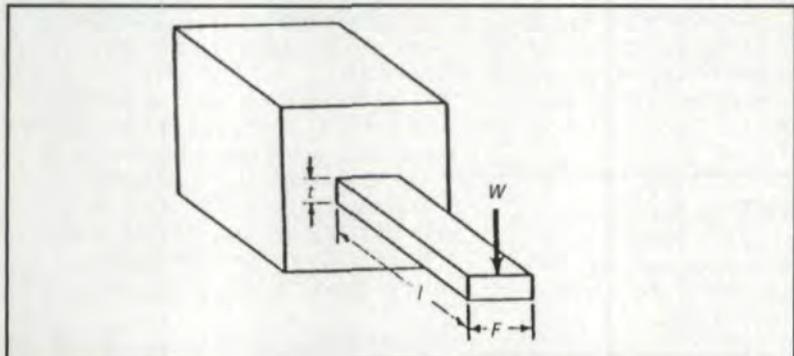


Fig. 2 — Gear tooth as simple cantilever. Courtesy of Technomic Publishing (Ref. 1).

If You Were Thinking of
Engis® or ACCU-CUT... **Think Again.**

The Test Results Are In...

SINGLE-PASS BORE SIZING AND FINISHING

DESCRIPTION	SUNNEN	ENGIS	ACCU-CUT
Highest HP and torque per spindle	✓		
Fastest cycle times	✓		
Most advanced machine control	✓		
Best technical support and service in the industry	✓		

The New Sunnen MVH™ Single Stroke® Honing System Is Tops In Its Class!

It's completely new ... and it's more than competitively priced.

The high-performance, high-production MVH (Modular Vertical Honing) Single Stroke Honing System from Sunnen outscores the competition in virtually every way. Starting from scratch, we designed the MVH Single Stroke Honing System with one goal in mind – to be superior in every way. And since it's modular, we can easily tailor a system to meet your specific application.

Put us to the test. Let us prove to you that we've got the industry's best single-pass bore sizing and finishing system ... at a cost you won't believe. Call today.



SUNNEN PRODUCTS COMPANY
7910 Manchester Ave.
St. Louis, MO 63143 U.S.A.
Toll Free: 800-325-3670
Phone: 314-781-2100
Fax: 314-781-2268
www.sunnen.com

COME VISIT
US AT IMTS
BOOTH #B1-7303



Where Precision Starts

J is the geometry factor for tooth bending strength
 K_o is the overload factor
 K_v is the dynamic factor
 K_s is the size factor
 K_m is the load distribution factor
 K_R is the reliability factor
 K_T is the temperature factor
 S_{at} is the allowable bending stress number
 Y_N is the stress cycle factor for pitting resistance
 S_F is the safety factor for tooth bending strength

From these two fundamental rating formulas, the important elements can be considered in terms of dynamic effects, material properties, loading characteristics and tooth geometry. There are also some basic differences between straight spur gears and helical gears to consider.

The way these attributes are chosen, applied and controlled during design and manufacture can significantly influence the reliability of the gears. Further elaboration of these aspects is therefore most relevant to the subject at hand.

Gear Selection

Single helical gearing provides significant advantages over spur gears. It is the meshing of the helical teeth along multiple contact lines inclined at an acute angle to the pitch line that contributes most to the ability of helical gears to transmit more load than straight spur gears.

Moreover, smooth transfer of load occurs gradually and uniformly by a combined sliding and rolling action as successive teeth come into contact along the engaging helicoidal surfaces. This situation is usually referred to as helical overlap. The helical overlap ratio is equal to the ratio of the face width to the axial pitch. Similarly, the ratio of the length of action (length of engagement) of the meshing gear teeth to the transverse base pitch is the transverse contact ratio.

The choice of helix angle for low speed gears is usually a balance between minimizing the axial thrust and maintaining a helical overlap ratio of at least 1.1. This means that the face width of the gear is at least 10% wider than the axial pitch and ensures that before a tooth begins to leave the mesh, the next tooth has already begun to take some share of the load.

Spur gears, on the other hand, rely totally on the conjugacy and contact ratio of the meshing involute tooth forms for the smooth transmission of the load. The average number of teeth in mesh (transverse contact ratio) is usually about 1.2 to 1.7 for both spur and helical gears. Helical gears have typically twice this average amount of teeth in mesh since the overall contact ratio of helical gears consists of the helical overlap ratio plus the transverse contact ratio.

Herringbone or double helical gears typically have helix angles from 20° to 30° . This results in a larger number of teeth in mesh in any given instant and hence high helical overlap ratio. The gears then operate smoothly and are much more tolerant of tooth variations.

Double helicals can, however, be sensitive to variations in accumulative pitch between the two helices that are not synchronized. The floating member otherwise tends to shuttle back and forth, or due to its inertia, the dynamic tooth loads become amplified to the detriment of the gear drive.

The critical tooth bending load for spur gears can occur either at the tip or close to it at the highest point of single tooth contact, but for normal helical gears, the load is designed to be distributed evenly over the oblique helical contact line (or in reality, finite width contact band due to elastic material properties) which extends from the bottom of the tooth to the tip as shown in Fig. 4.

By virtue of their load sharing ability, helical gears can have approximately 50% greater load carrying capacity than the equivalent spur gear of the same physical size when rated to AGMA standards.

Materials

The type and choice of materials obviously plays a vital role in the design and performance of gears. Steel of one type or another tends to be favored for gear materials because it has a high strength to cost relationship. Since gear teeth are subjected to cyclic loads, the fatigue strength rather than the normal mechanical strength determines the allowable design stresses.

The allowable stresses (S_{ac} and S_{at}) are influenced by many factors including hardness, chemistry, cleanliness, residual stress, microstructure, quality, heat treatment, processing practices and number of stress cycles.

There has been a trend over the years towards ever increasing gear tooth hardness. The reason for this is simple. Generally, the harder the material and tooth surface employed, the greater the resis-

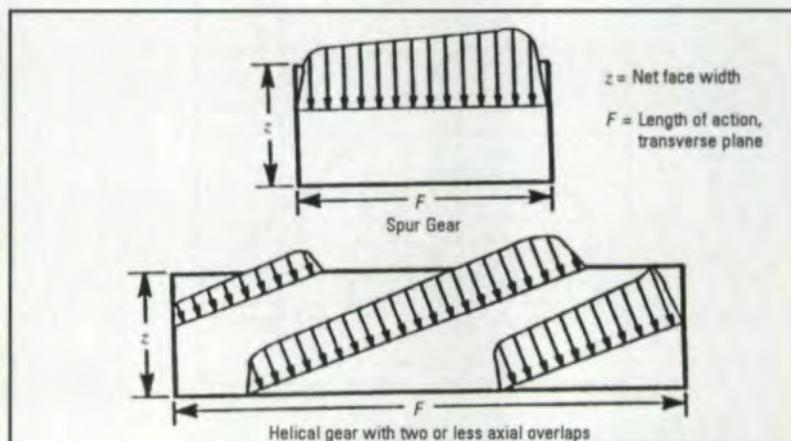


Fig. 4 — Instantaneous contact on spur and helical teeth. Illustration ©ANSI/AGMA 2001-C95.

tance to pitting and tooth bending fatigue. This allows gears to be made smaller in size for a given torque. A reduction in diameter reduces pitchline speeds, and reductions in face width increase the prospects for good gear tooth alignment.

Due to the nonlinearity of the allowable stresses as a function of hardness, the pitting resistance of through hardened gearing varies exponentially with hardness to the power of 1.6. On the other hand, the tooth bending strength varies to the power of only 0.6. The latter explains why increased tooth bending strength is usually achieved by a larger tooth size or greater face width.

Gear steels typically have carbon contents in the range of 0.3% to 0.5%, and they are alloyed to enable the desired hardness on the flanks and roots of the teeth. Below 0.3% carbon the gears have poor wear resistance. The 0.3% carbon alloy steels produce the greatest toughness compared with higher carbon steels, but 0.4% carbon has higher hardness potential. Above 0.5% the toughness of these steels tends to be quite low.

The AGMA gear rating codes assign allowable design stresses based on the verification undertaken to confirm the cleanliness, quality, homogeneity and integrity of the materials employed. It should be noted that for a given hardness, the selection of allowable stress must be made from a design range.

The lower values for allowable stress might be appropriate for castings which are relatively free of harmful defects, but which may contain some innocuous defects such as discrete gas holes and porosity, but not cracks and shrinkage.

Intermediate values for allowable stress may be applied to commercial grade forgings and maximum values for extra high quality steel forgings, such as those offered by the Electro Slag Refined steel making process. Vacuum degassing has also been a steel making process of significant benefit to improving gear steel quality.

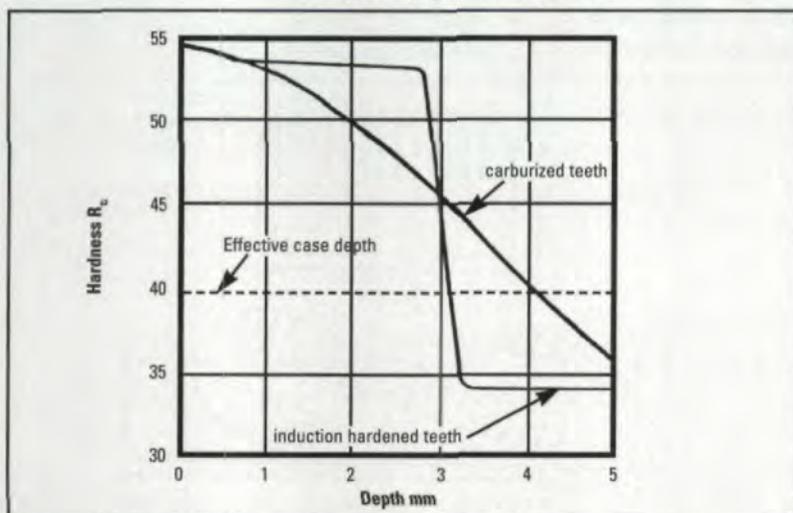


Fig. 5 — Induction hardened & carburized case core relationship.

The most important part of a gear contains the teeth, and so it often pays in the long run to invest in the best material available. For cyclically loaded components such as bearings, it has been well established that cleaner steels improve the life expectancy. The ESR steels boast extremely clean microstructures, which are inherently very resistant to the initiation of fatigue.

Lower alloy steels can be employed where low hardness will suffice or when the teeth can be gashed prior to heat treatment. The structure of the gear should also maximize the potential of the heat treatment. In order to encourage quicker quenching rates, the sides of large solid gears or pinions can also be dishd to reduce the mass effect.

Even with high hardenability alloy steels, the teeth of coarse pitch, through hardened gears benefit significantly when practical from pregrinding the teeth prior to heat treatment. This ensures uniform and effective hardening to flank and root when the hardness required is greater than 300 HB.

These days, foundry facilities and expertise have been developed to the point where even large gear castings can now be water quenched to produce a very tough and much improved fatigue resistant martensitic microstructure not previously possible by air hardening (normalizing), which produces a bainitic microstructure.

Surface Hardened Gearing

The pursuit of ever harder gears has seen the emergence and now dominance of case carburized gears in gearboxes. Typical hardnesses for such gears would be 58 to 62 Rc, so the teeth are invariably precision ground after hardening. The gears therefore boast high accuracy, high surface load carrying capacity and smoother operation.

As a consequence of surface hardening gear teeth, beneficial residual compressive stresses are induced into the surface layer. This effectively reduces the tensile bending stresses in the critical tooth root fillet region. It is most important therefore not to grind the roots of the teeth as the grinding can remove the residual compressive stress. Shot peening, however, can be employed to restore the residual stress if grinding becomes necessary to remove excess distortion.

Where the gearwheel itself might be too large to be case hardened, a significant benefit can still be gained by the use of a case hardened pinion meshing with a through hardened gearwheel. This has evolved even though pinions typically need only 20% to 40% hardness differential over and above that of the gearwheel to account for the greater number of stress cycles experienced by the pinion. The tooth hardness of the gearwheel might typically range from 300 HB up to 400 HB.

The benefit of this combination may be explained in terms of the ability of alloy steel gear teeth to strain harden under the influence of cold work by the much harder surface of the engaging pinion teeth. AGMA Standard 2001 recognizes this phenomenon and applies the hardness factor C_H to achieve a rating gain corresponding to the subsequent increased hardness. Actual measurements would suggest that alloy steels can increase the active tooth surface hardness by as much as 15% in this action.

Even though the carburized teeth can develop beneficial residual compressive stresses in the surface layer, the drawback experienced with producing carburized gear teeth is the volumetric expansion that occurs when the tooth surface is enriched with carbon and subsequently transformed to martensite when quenched. The associated distortions require further finishing in order to correct these distortions.

These movements can be quite uneven. Single helical teeth tend to unwind slightly, and long pinions can develop an hourglass shape. Therefore, subsequent finishing removes more material than expected, and thin localized case depths can occur.

Testing of the surface hardened layer is an important issue. Some tests, such as hardness, can correlate the success of the hardening process on the actual gear teeth with the test piece. Most of the testing, though, must be done on test samples independent of the actual work piece. It is therefore essential that the test samples be totally representative of the gear.

Induction hardening offers an alternative means to provide high surface hardness and increased strength in the root of gear teeth. Hardnesses typically 50 to 56 Rc can be readily achieved depending on the carbon equivalent, the type of steel and the quenching rates employed. The advantage of induction hardening is considerably less distortion than with carburizing.

However, induction hardening requires a heavier case thickness. This is because the induction hardened case has a more abrupt transition from case to core in contrast to the more gradual transition of carburized surface layers. This is illustrated in Fig. 5. Induction hardened case depth is also measured differently.

In specifying the case depth, it is important to ensure that the maximum subsurface shear stresses do not occur at this transition zone.

Nitriding also provides a very useful surface hardening technique where very high hardnesses are needed. It is limited, though, where only a thin surface layer can be used such as that found in small and high speed gears.

Using a very hard pinion is contrary to the practice of using a sacrificial pinion with particularly soft teeth. The disadvantage of allowing the pinion teeth to become worn and misshapen is uneven wear on the gearwheel teeth.

Very hard pinion teeth do not yield or suffer so easily from the usual perils of through hardened surfaces such as pitting, spalling and scoring (assuming adequate lubrication). As a result, the pinion can then be expected to always maintain its true involuted shape and in turn help to maintain the tooth profile of the gearwheel. The gearwheel teeth might otherwise suffer if the pinion tooth form became distorted for any one of the forgoing reasons.

Dynamic Considerations

The dynamic factor K_v takes into account the internally generated gear tooth loads induced by non-conjugate action (non-uniform motion) of the meshing teeth. Dynamic forces arise from the relative accelerations between the gears as they vibrate in response to excitation referred to as "transmission error."

Ideally, gears should have uniform transfer of motion from input to output gear. It is impossible to produce perfectly true gears, and it is the departures from the ideal geometry that contribute to non-uniform motion and transfer of load. These deviations can be caused by many factors including residual stresses in materials, variations in material metallurgy and hardness, poor machine tool condition, inaccurate tooling, poor machine setting practice and many more. Stiffness of the teeth and mesh also contribute to non-uniform motion.

The common source of transmission error occurs from variations in the elemental tooth parameters. These individual elemental parameters include the tooth spacing (pitch), involute profile, tooth alignment (helix) and runout (eccentricity).

Gear metrology is used to identify and quantify the various elemental parameters of the teeth and gear body. The somewhat peculiar geometry of gear teeth requires some unique measuring methods and facilities. In addition to verifying compliance with allowable tolerances, gear metrology can be used as a diagnostic tool to identify the source and cause of the deviations.

The objective is therefore to minimize the deviations by taking appropriate action during design and manufacture. In some situations, the deviations can be removed by subsequent processes such as grinding. In many cases, though, the deviations remain in the installed gearing. By improving gear accuracy, the dynamic load induced by non-conjugate meshing of the gear teeth can be reduced.

Fig. 6 provides some indication of the accuracy required as a function of pitchline speed.

The measurement precision needs to be better than that of the component tolerance by a factor of approximately 10. Gear tolerances vary from 50 to 100 μm right down to only several microns. Therefore, gear measuring equipment needs to have an accuracy of just 1 to 2 microns when measuring a component having a tolerance of 0.01 mm.

High accuracy, particularly in gears, can incur considerable manufacturing cost. The desired gear accuracy should therefore be chosen carefully so as to obtain maximum benefit without excessive cost.

Load Conditions

The load distribution factor K_M accounts for less than uniform load across the width of the teeth and from one tooth to the next. Ideally, the load should be uniform over the full width of the teeth and the full working depth.

Many factors can affect this condition, which in turn greatly affects the reliability and performance of the gears. Poor load distribution can occur due to misaligned shafts, excessive clearance in bearings, deflections in teeth, shafts and gear structures. Obviously, misalignment of shafts must be minimized or avoided. The deflections, on the other hand, are somewhat unavoidable since they invariably result from the applied loads.

Traditionally, the supporting structures of gears (webs, stiffeners, diaphragms and tubes) have relied almost totally on empirical or intuitive techniques. As a consequence of the ability of modern gearing to transmit high loads from the use of very hard tooth surfaces, higher achieved accuracy and higher pressure angles, the imposed loads increase the stress and strain on the supporting structures.

Empirical data becomes somewhat scarce for such situations, and so to improve the potential reliability of these high specific load (load per mm of face width) gear wheels failing to perform satisfactorily from lack of strength or rigidity, the

method of finite element analysis (FEA) for stress distribution (and strain) provides a valuable tool for the evaluation of the loads in the structure of gearwheels.

Accurate stress analysis also permits the elimination of redundant material, which contributes to reductions in unnecessary cost, weight and inertia effects. However, it has been found from these studies that it is in fact the need for stiffness rather than the level of stress that most often dictates the selection of structural dimensions. The reason is that uniform load distribution and load sharing between adjacent teeth is significantly influenced by the deflections of teeth, rim and supporting structure.

The dynamic gear alignment can be very much determined by the accuracy of manufacture. During gear cutting, significant movement can occur in the blank due to the release of residual stress. The circularity of a gear can be affected by as much as 10 to 12 mm, which would be considerably outside the permissible runout tolerance.

Residual stress in the form of tensile hoop stresses induced by improper welding practices or simply by the excessive interference with shrink fitted gear rims onto a hub can create a parasitic stress condition that combines with the normal (tensile) tooth bending fatigue stresses, which in turn often leads to broken teeth.

The dynamic load distribution can also be affected by elastic tooth deflections. Since the deflected tooth is slightly behind where it should be, the approaching tooth engages with an impact. Tip relief and sometimes root relief is applied to account for this interference. It is imperative that the tip relief, especially with spur gears, does not reduce the contact ratio below 1.0, though. A minimum contact ratio of 1.2 ensures conjugate action (uniform motion) is maintained.

The correct amount of tip relief is a function of the tooth stiffness and applied load. Tip relief can be imparted to the teeth by modifications incorporated into the gear cutting tool. The actual tip relief produced in the teeth is a function of the diameter and addendum modification.

For standardized tooling, gearwheels tend to receive a generous amount of tip relief, but pinions tend to acquire little or none. Fortunately, in speed reducing drives, the tips of the gearwheel teeth engage first. The interference of the deflected tooth (Ref. 3) can be seen in Fig. 7.

Uniform load distribution can likewise be affected by the elastic deflections of long and slender pinions. Such pinions can suffer from excessive bending and torsional deflections. It is especially important with case hardened gearing

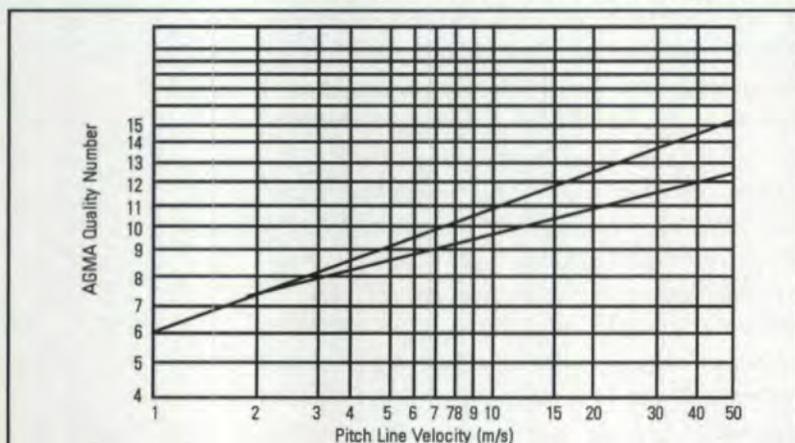


Fig. 6 — Gear quality as function of pitchline speed.

Power Integrated Pop-up™

Lift/Rotate Induction Heat-Treating System

Radyne's Power Integrated Pop-up™ heat-treat center is a self-contained system for hardening and tempering components in a lift/rotate, submerged quench method to meet the specific needs of the heat treater. A user-friendly machine interface panel and PLC control enable quick and easy setup and operation. An integrated, modern, efficient, transistorized inverter power supply can match a wide variety of heating coils with easy-to-change tuning capacitors and a multitap output isolation transformer.

The lift actuator assembly includes a ball bearing linear way mounted under a stainless steel sink through double lip wave seals. A chrome-plated stainless steel spindle is mounted on a tapered roller bearing, enclosed in a steel housing. The lift mechanism allows load/unload, heat and quench positions.

The Perfect Integration

The combination of Radyne's Power Integrated Pop-up™ and APEX QA™ Quality Assurance system represents the latest in induction heat-treating technology.



COME VISIT
US AT IMTS
BOOTH #C2-5364

RADYNE

Innovators in Induction Heating

1-800-236-8360

211 W. Boden Street
Milwaukee, WI 53207, U.S.A.
(414) 481-8360 • Fax: (414) 481-8303
e-mail: radyne@execpc.com
<http://www.radyne.com>

CIRCLE 139

to apply a small amount of end relief to avoid loading the ends of the teeth.

Rim Proportions

The rim factor K_B considers the reduction in ratings when the rim thickness is less than 1.2 times the tooth depth. Excessive deflections of the rim can seriously impair the reliability of the gear to perform properly (Ref. 4).

While AGMA suggests a factor of 1.2 times tooth depth as a safe minimum, the gears with higher specific load and those gearwheels with very wide face widths require proportionally greater rim thickness or other means of support to counter these deflections.

Tooth Geometry

The tooth shape or geometry also plays a major role in the overall performance of gearing. The constant angle between the line of action of involute gear teeth and the common tangent to the kinematic pitch circles at the pitch point is called the pressure angle.

Standard pressure angles evolved to rationalize the tooling required to produce gears. The Australian standard AS 2938-1995 for gearing promotes the use of ISO 53 tools with 20° pressure angle. Various other standard pressure angles are used, though.

The operating pitch line speed of the gears tends to govern the choice of pressure angle for a given application. At one extreme, pressure angles of 14.5°, 15°, 16° or 18.5° are employed to minimize noise and vibration excitation at high pitch line speed by virtue of a greater number of teeth in mesh (higher contact ratio) at any particular instant with such pressure angles.

With higher loads and slower speeds, it becomes more important to maximize tooth bending strength and pitting resistance. Pressure angles of 20°, 22.5°, 23° or 25° can be used on gears with high specific tooth loads and low pitch line speeds.

The disadvantage of high pressure angles is the reduction in transverse contact ratio (number of teeth in mesh) and a narrower top land thickness. Despite this, the use of a 25° pressure angle for low speed,

high torque drives has achieved wide acceptance in many industries following its success in the gearing of draglines used in open-cut coal mines.

The geometry factors I for pitting and J for tooth bending strength both benefit from pressure angles larger than the traditional 20°. This is because for a given diameter, as the pressure angle increases, a lower radius of curvature on the teeth can be obtained, and so in turn, the Hertzian stress is reduced.

Similarly, a gain in tooth bending strength results from the increased tooth thickness at the base of the tooth. The 25° tooth form will carry about 20% more torque than the 20° nominal tooth form, all other factors being equal.

Additionally, the tooth geometry and effective pressure angle can also be influenced by addendum modification. Positive addendum modification is considered crucial for low numbers of teeth (typically < 17) where the base circle, from which the involute originates, intrudes on the active portion of the tooth profile.

Positive addendum modification alleviates the undercut in the root fillet region that ensues from this intrusion. Undercut can seriously affect the tooth bending strength by reason of the narrower (undercut) tooth thickness at the base. The contact ratio can also be adversely affected from the reduced length of active tooth profile.

The gearset likewise benefits from an increase in the relative radius of curvature on the pinion tooth, thus improving the pitting resistance. The maximum sliding velocities occurring at the extreme points of engagement can also be optimized with judicious selection of addendum modification.

The gears will not perform very well or at all without proper lubrication. Besides reducing friction and preventing wear, the lubricant is also relied upon to remove heat from the tooth surfaces.

In the case of the total loss spray systems used on the open gears of metalliferous grinding mills, cement mills, kilns and sugar mills, the air blast used to purge the lubrication system should not be so great that it displaces the grease from where it has just been deposited on the pitchline of the teeth. This can occur particularly with the low base oil viscosity grades or the latest nonchlorinated solvent group of lubricants.

A reasonable surface finish is necessary to ensure the contact between meshing teeth. While a smooth surface finish is desirable, it is sometimes the bane of manufacturers to achieve a satisfactory surface finish with the materials employed. As the purity of gear steel increases, the machinability of such materials tends to decrease. The cleaner steels improve fatigue resis-

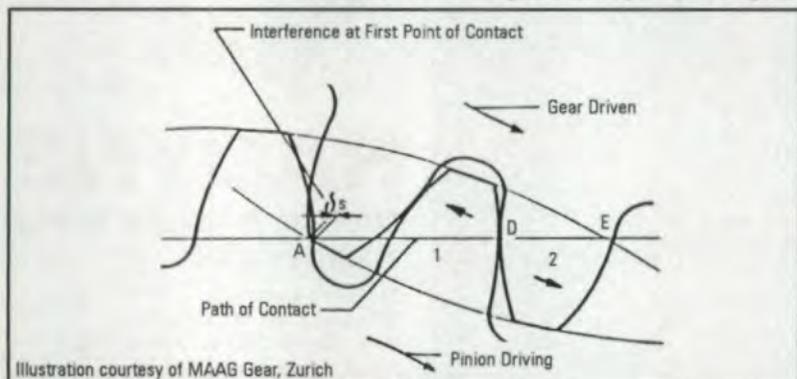


Illustration courtesy of MAAG Gear, Zurich

Fig. 7 — Tooth deflection and the need for tip relief.

tance but some trade-off sometimes occurs with surface finish. To date, none of the international gearing standards specify limits on surface finish other than the benefit of smooth pinion surfaces to encourage work hardening.

In addition to maintaining an acceptable surface finish on the teeth, the root fillet region deserves special attention. In this region, removal of lineated tool marks aligned with the axis of the tooth by finishing or shot peening can eliminate undesirable stress raisers.

Installation and Commissioning

Upon completion of the individual gears, the two components can be meshed together in the workshop to show how well the gears might ultimately perform. A simple mesh test with the gear and pinion set at the correct center distance and planar relationship can verify satisfactory compliance of runouts, profile, backlash and load distribution rather than taking for granted that these will be correct upon installation.

Dynamic testing methods that simulate the operating conditions can be employed to provide further information. A no-load test can be used to verify satisfactory gear design, manufacture and assembly in terms of potentially acceptable noise and vibration levels, satisfactory gear tooth alignment and bearings and lubrication operation.

A load test using either a brake or back-to-back test can simulate the actual service conditions for a much better validation. The back-to-back test can only be done with a pair of mirror-image gearboxes and not without incurring some additional cost.

The assembly of gearboxes has been found to directly affect their reliability when put into service. Since the gear case will have been machined to suit the bearing race size, final assembly must maintain the proper fit. The overzealous use of sealing compound on the gear case halves or simply a gap between top and bottom will allow the outer bearing races to spin, causing premature failure of the bearings and damage to the gear case.

In the case of rotating shafts, the fit of bearings to the shaft is also critical. The current design of some roller bearings uses reduced race thickness. The consequence can be increased hoop stress culminating in breakage of the race, particularly if the shaft size is at the upper tolerance or greater.

The installation can obviously have a direct bearing on the reliability of the gearset. The gear alignment and uniformity of load distribution across the width of large gears can be determined from non-contact temperature measurement using an infrared pyrometer (thermometer). The foundations and gear support structure must also be adequate and stable to maintain these alignments.

In bolting down the gearbox, an uneven foundation will distort the gear case. Even just a small amount of twist in the gearcase can significantly affect the gear alignments. This aspect can sometimes be used to advantage to achieve proper gear alignment when the gearbox bores are not machined just right.

Couplings play a vital function in the success of a gear drive. A case in point is herringbone or double helical gearing, which has the special need where the couplings must not restrict the axial movement of the floating member. The choice of couplings may also need to consider the necessity to isolate the gear elements from sources of resonant vibrations (or the coupled components from the gear mesh excitation).

Proper care and maintenance practices form an essential ingredient in order that the potential or intended reliability will be realized in service. The benefit of a regular inspection program should not be underestimated. Condition monitoring methods such as vibration levels, temperature measurements, oil analysis, visual inspections and non-destructive testing provide valuable information to assure the long-term performance and reliability of any critical or important gear elements.

In conclusion, the reliability of any gear set is influenced by many factors. The production of gears involves some very sophisticated machine tools and specialized processes and procedures, so gears tend to be rather expensive items. The designer plays a vital role in the success of these gearsets, but so too do those involved with the manufacture, installation and maintenance.

The whole of life cost should be considered since mediocre gear quality gearing rarely proves worthwhile, since the downtime can also be very costly. A considerable effort is expended in producing both good and not-so-good gearing, but hopefully the preceding information provides some insight into the many aspects that contribute to achieving the best and most reliable gearing. ☉

References

1. Dudley, Darle W. *The Handbook of Practical Gear Design*. Technomic Publishing, 1994.
2. ANSI/AGMA 2001 - C95. *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth*. American Gear Manufacturers Association, 1995.
3. Maag Gear Company Ltd. *MAAG Gear Book*. Zurich, 1990.
4. R.F. Beale. *Rating of Heavy Duty Gears and Experiences*. Congress on Gearing, Paris, France, 1986.
5. Nolan, C. J. *Metals Engineering Quarterly*. Vol. 13, No. 2, 1973.

Tell Us What You Think . . .

If you found this article of interest and/or useful, please circle 201.

This article first appeared in the proceedings of the "Gear and Shaft Technology Seminar" held by the Institute of Materials Engineering Australasia Ltd (formerly Institute of Metals and Materials Australasia Ltd) at Wollongong, NSW, July 29, 1997.

Complete Gear Manufacturing Process Control

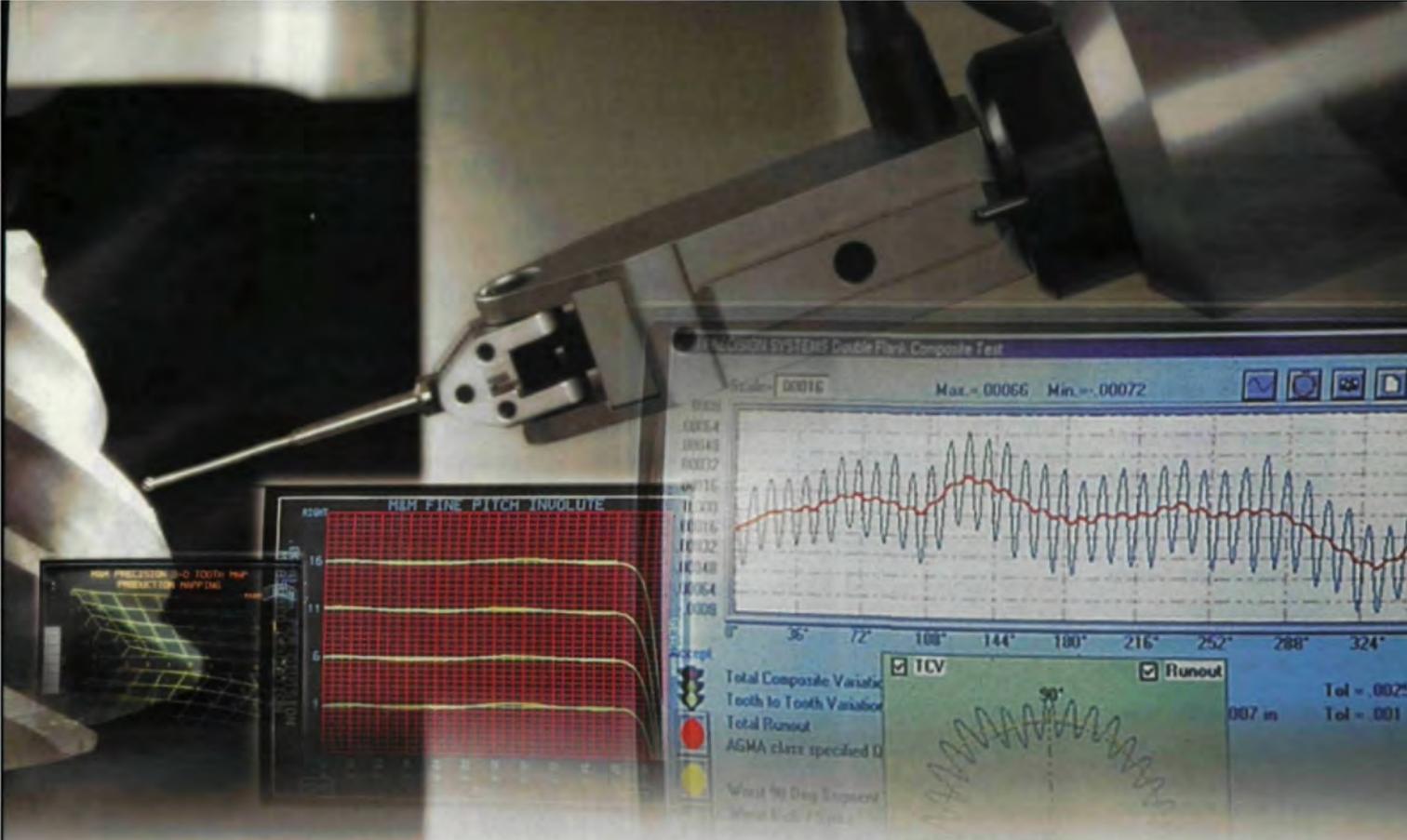
From your single source for computerized analytical and functional gaging systems

- GearNet™ server automatically shares data for SPC, remote analysis and archiving.
- Simple, familiar interface ideal for manufacturing cell operators.
- Unmatched software selection, including bevel gear machine correction package.
- Pentium® based technology.
- Complete training and applications support with every system.

3500 Series CNC Gear Manufacturing Process Control Systems offer full four-axis flexibility and unsurpassed accuracy. Certification to .001mm traceable to NIST and probe resolution to .00002mm. You get greater productivity, too, with up to 20% faster throughput and capacities to 95" in diameter.

200 Series Systems provide all the performance and durability of the larger systems, but in a compact size that's perfect for high production parts up to 10" in diameter.





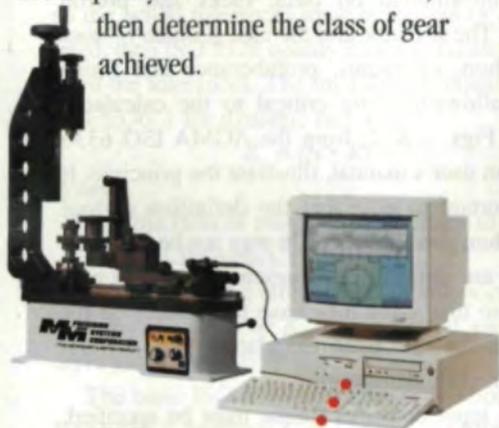
GRS-2 Double-Flank Gear Roller System combines proven performance with easy-to-use PC compatible software to make inspection accurate and simple. Total composite, tooth-to-tooth and runout tests determine if parts conform to specification. Computer analysis lets users specify AGMA or DIN standards, then determine the class of gear achieved.

Dimensions Over Pins Gage measures actual tooth thickness at the pitch diameter. A unique constant-pressure gaging head assures repeatability and accuracy over the full range of the gaging system—while greater throughput allows you to inspect more parts and reduce production costs.

Other M&M Precision Systems inspection products:

- Master Gears
- Spline Gages
- Variable Spline Indicators
- Fixture Gages
- Arbors

Free brochure Call 937/859-8273 or fax 937/859-4452.



M&M PRECISION SYSTEMS CORPORATION

"THE METROLOGY & MOTION PEOPLE"®
 COME VISIT US AT IMTS BOOTH #B1-7149 CIRCLE 140

Comparing Standards

The keys to understanding ISO 6336-1 gear rating

Don McVittie

This is the second of a series of articles introducing the new ISO 6336 gear rating standard and its methods of calculation. The opinions expressed herein are those of the author as an individual and not necessarily those of any organization of which he is a member.

One of the best ways to learn the ISO 6336 gear rating system is to recalculate the capacity of a few existing designs and to compare the ISO 6336 calculated capacity to your experience with those designs and to other rating methods. For these articles, I'll assume that you have a copy of ISO 6336, you have chosen a design for which you have manufacturing drawings and an existing gear capacity calculation according to AGMA 2001 or another method. I'll also assume that you have converted dimensions, loads, etc. into the SI system of measurement.

ISO 6336 looks into more details of your design, so it requires about 80 input values compared to about 60 for AGMA 2001. The additional information required includes details about things like blank construction, root fillet finish, lubricant viscosity, arrangement of the gear set with respect to the bearings and location of light load contact pattern with respect to the bearings. We'll cover these differences as they apply, section by section.

Input Data

Most of the input data is similar to other rating standards, like AGMA 2001. The basic gear

geometry values of numbers of teeth, center distance, outside diameters and face widths are the same. ISO 6336 requires the input of minimum safety factors for surface contact (pitting) and root bending stresses. The safety factors are used in the calculation of allowable working stresses in parts 2 and 3. While safety factors as low as 1.0 are permitted, most users will want to select a higher value for root bending, such as 1.2 or more. If the required safety factor is not achieved with the input values of materials, geometry and load, one or more of the inputs should be changed until the required safety factor is reached.

Module, normal pressure angle and helix angle are determined at the reference (generating) diameter, based on a carefully defined basic rack geometry per ISO 53. The basic rack is a gear with an infinite number of teeth whose reference plane is located where the tooth thickness and the space width are equal. The basic rack is not the cutting tool. It is conjugate to a hypothetical rack shaped tool which defines the tooth shape.

Tooth thickness is defined in terms of the profile shift factor X of a "zero-backlash" gear pair derived from the basic rack geometry. (See the article in July/August 1993 and a correction to one of the formulas in January/February 1994 for more information on basic racks and profile shift.) The X factor and the tool geometry—tool addendum, tip radius, protuberance and finish stock allowance—are critical to the calculated result. Figs. 1 & 2, from the AGMA ISO 6336 program user's manual, illustrate the principle. It is important to note that the definition of tool addendum used in ISO 6336 may not be the same as you are using in your present gear rating program, so that value may have to be adjusted for input to the ISO 6336 calculation. Fig. 3 illustrates the ISO definition.

The input power or torque must be specified, since the ISO dynamic and load distribution factors are load dependent. Although the ISO standard lists numerical application factor values which are identical to AGMA's, those values should be used with caution. The ISO definition of application factor is broader than AGMA's, including many "dynamic" effects, such as the effect of tooth spacing deviations which are part of the AGMA dynamic factor. The differences are most noticeable in the calculat-

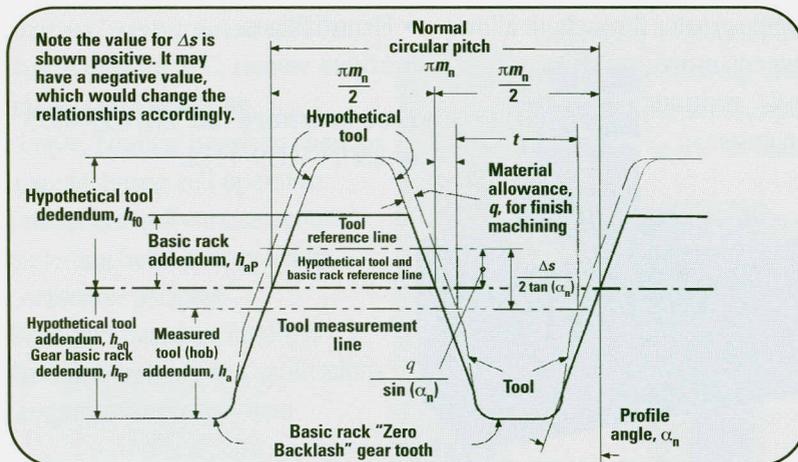


Fig. 1 — Basic rack and hypothetical tool represented in rack form (©AGMA)

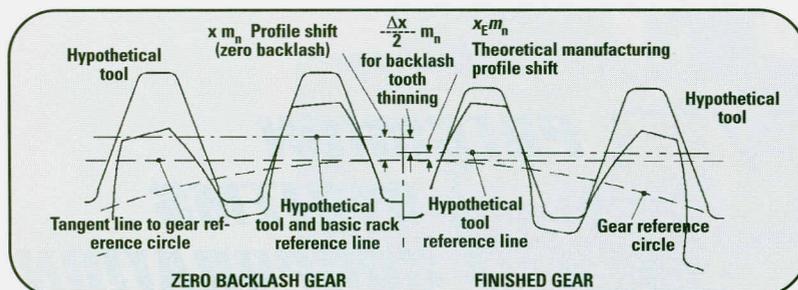


Fig. 2 — Hypothetical tool with zero backlash and finished gear (©AGMA)

ed capacities of large, low speed, relatively less accurate gears, such as those found in bridges, mill drives, train positioners and antennas. The ISO dynamic factor estimates gear pair resonance as an equivalent single mass system with the mesh stiffness as a spring. The ISO dynamic factor is strongly influenced by the ratio between the mesh pass frequency and the calculated resonant frequency of the single mass model. High speed, lightly constructed, lightly loaded gear sets have high ISO dynamic factors and low speed, heavily constructed, heavily loaded gear sets have very low ISO dynamic factors. Many of the "dynamic" effects which AGMA includes in its dynamic factor are shifted to the application factor by ISO. You will need to be careful in your evaluation of the differences and in the application factor you choose to evaluate your gear sets. The product of $K_A \cdot K_V$ should be nearly the same in both systems if rated gear capacities are to be comparable.

Calculating the Dynamic Factor

The ISO dynamic factor calculation estimates the rotational moments of inertia of the pinion and wheel from the inside diameters of their rims and their calculated root diameters with an adjustment for webs, if any. The gear blank geometry must be provided for this calculation. The mesh stiffness and root diameters are calculated from the X factors and tool geometry, so accuracy of these input values affects the dynamic factor. A smaller portion of the dynamic factor is a function of tooth accuracy, expressed as an ISO 1328 quality number. There is no consistent way to estimate ISO 1328 quality from AGMA 2000 quality numbers, so the actual tolerances must be known or calculated, then ISO 1328 quality numbers recalculated from the tolerances. The fundamental equation in ISO 6336-1 for dynamic factor is:

$$K_v = (N \cdot K) + 1$$

Where:

N is the ratio of mesh pass frequency to resonant frequency.

K represents the effect of gear tooth accuracy.

Typical values of K_v for industrial enclosed drive gears are 1.05 or less.

The basic ISO dynamic factor is Method B of ISO 6336-1. Methods C and D are simplified versions of method B with applicability restricted by their underlying simplifying assumptions.

The AGMA dynamic factor is included in ISO 6336-1 as alternative method E for those who prefer it. If method E is used, it might be appropriate to use a lower (AGMA) value for application factor.

Evaluating Load Distribution

Much of ISO 6336-1 is devoted to various methods of evaluating load distribution across

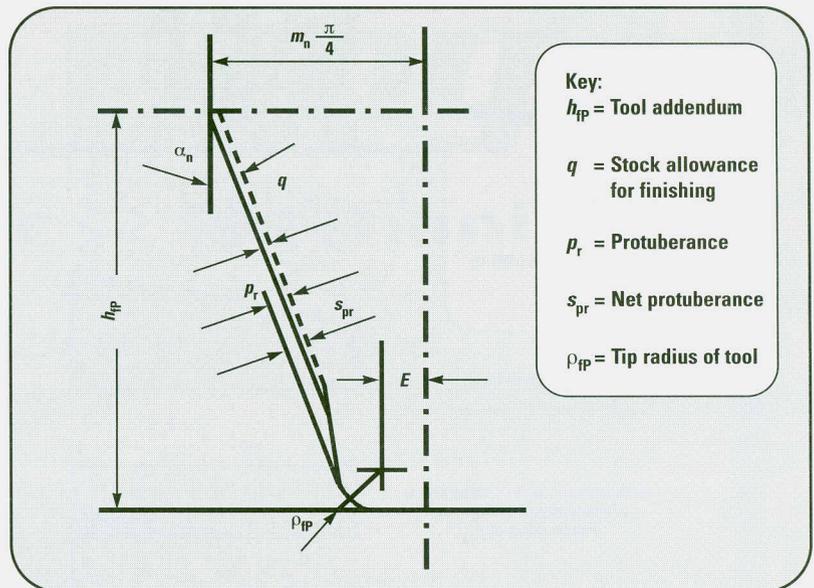


Fig. 3 — Dimensions and basic rack profile of the teeth (finished profile with undercut).

and between the teeth. Although different influence factors are defined for load distribution in root bending stress and contact stress in the face and transverse directions, the principal influence on the load capacity of the gear set is $K_{H\beta}$, the face load distribution factor for contact stress. $K_{F\beta}$, the face load distribution factor for root bending stress has a similar value and the transverse load distribution factors $K_{H\alpha}$ and $K_{F\alpha}$ are usually nearly 1.0.

The correct evaluation of the load distribution factor is critical to obtaining satisfactory results with ISO 6336, just as it is with other gear rating systems, such as AGMA 2001. I suggest that you try the various optional methods in ISO 6336 while making comparative capacity calculations with your own gear designs, to develop experience with them. Since the mathematical definition of face load distribution factor is the same in ISO 6336 as in AGMA 2001, you should expect similar values of this factor from either method. If the values are not within 10% of each other, you should investigate further and resolve the difference. It may be necessary to make an experimental investigation or a detailed calculation of deflections under load to get the "right" answer. It is important to consider the effects of manufacturing variations as well as the average meshing conditions in this analysis. Method A is commonly used to evaluate $K_{H\beta}$ —assuming that a mathematical model gives satisfactory results. Recent investigations by an ad hoc group sponsored by ISO/TC60/SC2/WG6 in which the same gear sets are calculated by different "correct" mathematical models have shown that the value of $K_{H\beta}$ can vary more than 10% depending on small variations in the calculation method and the underlying assumptions. Future editions of ISO 6336-1 are

Don McVittie

is one of Gear Technology's technical editors. He is president of Gear Engineers, Inc., Seattle, WA and a former president of AGMA. McVittie is a licensed professional engineer in the state of Washington and has been involved with gear standards development for more than 25 years.

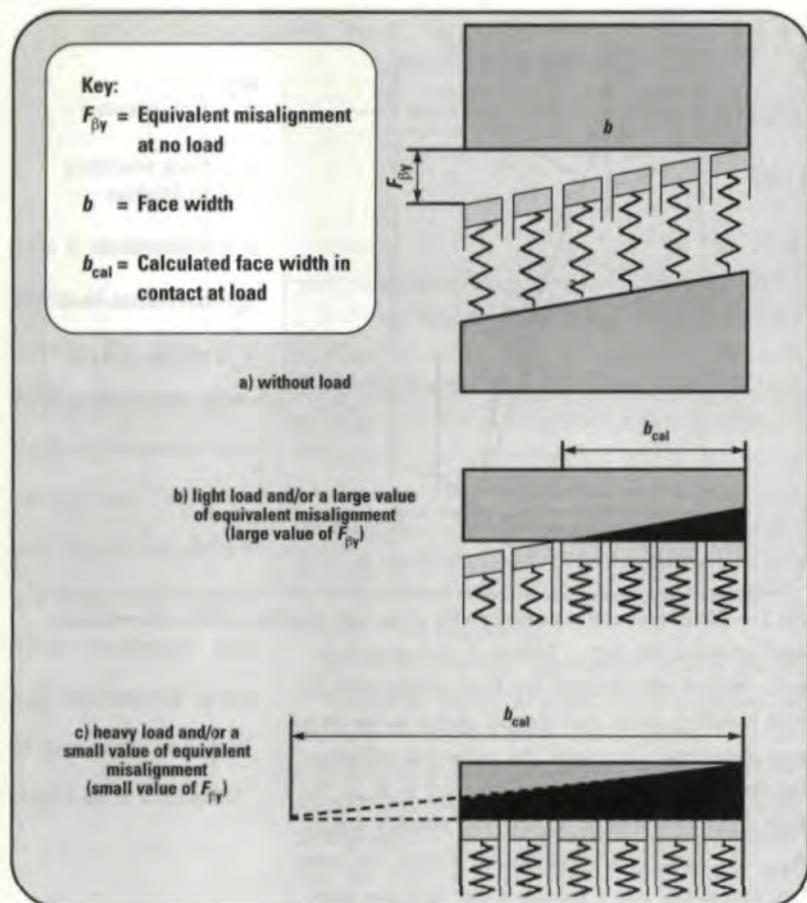


Fig. 4 — Distribution of the load along face width with linear equivalent misalignment.

expected to specify a more detailed calculation method as method B and to restrict method A to experimentally verified values of K_{HB} . In general, values of C_m calculated by AGMA 2001's empirical method are somewhat more conservative than the values of K_{HB} commonly used as method A by European manufacturers of industrial enclosed drives.

Methods B, C and D are based on a simple mathematical model of mesh deflection under load. The mesh stiffness constant is the same as the spring constant used in the method B dynamic factor. That constant is about 1/3 higher (more stiff) than the factor which was used in the AGMA standards, so load distribution factors calculated by methods B, C and D tend to be higher than AGMA values.

Method B assumes a linear load distribution model with constant mesh stiffness, similar to the analytical method which was used in pre-1995 editions of AGMA 2001 (See Fig. 4). The fundamental input is the total loaded mesh misalignment including the effects of manufacturing variations, and elastic deflections due to load. The deflection of the wheel shaft can optionally be included in the total mesh misalignment. Method B doesn't implicitly recognize the benefits of tooth crowning, but it does recognize the benefits of running in and helix modification to compen-

sate for torsional and bending deflections of the pinion. The evaluation of total misalignment is very important, since it has a large influence on K_{HB} and the calculated capacity of the gear set. If you elect to use method B, be sure to read all of the detailed instructions and limitations which are included in section 7 of ISO 6336-1.

The AGMA computer program for ISO 6336 allows the input of a K_{HB} value (method A), the input of a mesh misalignment (method B) or the input of detailed information about the mesh to calculate K_{HB} according to method C. Method C is limited to the case where the center of the pinion is within 30% of the center of the bearing span. Gear sets which do not meet this limit must be calculated by methods A or B. A subset of method C (C1) is a further simplification for symmetrically located pinions, but the same inputs are required. Method C considers the gear set arrangement, pinion shaft deflection, type of crowning or lead correction and the location of the light load contact pattern, so inputs for all of those factors are required. Method C is a bit complicated to use in hand calculations but, once programmed, allows the user to see the effects of changing pinion proportions and crown or lead corrections. Method C can give results which are similar to the empirical method of AGMA 2001 for heavily loaded narrow face width pinions. Lightly loaded wider faced pinions can be heavily penalized. Method D is a further simplification of method C1 for symmetrically located pinions.

This concludes our exploration of ISO 6336-1. It contains the most important influence factors, which are also the most difficult to evaluate and which have the most potential to be different from AGMA or other calculation methods.

The calculation methods for surface contact (pitting) stress and root bending stress in ISO 6336 are very similar to AGMA 2001. The nominal stresses, which depend only on load and geometry, have similar values. The combined effects of the general influence factors from ISO 6336-1 modify the nominal stresses to "calculated" values which have essentially the same definition as AGMA's "stress numbers." Most of the differences between gear ratings by ISO 6336 and AGMA 2001 are explained by the general influence factors of ISO 6336-1. These general influence factors offer the greatest opportunity for further research and improvement of the standard. Users of the standard will need to exercise good judgment in picking the calculation methods to be used and the values of input variables in order to be satisfied with the calculated results. ☉

We will be back on more familiar ground in the next article, which looks at the details of calculating surface contact and root bending stresses in ISO 6336-2 and -3.

Tell Us What You Think . . .

If you found this article of interest and/or useful, please circle 202.

Why?

Hydraulic vs. Mechanical



Hydraulic Arbor with and without gear.

The advantages are obvious:

- $<.00012''$ TIR
- Maintenance free totally enclosed system ensures trouble free operation.
- Workpiece clamping for:
Grinding Sharpening Turning
Milling Inspection Balancing Fixturing
- Standard hardness: 52-54 HRC.
- Multiple workpiece clamping.

We offer more...

Hydraulic Expansion Arbors

- Available in steel or plastic.
- Expansion rates up to 1% of the diameter.
- Manual & automatic actuation.
- Custom designs available to fit your requirements.

CIRCLE 143



Now Made in the U.S.A. - Order your free catalog today!

For the World of Precision

See us at IMTS '98 BOOTH # E12471

SCHUNK Inc. • 211 Kitty Hawk Drive • Morrisville, NC 27560
Tel. (919) 572-2705 • 1-800-772-4865 • Fax (919) 572-2818

SCHUNK
PRECISION WORKHOLDING SYSTEMS



www.schunk-usa.com

EXPANSION ARBORS

Industry In Motion

SCHAFER GEAR ACHIEVES QS 9000/ISO 9002 STATUS

Schafer Gear Works, a manufacturer of gears and related components for industrial, automotive, agricultural, aircraft avionics and consumer products companies, has met the requirements of the International Standards Organization for its South Bend, IN plant and has been awarded QS 9000/ISO 9002 registration, according to Bipin N. Doshi, Schafer president.

The qualification process, according to Schafer quality assurance manager, Robert Worrell, was undertaken on the company's own initiative. Although not a Tier 1 supplier providing products directly to the end-product manufacturer, but rather through other sub-suppliers, Schafer management initiated the process to improve its own internal performance and to offer its customers the benefits of Tier 1-level quality and service.

IMTS 98 YOUTH SUMMIT PLANNED

It is common knowledge that the machine tool industry faces a shortage of skilled workers—the workforce is getting older and there are not enough young people entering manufacturing to replace them. To meet the need of introducing students to careers in manufacturing technology, a diverse group of industry leaders has planned the IMTS 98 Youth Summit.

The primary aim is to utilize IMTS as a means of attracting students to careers in manufacturing technology. At the show, students will learn that the number of job openings within the industry is high and that beginning precision machinists and toolmakers command impressive salaries. They will also see that grimy, dimly-lit, rust-belt workplaces are history, replaced by high-tech, computer-driven "clean room" environments and that manufacturing desperately needs an infusion of skilled and trainable workers.

Members of the group putting on the IMTS 98 Youth Summit include the American Machine Tool Distributors Association, The Association for

Manufacturing Technology, Focus:HOPE, Gardner Publications, Inc., National Coalition for Advanced Manufacturing, National Institute for Metalworking Skills, National Tooling and Machining Association, Precision Metalforming Association, Society of Manufacturing Engineers, Tooling and Manufacturing Association and Vocational Industries of America.

IMTS 98, September 9–16, 1998, at Chicago's McCormick Place, will be the largest International Manufacturing Technology Show in the 71-year history of the event. Over 1,400 exhibitors will showcase 50 million pounds of advanced technology over 1.3 million square feet of exhibit space.

CARBIDE MANUFACTURING CELL HELPS PFAUTER-MAAG CUTTING TOOLS MEET INCREASED DEMAND FOR SOLID CARBIDE HOBS

Faced with unprecedented industry demand for its solid carbide hobs, Pfauter-Maag Cutting Tools has established the industry's first carbide manufacturing cell at its ultra-modern manufacturing facility in Rockford, Illinois.

This dedicated resource, consisting of the most advanced CNC grinding machines available, allows Pfauter-Maag to meet both increased demand and address the special handling and quality issues carbide tool production involves.

TIMKEN STEEL WINS CHRYSLER SUPPLIER AWARD TWO YEARS RUNNING

For the second year in a row, the Timken Company Steel Business has been awarded the Chrysler Corporation's Gold Pentastar Award for exceptional quality, delivery and warranty performance.

"The Timken Company has a reputation for manufacturing quality products," said Dan A. DeMare, senior buyer, Chrysler Corp. "But this award also recognizes its exceptional service and delivery to Chrysler. Once again, Timken's performance—as a supplier and a part-

ner—is deserving of our company's special recognition."

Timken supplies Chrysler with seamless steel tubing used to manufacture gears and races for automatic transmissions.

BALZERS TOOL COATING APPOINTS PETER BJORKMAN PRESIDENT

Balzers Tool Coating, Inc., a supplier of thin film wear protection coatings to manufacturers and users in the metalworking industry, has appointed Peter Bjorkman to the position of president, replacing Roger D. Bollier who left to become president of N.C. Industries. Previously, Bjorkman was



Peter Bjorkman

the president of Balzers Sandvik, a joint venture company in Stockholm, Sweden, serving the wear protection coating market in Scandinavia.

AJAX MAGNETHERMIC APPOINTS NEW DIRECTOR OF MARKETING

Frank C. Wilson has been appointed Director of Marketing for Ajax Magnethermic Corporation. Wilson has been involved in the induction heating business for over thirty years. His experience includes all areas of sales and marketing, as well as technical application and machine design concept expertise.

In his new post, Wilson will be responsible for the four U.S. service centers that provide coil repairs and rebuilds, replacement coils and other maintenance and repair parts and services. Wilson will also provide other marketing services in support of Ajax's sales efforts.

LINDBERG EXPANDS OPERATIONS— RECEIVES QUALITY RECOGNITION

Lindberg Corp. (Nasdaq: LIND), the largest commercial heat treater in the United States, has announced the establishment of its first heat treating facility in Monterrey, Mexico. The site is expected to be fully operational during the second quarter of 1998. "We will process materi-

als for a variety of metal-working customers that were identified in a recent market study," said Leo G. Thompson, president and CEO. "This will establish a base of operations that could expand over time to meet other market needs. We are excited about the opportunities we have discovered in Mexico, particularly in the growing metal-working markets of northern Mexico."

Lindberg also announced the acquisition of Houston Heat Treating Company, which primarily serves the oil and gas industries. Privately held Houston Heat Treating reported sales of about \$6 million in 1997. Terms of the cash deal were not disclosed. "This will be our second division in the Houston market," said Thompson. "Our other recent acquisitions have focused on the aerospace industry. In keeping with our expansion strategy, we are continuing to search for profitable heat-treat businesses serving a variety of industries."

In an unrelated matter, Lindberg Corporation's Industrial Steel Treating Division, located in Huntington Park, CA, has been awarded a letter of compliance to the AS-9000 aerospace quality standard. The division had previously received and continues to maintain ISO-9000 and NADCAP (North American Defense Contractors Accreditation Program) accreditation. Lindberg's Vac-Hyd Division, located in Rancho Dominguez, CA, was the first commercial heat treating operation in North America to receive an AS-9000 letter of compliance in late 1997. The Industrial Steel Treating Division provides heat treating and brazing services for customers primarily in the aerospace industry.

NADCA ASSUMES MANAGEMENT OF THE DIECASTING DEVELOPMENT COUNCIL

The North American Die Casting Association will assume management of the Diecasting Development Council (DDC), the marketing affiliate of NADCA. The new Executive Director of the DDC will be Leo J. Baran and, under the new management, the DDC will relocate to 9701 W. Higgins Rd., Suite 855, Rosemont, IL 60018-4721. The new

phone number will be 847-292-3625 and the fax will be 847-292-3613.

The DDC's mission stresses the need to expand the North American marketplace for die cast components of all major alloys. It provides design, specification and sourcing assistance to OEMs as well as literature, manuals, video production, regional and on-site seminars and marketing and advertising to help generate qualified sales leads for DDC member companies. ⚙

**IF YOU HAVE AN INDUSTRY NEWS ITEM
YOU'D LIKE TO SHARE, PLEASE SEND IT TO**

**GEAR TECHNOLOGY
P.O. BOX 1426
ELK GROVE VILLAGE, IL 60009**

Tell Us What You Think . . .
If you found this article of interest and/or useful, please circle 203.



Amarillo Gear Company combines years of experience with quality materials and workmanship to create spiral bevel gears that are a cut above the field.

Amarillo builds high quality spiral bevel gears up to 100 inches in diameter for industries across the globe. Each set is manufactured for quiet operation and durability to suit the exact production requirements of our customers.

Contact Amarillo Gear about your custom application. You'll find a ready ear and a quick response to your needs.



Amarillo Gear Company

P.O. Box 1789 Amarillo, Texas 79105 (806) 622-1273
FAX (806) 622-3258 • www.amarilogear.com



© AGC 1998

GROUND GEARS



BY NIAGARA

The answer for your most demanding gear applications.

For today's tighter specifications, conventional gear manufacturing methods just don't cut it.

Niagara Gear does.

As ground gear specialists, we use the latest grinding technology including Reishauer RZ300E fully Electronic Gear Grinders and Gleason TAG 400 CNC High Production Gear Grinders.

By meeting even the most demanding close-tolerance gear requirements, our ground spur and helical gears give you:

- Over 30% more load capacity than commercial quality gears
- Higher gear quality - up to AGMA Class 15 with crowning
- Quieter operation
- Uniform tooth profiles
- Lower costs due to the elimination of scrap and any hand sorting

More than 80% of our customers are Fortune 500 companies. Let us quote on your next gear requirement and you'll see why.

800-447-2392

Fax: 716-874-9003

www.niagaragear.com

email: info@niagaragear.com

941 Military Road • Buffalo, NY 14217



CIRCLE 129

ADVERTISER INDEX

For more information about a product or service advertised in this issue of *Gear Technology*, circle the appropriate number on the Reader Response Card and put the card in the mail.

Advertiser	Reader Service Number	Page Number
A/W Systems	111,154	18,54
A.G. Davis/AA Gage	135	42
Ajax Magnethermic	153	54
Allied Gear Company	142	62
Amarillo Gear Co.	112	39
American Metal Treating Company	144	63
Barit International Corp.	136	44
Basic Incorporated Group	113	53
Bourn & Koch Machine Tool Co.	172	55
Colonial Tool Group	166,169	13,17
Crown Gear B.V.	146	47
DIGIT, Inc.	133	46
Dr. Kaiser/S.L. Munson Co.	123	19
Dura-Bar	158,155	49,54
Elk Rapids Engineering	161	IBC
Emuge Corporation	103,156	4,54
Euro-Tech Corp.	177	43
Fässler	125	50
Forest City Gear	138	14-15
Gear Industry Home Page	275	55
Gleason Pfauter Hurth Worldwide Sales	100	IFC-1
Great Taiwan Gear Ltd.	152	42
Holroyd	121	45
ITW Heartland	110,170	56,54
Kapp Sales & Service	145	8-9
Koepfer America	171	61
Koro Sharpening Service	147	62
LeCount, Inc.	130	60
Liebherr Gear Technology Co.	126	5
M&M Precision Systems, Inc.	140	32-33
Mahr Corporation	157	55
Midwest Gear Corp.	148	62
Midwest Gear & Tool	137	46
Mitsubishi Machine Tools	109,175	20,21
MMT/Ikegai America	116	12
Moore Products Co.	106,179	51,54
National Broach & Machine	114	6
Niagara Gear Corporation	129	40
Nye Lubricants	141	44
Parker Industries	167	47
Perry Technology	134	60
Pfauter-Maag Cutting Tools, L.P.	102,149,168	BC,62,10
Presrite Corporation	108	58
Pro-Gear Company, Inc.	150	62
Profile Engineering	119	59
Purdy Corporation	122	57
Radyne	139	29
Roto-Technology, Inc.	178	48
Schunk Inc.	143,159	37,54
Star Cutter Co.	128,151	2,62
SU America	107,163,174	16,54,63
Suda International	176	52
Sunnen Products Corporation	165	24

The Basics of Gear Metrology and Terminology Part I

Edward Lawson,
Senior Applications Engineer, Mahr Corporation

It is very common for those working in the gear manufacturing industry to have only a limited understanding of the fundamental principals of involute helicoid gear metrology, the tendency being to leave the topic to specialists in the gear lab. It is well known that quiet, reliable gears can only be made using the information gleaned from proper gear metrology.

Part I: Gear Inspection

Gears are one of the most common devices within the world of engineering, offering an elegant solution to the problem of effective power transmission. Modern gear drive designs must provide quiet, reliable service at high power densities, which can only be achieved by using gears which accurately embody a geometry like the involute helicoid system. Gear metrology may be divided into two subtopics, functional gaging and analytical testing. These two categories of gear inspection provide fundamentally different types of information, each with its advantages and disadvantages. They can each be further divided into single flank and double flank testing procedures. It is important to understand the capabilities and limitations of these categories because misconceptions about the proper meaning and usage of the information they provide are very common.

The functional gaging type of gear inspection can be characterized as an "attribute inspection," meaning that it determines if a given production piece will function as intended in the product. It does not determine whether the various elemental specifications affecting functional performance are in tolerance or control since such elements often combine in either a cumulative or compensatory fashion. Functional gaging is, therefore, more qualitative than quantitative. More sophisticated versions of gear functional gaging instruments can provide an assortment of numerical test data. However, since most of this information is based upon a fundamentally composite observation, it is usually best applied to process performance rating exercises rather than to control of process variables as these relate more directly to elemental test parameter data.

Functional gaging observations can be based upon either single flank or double flank meshing configurations of the master and production gears. The single flank version provides a direct observation of transmission errors, while the double flank version provides observation of variation of center distance.

The analytical testing type of gear inspection would be characterized as a "variable inspection," meaning that it pro-

vides numerical information pertaining to given elemental parameter specifications of a production piece. This type of test data often serves as the basis for accept/reject decisions. However, since analytical testing is unavoidably based on sample type data (the number of teeth tested, number of test traces per tooth), it could fail to detect anomalous errors such as nicks or hard spots. Composite action testing, which includes observation of all surfaces of all teeth, would be a more reliable method for detecting such errors which, though not systematic, could adversely affect product performance.

Analytical testing is generally quantitative rather than qualitative and is usually the most valuable source of process control information since process variables usually relate more directly to elemental parameters. Like functional testing, analytical testing observations can be based upon either single flank or double flank inspection practices. AGMA tolerances are provided for involute profile, tooth alignment (formerly called lead), pitch and pitchline runout parameters. All are single flank parameters except pitchline runout.

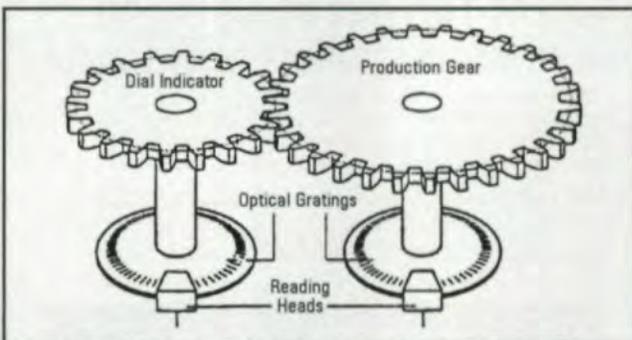


Fig. 1 — Functional Gaging: Single Flank Composite.
© ANSI/AGMA 2000-A88.

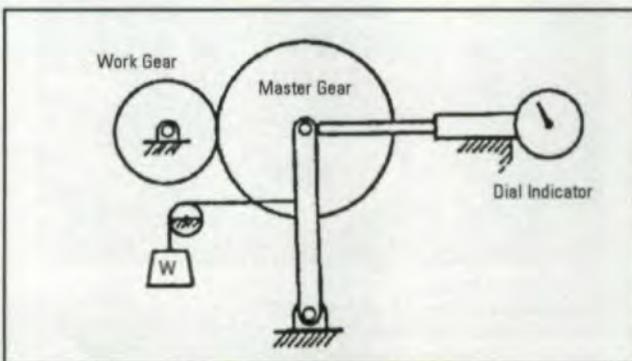


Fig. 2 — Functional Gaging: Double Flank Composite.
© ANSI/AGMA 2000-A88.

PRECISION FACE GEAR COUPLINGS



- Designed To Your Specifications • Supernatural Life
- Incredible Repeatability • Natural Positioning Accuracy



A. G. Davis/ AA Gage

6533 Sims Drive, Sterling Heights, Michigan 48313
Telephone 810 977-9000 Fax 810 977-9190

SEE US AT IMTS BOOTH #E1-2332

CIRCLE 135

AFFORDABLE PRICE ... QUALITY ... AVAILABILITY ... GREAT TAIWAN GEAR DELIVERS

GEAR MANUFACTURERS FROM TAIWAN

Spur, helical, worm, bevel, and hypoid gears.
Fine to coarse pitch gears. Gear head and gear reducer.
Plastic, sintering, nonferrous, alloy and stainless steel.
Skiving and grinding. Skive and crown hobbing after heat treat.

Hob and Shaving Cutter from Luren Precision Co., Ltd.
We welcome distributor inquiries.

Hobs: DIN AA, DIN A, T1N, TiCN TiAlN Coating
Dia. 1.25"-10" Max. Length 8" 2.5-32 DP

Shaving Cutters:
Max. Dia. 10" 6-28 DP



Great Taiwan Gear Ltd.
115 Bendingwood Circle • Taylors, SC 29687
Tel: 864-322-1266 • Fax: 864-609-5268
E-mail: GreatTaiwanGear@worldnet.att.net

GREAT TAIWAN GEAR

CIRCLE 152

Single Flank vs. Double Flank

Single flank testing provides observations (analytical or functional) of gear geometric quality involving only one flank at a time. The data provided is tangential rather than radial in direction, thereby offering information about the way the gear operates—an advantage over double flank testing operations. A single flank composite testing instrument (see Fig. 1) provides two spindles, to carry the master and production gears, mounted in fixed locations on the instrument to simulate the mounting of the gears at their proper center distance with backlash. Each spindle is fitted with a high-precision angular encoder as well as a means to apply a braking load to one of the gears as they are rotated through mesh, thereby maintaining contact on the loaded flank. The gears are placed on the spindles, brought into single flank contact with backlash and rotated through at least one revolution of the production gear. During that rotation, variation in the relative rotational velocities of the gears is observed. This procedure is based upon the assumption that two perfect gears would produce zero variation in rotational velocity, or no transmission error.

Double flank testing provides observations (analytical or functional) of gear geometric quality involving both flanks simultaneously. It provides radial rather than tangential data, information related only indirectly to the way the gear operates. The double flank composite testing instrument (Fig. 2) provides two spindles to carry the master and production gears. One of the spindles is mounted in a fixed location on the instrument and the other is mounted on a linear slide which is arranged to permit the center distance between the two gears to vary. A means is also provided to apply a load to the slide mechanism which will serve to maintain zero backlash between the gears. In operation, the gears are mounted on the spindles, brought into zero backlash mesh and rotated through at least one revolution of the production gear. During that rotation, variation in center distance between the gears is observed. This procedure assumes that two perfect gears thus tested would produce zero variation in center distance.

Double flank composite action test data can reveal radial eccentricity or out-of-round errors that can produce gear transmission error. It cannot, however, reveal angular tooth position errors which also produce transmission errors. Certain manufacturing processes (i.e. shaving) often produce gears with significant angular errors that cannot be detected by double flank testing. It is also not possible with this testing method to directly relate large tooth-to-tooth errors to gear function, including noise problems. It can, however, find non-systematic errors such as nicks, burrs or hard spots and it does offer an ideal means for evaluating functional tooth thickness based upon observations of the average center distance during testing with a calibrated master gear. Occasionally, one of the spindles is fitted with a gimble mounting to permit tilting in response to line of contact errors in the production gear. For spur gears this observation relates very well with tooth alignment errors. However, for helical gears the observation is equally and inseparably affected by both lead and profile errors.

Errors Detected by Composite Action Testing

If the error observed during either a single flank composite action test, or a double flank composite action test is plotted, the resulting trace will typically consist of long term and short term error components.

The long term component is composed of two categories of error, the most common occurring in a sinusoidal pattern once per revolution of the production gear and relating to the eccentricity of its pitchline. The second category relates to errors of the gear's shape or roundness. For example, a thin-walled ring gear which has been held in a three-jaw chuck with excessive force could display a long term error of three cycles per revolution.

The short term component is normally observed at a frequency of one cycle per mesh cycle. In a single flank test, this type of error relates to errors of tooth geometry and is directly related to noise problems, which may only be inferred from double flank tests. Frequency spectrum analysis of single flank test data usually correlates very well with the noise patterns generated by problem gears. Also, because short term errors occurring in regions of substantial slope on the long term component are affected accordingly, some standards permit the removal of the long term component from the test data before observations of the short term component proceed.

Occasionally, another pattern of short term error is observed in the single flank composite action test which does

not correlate with the meshing cycle frequency. Commonly referred to as ghost harmonics, these patterns typically relate to kinematic errors in the associated machining operations.

Testing Machines

The classic method of testing an involute is to employ a base circle disk made to the same diameter as the base circle of the gear to be tested. That disk is mounted on a spindle which can also carry the gear. The device must also provide a linear slide arranged so as to operate in a direction tangential to the base circle disk. The slide carries a straight edge which is held in firm contact with the disk. A sensitive measurement probe is also carried by the slide. The probe is placed so that it will contact one of the gear teeth within the plane of action.

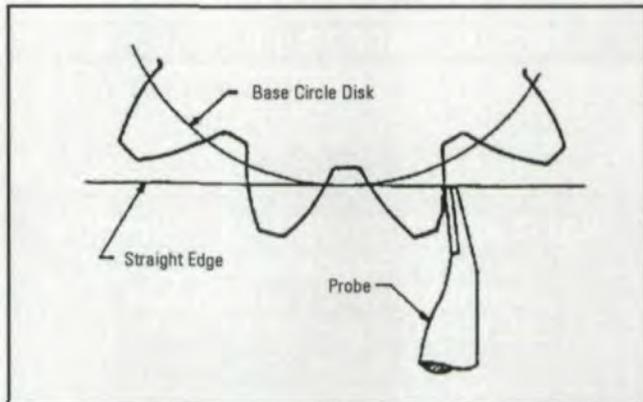


Fig. 3— Involute Profile Testing Probe. © ANSI/AGMA 2000-A88.

IN EXPANSION ARBORS A PICTURE IS WORTH A THOUSAND WORDS

Hobbing • Grinding • Spline Holding • Shaving • Hob Sharpening/Inspection • Hobbing • Grinding

Now you can see the difference in expansion arbors and chucks. Eliminate losses and downtime caused by accidental actuation or leaking seals that affect products of lesser quality.

MYTEC manufactures a superior self-contained hydraulic work holding/tool holding system designed for your needs.

DON'T SETTLE FOR LESS THAN MYTEC — COMPARE OUR FEATURES

- Hardened Tool Steel Sleeves
- Brazed one piece construction eliminates the use of Rubber "O" Rings or Bladders
- Hardened Steel Body



- **RUPTURE PROOF**
May be fully expanded with no part...Allows a true inspection of the arbor/chuck with no inspection rings or plugs.
- **INCREDIBLE ACCURACY**
.000080" TIR or less for most applications.
- **EXTREME HOLDING POWER FOR GEAR PRODUCTION**
Up to 7200 PSI clamp force.
- **AUTOMATIC OR MANUAL ACTUATION**
Adaptable to most gear machines.
- **NO HYDRAULIC SLEEVE SEALS**
Eliminates leakage, increases accuracy, virtually maintenance free.



14665 W. Lisbon Road
Brookfield, WI 53005-1626
Phone 414-781-6777
Fax 414-781-2822
E-mail: eurotech@execpc.com

SEE US AT IMTS BOOTH #E1-2530



**BARIT
INTERNATIONAL
CORPORATION**

**GEAR CUTTING TOOLS
DIAMETRAL & MODULE**

ON THE SHELF INVENTORY



- HOBS
1DP and finer
- SHAPER CUTTERS
Made to AGMA standard



SPECIAL MADE TO ORDER TOOLS

- HOBS
- SHAPER CUTTERS
- FORM RELIEVED INVOLUTE MILLING CUTTERS
- SHAVING CUTTERS
- BROACHES

BARIT INTERNATIONAL CORPORATION

3384 COMMERCIAL AVE.
NORTHBROOK, IL USA 60062-1909
TEL: 847-272-8128 • FAX: 847-272-8210
E-mail: people@barit.com
or visit us at <http://www.barit.com>

CIRCLE 136

GEAR FUNDAMENTALS

The device is moved through a course of motion which will cause the probe to traverse the gear profile from root to tip following an involute path (Fig. 3). Because of the arrangement of the inspection device, rotating the gear with the disk and carrying the probe with the straight edge, this is automatic. As the disk and straight edge roll past one another, the straight edge and probe travel a linear distance equal to the circumferential distance upon the base circle disk associated with the angle through which the disk and gear have been rotated. During this motion, the probe is carried along within the plane of action by the straight edge. If the cam (the involute gear tooth) is an accurate involute, the sensitive probe will measure no error during the motion.

There are several different kinds of test machines. The involute test instrument uses the method described above. The straight edge mounted on the slide rolls tangentially with the disk mounted on the spindle. The probe is carried within the plane of action while contacting the gear tooth that is carried along with the disk. A related device uses a master involute cam on the spindle instead of the base circle disk. This cam drives a follower on the slide which carries the probe. The gear tooth's involute profile can also be inspected using a coordinate measurement machine (CMM). This method considers the involute helicoid surface in rectilinear coordinates, a considerably more complex procedure than the classic generative methods described above and not very common.

The most common category of involute test instrument today is the CNC tester. These devices employ a rotary axis and linear slides that are not kinematically connected to one another. Instead, each axis is fitted with a high resolution scale so that its movements can be controlled by a CNC module. Typically, an axis radial to the rotary axis positions the measurement probe to contact the involute tooth flank within the plane of action. The rotary axis and tangential linear slide are then commanded to move at constant velocities such that the linear distance travelled by the slide is equal to the circumferential distance upon the theoretical base circle of the gear associated with the angle through which the rotary axis travels.

Another type of CNC tester uses the computer controlled axes in a fundamentally different way to inspect the involute. Such instruments move the measurement probe in a radial direction only, while the rotary axis is moved in a nonlinear relationship according to the given involute. This practice lowers the cost of the instruments due to the lack of the tangential measurement axis normally used to generate the involute according to the constant rise cam principal.

Part II: The Involute Profile

An ideal gear would provide both the smooth running properties of friction disks and the positive power transmitting qualities of teeth. This can be accomplished by using teeth with a geometry which conforms to the law of gearing: "In order for two gears to transmit uniform rotary motion, the common normal of the mating profiles must pass through the same point on their line of centers at every point of contact." Such gears exhibit conjugate action, which is to

P e r f o r m a n c e

S e r v i c e

**Design
Your Own
Plastic
Gearing
Lubricant**



C u s t o m L u b r i c a n t s

Challenge us! Tell us what you want from a plastic gear lubricant — besides compatibility with plastics. Operating temperatures from -70°C to 200°C? Quiet operation? Reduced backlash? Lower power consumption? A lube for micro-powered gear boxes or more robust requirements? Chances are that we have what you need. We've been designing synthetic lubricants for appliance, power tool, and automotive component manufacturers for more than 35 years. We offer a broad family of proven gearing lubricants, and the know-how to formulate new lubricants whenever unique customer applications demand them. For more information about specialty lubricants for plastic gearing, call Nye. Working together, we'll design exactly what you need.

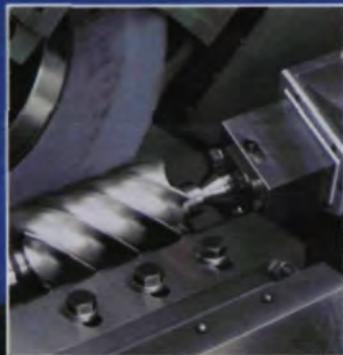


ISO 9002 REGISTERED

PO Box 8927
New Bedford, MA 02742-8927
Phone: 508-996-6721
Fax: 508-997-5285
E-Mail: techhelp@nyelubricants.com
Website: www.nyelubricants.com

T e c h n i c a l I n s i g h t

CIRCLE 141



HOLROYD THREAD GRINDING CENTERS

"Ultimate component accuracy with minimal operator intervention"

The latest generation of Holroyd Thread Grinding Centers are built for production output with minimum set-up.

The machines incorporate the latest 3D closed loop deviation and correction measurement probes to completely remove the need for off machine inspection.

The first part can be placed in the machine, ground, measured and any deviations automatically corrected before completing the cycle.

To discover how Holroyd can reduce your set-up times, and increase accuracy and throughput in your plant contact us today.



HARBOUR LANE NORTH, MILNROW,
ROCHDALE, OL16 3LQ ENGLAND

Tel: +44 (0) 1706 526590

Fax: +44 (0) 1706 353350

Web: <http://www.holroyd.com>

Email: mail@holroyd.com

RLH Associates, Inc
3302 Hwy. 74 West, Unit C
P.O. Box 807
Monroe, NC 28111
Tel: 704 282 4895
Fax: 704 289 9147

On display for the first time at

 **IMTS 98**
CHICAGO, SEPTEMBER 9-16, 1998

Booth No. B2-6516

CIRCLE 121



Certificate Number FM 32340
BS EN ISO 9001:1994

HOLROYD - The Renold Center of Excellence

SPIRAL BEVEL GEARS



Spiral & Straight Bevel Gear Manufacturing.
Commercial to aircraft quality gearing.
Spur, helical, splined shafts, internal & external,
shaved & ground gears. Spiral bevel grinding.

Mil-I-45208 • Mil-STD-45662, SPC



**MIDWEST GEAR
& TOOL, INC.**
26069 Groesbeck Hwy.
Warren, MI 48099

**CONTACT:
CRAIG D. ROSS**
(810) 776-7580
FAX (810) 776-2322

CIRCLE 137

NEW ROLLING MESH & PITCH DIAMETER ON THE SAME GAUGE

TRUE PITCH DIAMETER

CONCENTRICITY

ROLLING MESH

ALL IN ONE GAUGE



**CUSTOM GAGING OF ALL TYPES
DEMO AT YOUR FACILITY**

PHONE OR FAX FOR BROCHURE OR DEMO

DIGITAL
INTERFACE
GEAR
INSPECTION
TERMINAL

DIGIT

Member of AGMA

P.O. Box 367 • Springboro, OH 45066 • Fax: 513/746-5103
Phone: 513/746-3800 • E-mail: digit@erinet.com

CIRCLE 133

GEAR FUNDAMENTALS

say they exhibit progressive contact between mating teeth while their pitch circles rotate together at uniform, proportionate velocities.

There are limitless geometries which will satisfy the law of gearing, but no geometry accomplishes this task with the elegant simplicity of the involute helicoid system. Since it meshes with a straight sided theoretical rack, it can be accurately manufactured with relatively simple, straight-sided cutting tools. The involute helicoid geometry also has the property of operating on varied center distances without affecting its ability to provide uniform transmission of rotational motion at the same ratio. All other geometries are conjugate only at their design center distance.

Involute Geometry

An involute can be defined as the locus of a point on a line rolling on its base circle or, in three dimensions, a base cylinder. It can be imagined like this: envision a tin can as the base cylinder. Fasten a string to some point on the can and wrap it part way around while holding it taught. The string now represents a line or plane tangent to the base cylinder. This is the line (or plane) of action. Focus on a point where the string lies wrapped next to the can and begin to slowly raise the string away, keeping it taught all the time (Fig. 4). As it rises, the path followed by the point on the string as it moves up and away from the can will be an involute. At first, the point will move nearly straight up from the surface of the can. It will then quickly begin to follow a curved path similar to an Archimedes spiral. That path is the involute curve.

Two things are important to note here. The first is that this only occurs within the plane of rotation, perpendicular to the axis of the base cylinder. It is also important to note that, at any point you wish to consider along the involute curve, the string (line/plane of action) is perpendicular to the involute. Further, the curvature radius of the involute is always equal to the length of the string (line/plane of action) from the involute to the point of tangency of the string with the can (base circle/cylinder).

Consider now the same base circle (Fig. 5) with a single line of action tangent to it. In this case, the base circle can rotate about its axis when the line of action is pulled to the left. Two equally spaced points along the line of action have generated two parallel involutes as the line of action was pulled left. The distance between the involutes along the line of action is equal

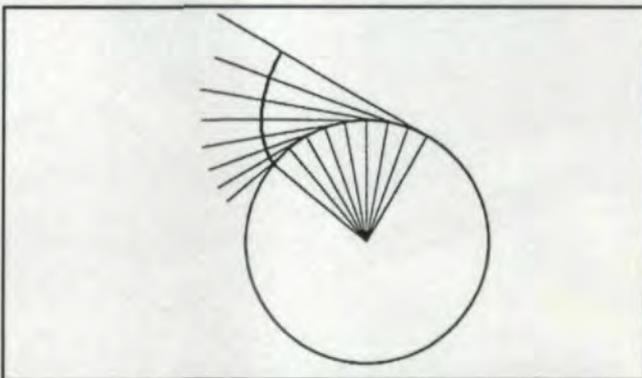


Fig. 4 — Circle with tangent lines describing an involute curve.
Courtesy of AGMA.

GEAR FUNDAMENTALS

to the distance along the circumference of the base circle. This is true because the same points on the line of action (string) that have generated these two involutes were once resting upon the surface of the base circle (can) before the involutes were generated by pulling away the string.

The Involute Cam

This observation gives rise to the most important property of the involute, that it will serve as a constant rise cam to a follower that is constrained to move within the plane tangent to the base cylinder of that involute. Imagine that such a follower has been positioned within the plane of action and in contact with the involute curve to the right. Now consider what will occur if the base circle is rotated counterclockwise through the angle required to move the involute at the right to the position of the involute at the left. The follower will be driven to a position within the plane of action contacting the left involute. It has been driven a distance along this line equal to the length of the base circle circumference swept by the counterclockwise rotation of the base circle. Any such rotation of the base circle and its involute "cams" will produce such a constant displacement of such a follower.

Figure 6 shows two base circles with a single line of action tangent to both. Involute profiles from both base circles interact with the string as we have seen before but now, with the two circles arranged to share this single line of contact, we can also see the two associated sets of involutes interacting. It can be seen that these involute profiles only contact one another within the plane of action. This condition also exists for all involute helicoid gear sets, where the mating tooth flanks only contact one another within the plane of action which is tangent to the base cylinders of both gears.

Observe the interaction of these mating constant rise involute cams. Begin with the point of contact labeled 2 near the base circle of the upper gear (driver) and at the OD of the lower gear (driven) in Figure 6. Now, rotate the driver counterclockwise through an angle necessary to move its involute to location 3. As this move proceeds from location 2 to 3, the point of contact with the mating involute is driven along the line of action, carrying the driven profile also to location 3. The distance travelled along the line of contact is equal to the circumferential distances along both base circles swept by their rotations which will be in proportion to their diameters.

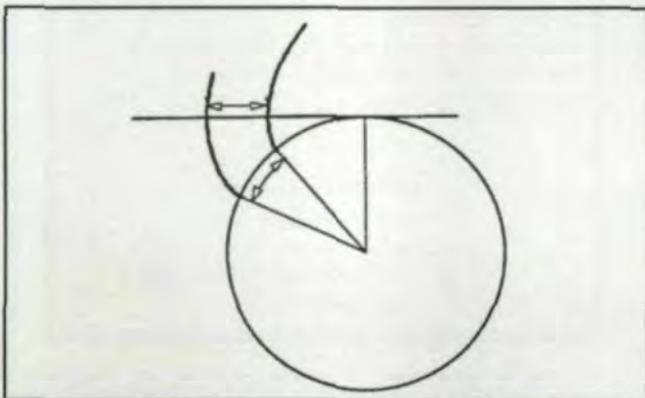


Fig. 5 — The Constant Rise Cam. Courtesy of AGMA.

CROWN GEAR



Cylkro® angular face gears

The revolutionary Cylkro® technology stands up to all your transmission demands. Whether it is the need for any axis angle between 0° and 110°, straight or helical teeth, with or without axis offset, Cylkro® angular face gears offer the solution.

Visit our Website at www.crowngear.nl



CROWN GEAR B.V.

Buuserstraat 200 NL-7544 RG Enschede
Call +31-(0)53-4773622 Fax +31-(0)53-4779147
or E-mail sales@crowngear.nl

CIRCLE 146

Where would you go to tool up for an aircraft quality double helical gear?

Don't waste your time with hobbing experts — the three teeth are continuous 45° RH & LH Helix 2.5 TDP 30° PA (modified). All machinery and tooling supplied by Parker. If you have a difficult gear, why not consult us. We know the gear tool business after 33 years of success.



1650 Sycamore Avenue, Bohemia, NY 11716
516-567-1000 • Fax: 516-567-1355

YOUR SINGLE SOURCE FOR GEAR CUTTING TOOLS AND GAGES

CIRCLE 167

Therefore, any rotation of the driver will cause an exactly proportionate rotation of the driven gear according to their diameter ratios.

Profile errors — Symptoms

Involute profile errors can result in gear noise, strength problems associated with dynamic loads promoting fatigue and durability problems associated with localized contact stress. Gear noise invariably relates to transmission error or inconsistent rotational velocities caused by geometry errors. Profile errors have a particularly troublesome effect upon

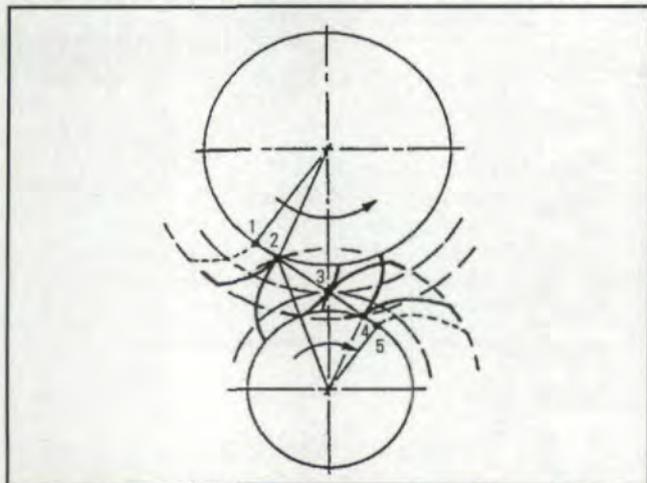


Fig. 7 — The Constant Rise Cam produces constant transmission of rotational motion. Courtesy of AGMA.

transmission error because they tend to be consistent in the teeth of the gear. This causes transmission errors at mesh frequency which is usually in the range of human audio acuity. Also, since the error is typically consistent for all teeth, the associated mesh frequency transmission error is usually of consistent amplitude throughout the rotation of the gear. This is perceived by the ear as a pure tone which is much more objectionable than a noise source of equal average amplitude that exhibits a modulated frequency of amplitude.

Involute profile errors can also adversely affect the strength and durability of a gear. Tooth strength ratings are calculated assuming that the torque load will be applied consistently and that loads applied at the critical region near the tooth tip will be shared by adjacent teeth entering mesh. Profile errors can increase dynamic loading and tip loading conditions thereby promoting fatigue and premature failure. Localized tooth contact stresses are also increased by profile errors that accelerate pitting and similar durability failures.

Profile errors—Causes

It is clear the primary contributors to involute profile errors are cutting tool accuracy and mounting errors. Cutting tool geometry errors typically transfer consistently to the gear profile on a one-to-one basis. Since other influences can also affect the gear profile, it is important that the cutting tools are significantly more accurate than the gears they are expected



We want to work with you!

your GEARS using ROTO-SMART TECHNOLOGY CNC Automatic Inspection Systems—the RC 400!

- Gears
- Splines
- Hobs
- Shaper Cutters
- Camshafts
- Worm Sets
- Crankshafts
- and more



The field-tested, PC user-friendly RC-400, has quality, accuracy, small footprint, 360° rotational probe, and is affordable.

Basic package inspects space, lead and involute. Many software options are available as well as custom-designed packages.

Free Video Available

Roto Technology, Inc.

351 Fame Road, Dayton, OH 45449-2388
TEL: (937) 859-8503, FAX: (937) 865-0656

www.rototech.com



Quieter Gears. Engineered Metals.

There's only one way to ensure that the gears you produce will always deliver superior and quiet performance. Make sure they're bred from quality stock.

Dura-Bar® continuous-cast gray and ductile iron performs like free-machining steel with an important added bonus – quieter operation.

Like steel, Dura-Bar can be austempered, through-hardened, flame-hardened, or induction-hardened for added wear resistance. But the superior vibration-damping characteristics of Dura-Bar make for quieter running gears. And Dura-Bar is 10% lighter than steel.

Dura-Bar round bars are available in diameters ranging from 5/8" to 20" and lengths of 6-20'. So you won't need to make major changes in your machining equipment. And our extensive inventory means Dura-Bar is available now – when you need it.

When it's quality material, quiet performance, and quick delivery that count, look to continuous-cast Dura-Bar for your gear production needs.



1-800-227-6455 • 815-338-1549 (FAX) • 2100 West Lake Shore Drive, Woodstock, IL 60098-7497

E-Mail: sales@dura-bar.com

Contact us for the latest data on gear noise.

Fässler Focusing on Direct Honing!

Fässler K-300 & K-400 Gear Honing Machines



Fast, economical hard gear finishing process that increases gear life while reducing or eliminating gear noise.

- Internal or external gears
- Spur, helical, or cluster gears

With Direct Honing you can hob, heat treat, and hone your gears to market requirements.

With Universal Honing it is possible to finish a family of gears having the same tooth characteristics with varying numbers of teeth.

With Combi-Honing you can rough and finish on the same machine with honing stones mounted in tandem.

MACHINE FEATURES:

- 5 and 6 CNC controlled axes
- Synchronous drives on the K-400
- CNC control of lead crowning and taper
- Short setup times

CHARACTERISTICS OF HONED GEARS:

- Increased wear resistance
- High surface finish
- Favorable machining marks for noise reduction
- Low surface roughness guarantees a permanent oil film

Fässler

Fässler Corporation
11782 N. Maple Road
Germantown, WI 53022
Phone: 414-255-0695
Fax: 414-255-9676
E-Mail: fassler@execpc.com

Fässler AG
Ringstrasse 20
CH-8600 Dübendorf
Switzerland
Phone: 011-411-821-3745
Fax: 011-411-820-3906
Web: www.faessler-ag.ch

Fässler makes good gears better!

CIRCLE 125

GEAR FUNDAMENTALS

to produce. Mounting errors can be even more problematic. A perfect cutting tool mounted inaccurately will perform no better than a low grade, inaccurate cutting tool. The use of bent or dirty tool arbors and failure to check truing diameters are possibly the most common and costly sins occurring in gear cutting operations. Errors in cutting tool accuracy or mounting tend to produce involute errors that are consistent when one observes teeth located at various positions around the gear. Errors in gear blank accuracy or mounting tend to produce involute errors that vary when one observes teeth located at various positions around the gear.

Gear blank accuracy and mounting errors are composed of two categories, eccentricity and out-of-round. Eccentricity conditions produce a sinusoidal pattern of variation in the slope trend of the involute test traces taken at various positions around the gear. Out-of-round conditions produce deformation of involute traces according to the given roundness error pattern. Radial runout of a gear caused by either an eccentric blank or an eccentric mounting of a good blank will cause a characteristic error pattern in which the profiles will display a slope error that varies in a sinusoidal pattern around the gear). This category of apparent profile error will not adversely affect the strength or durability of a gear or contribute to the generation of noise. Runout can be the source of several types of problems that affect gear performance. However, the sinusoidal pattern of profile slope errors it creates is not one of those problems.

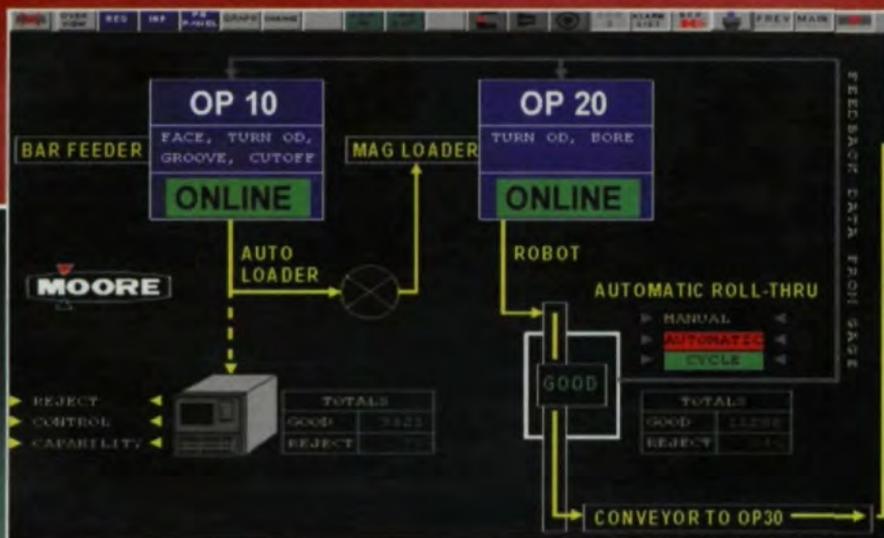
It is possible to produce a gear with a substantial out-of-round condition that would exhibit proper conjugate action with a mate. Such gears are sometimes produced when a cyclic acceleration/deceleration is desired in a mechanism. However, when a gear that is intended to be round is deformed into an out-of-round condition during manufacturing, it cannot be expected to operate without an associated detrimental effect, as would be the case with simple eccentricity.

Recognizing the absence of detrimental effects from eccentricity-based apparent profile error, procedures have been employed that tolerance only averaged profile errors. This practice is inadequate because averaging may also remove the detrimental effects of out-of-round conditions. Rather, it is only correct to adjust test results according to the gear's simple eccentricity condition which has first been determined by analysis of its radial runout or by a more complex geometry-based analysis of the profile traces. Watch for the conclusion in the next issue of *Gear Technology*. ◉

Tell Us What You Think . . .

If you found this article of interest and/or useful, please circle 204.

For more information about **Mahr Corporation**, please circle 205.



Only MOORE can help you set up very affordable process measurement & control

MOORE windows-based real-time monitoring system is available for integrating gaging and production equipment.

MOORE OFFERS THE INDUSTRY'S WIDEST RANGE OF FUNCTIONAL GAGING SYSTEMS FOR GEAR PRODUCTION

For high volume gear inspection systems, you can't beat Moore. Here's why:

MOORE Experience

Moore has been designing and producing high quality, reliable gaging systems for more than 50 years.

MOORE Technical Back-up

Moore's U.S. operations provides over 1,000 employees and a 375,000 sq. ft. manufacturing facility, full engineering services, plus additional operations worldwide.

MOORE High-end Electronics

Moore's Gaging Division draws on the technical skills and experience of the Moore Products Co., Instruments and Controls Division, which produces state-of-the-art computer systems and software for process control.

MOORE's Size

Moore is large enough to handle major programs and specialized enough to assure you personal attention.



Automatic light mesh inspection system



Semi-automatic light mesh inspection



Universal center distance gear checker



Pitch diameter inspection gage



Modular gear blank fixture



Manual roll stand

Call Or Fax The Moore Gear Gaging Experts Now

Tel: 1-215-646-7400 Ext. 2352

Fax: 1-215-653-0347

Attn: Gage Division, Gear Team



"The Measurable Difference"

Moore Products Co., Gaging Division
Sumneytown Pike, Spring House, PA 19477

Does Your Product Require Precision Ground Gears?



Bevel and Hypoid Gears to AGMA 13+

Spur and Helical Gears to AGMA 14+



Curvic Couplings® to the Highest Quality

We've been producing ultra-high-precision ground gears, Curvic Couplings®, tapered rack and pinions, and precision worm and worm wheels for world-leading machinery companies for five decades.

Allow us to quote your next requirements. Prototype or low production...1 to 1000 is our specialty.

For more information and references fax or write Les Kennedy,
SUDA Int. Gear Works N. American Office,
P.O. Box #4, Pittsford, NY 14534
FAX: 716-385-8537

SIG
Suda International Gear Works, Ltd.

Curvic Coupling® is a registered trademark of The Gleason Works

CIRCLE 176

TECHNICAL CALENDAR

Aug. 10-14. Heat Treatment of Steel. Materials Park, OH. A comprehensive course covering practical heat treating of steels, atmosphere control, quenching, temperature control and equipment types. For more information, e-mail: mem-serv@po.asm-intl.org or call 440-338-5151.

Sept. 9-16. IMTS 98. McCormick Place, Chicago, IL. Pavilions for Abrasive Machining/Sawing/Finishing, EDM, Environmental Safety & Plant Management, Factory Automation, Gear Generation, Lasers, Metal Cutting, Metal Forming & Fabrication, Quality Assurance and Tooling and Workholding Systems. The Society of Manufacturing Engineers will also hold its Manufacturing 98 conference. For IMTS information or registration, log on to www.imts.org. For SME conference information, log on to www.sme.org.

Sept. 21-25. AGMA Advanced Inspection Course. Richard J. Daley College, Chicago, IL. Advanced gear inspection and troubleshooting workshop. For more information, log on to www.agma.org or call 703-684-0211.

Oct. 12-15. ASM International Materials Solutions Conference and Exposition 1998. Rosemont Convention Center, Rosemont, IL. Where research and development meets industry for information exchange and networking. For more information contact ASM on-line at www.asm-int.org/event98 or by phone at (440) 338-4634.

Oct. 20-24. Euro-BLECH 98. Hanover, Germany. The 15th year for this outstanding international industrial trade show with over 1000 exhibitors from across the world. For more information visit the Euro-BLECH Web site at www.Euro-BLECH.de.

Oct. 25-27. AGMA Fall Technical Meeting. Cincinnati, OH. The Fall Technical Meeting features seminars and papers on the design, analysis, manufacturing and application of gears, gear drives and related products, processes and procedures. For more information, call 703-684-0211, fax 703-684-0242 or log on to www.agma.org.

Oct. 26-29. IMET. McCormick Place, Chicago, IL. IMET is an umbrella event comprising M/TECH (Computer Technology for Design and Manufacturing), Motions Systems Technology Week '98 (PT Design Show, Hydraulics & Pneumatics Show, Motion Controls & Sensors Show), Industry Week's Best Practices from America's Best Plants Conference, Computer Aided Engineering's Getting the Most from 3D and Parametric Design, Industrial Equipment & Maintenance Expo '98, Electronic CAD Conference and Metal Components Expo. For more information, log on to www.imetcongress.com.

Tell Us What You Think . . .
If you found this article of interest and/or useful, please circle 206.



NEW GEAR MACHINES



(FROM 8" TO 98" DIAMETER)

12 MODELS

STARTING AT \$39,995

MODEL #GS10-3CNC (SHOWN)

10" GEAR DIAMETER

3" FACE WIDTH

MAX. PITCH: 4.2 DP

"CNC" \$159,995

"MANUAL" \$64,795

GEAR SHAPING MACHINES



(FROM 3" TO 78" DIAMETER)

38 MODELS

STARTING AT \$35,995

MODEL #GH8-6FP (SHOWN)

8" GEAR DIAMETER

6" FACE WIDTH

50 TO 6.3 DP

POWER TAILSTOCK

AXIAL/RADIAL FEED

\$46,995

GEAR HOBGING MACHINES

Call now for more information:

TEL (323) 933-7191 FAX (323) 933-7487

**BASIC
MACHINE TOOLS**

Eastern representative
SPECK GEAR SERVICES, INC.
Phone: (630) 213-8340 Fax: 8441
P.O. Box 88177, Carol Stream, IL 60188

P.O. BOX 36276, LOS ANGELES, CA 90036

LITERATURE MART

Ajax Magnethermic
LR-PAK DATA SHEET

LR-PAK INDUCTION LIFT ROTATE FIXTURE

These Revolutionary LR-PAK Fixtures are available in a variety of sizes, from 1/2" to 24" diameter. They are designed to heat treat parts up to 1000 lbs. weight. The LR-PAK fixtures are completely assembled and interconnected. They are available in a variety of sizes, from 1/2" to 24" diameter. They are designed to heat treat parts up to 1000 lbs. weight. The LR-PAK fixtures are completely assembled and interconnected.

Standard Features:

- 1) Single shaft assembly
- 2) Precision lift
- 3) Precision guide
- 4) Precision lift and rotate
- 5) Precision lift and rotate
- 6) Precision lift and rotate
- 7) Precision lift and rotate
- 8) Precision lift and rotate

Ajax Magnethermic

INDUCTION FIXTURES
The LR-PAK data sheet describes induction lift rotate fixtures useful for heat treating parts such as transmission O.D. races, I.D. cams, hubs, spindles, C.V. joints and gears. LR-PAKs are completely assembled and interconnected.

Ajax Magnethermic Corp.
1745 Overland Avenue
Warren, OH 44482
800-547-1527
Fax: 330-372-8608

CIRCLE READER SERVICE #153

A/W Systems Co.

GEAR ROUGHING AND FINISHING CUTTERS

A/W Systems Co. manufactures new spiral cutter bodies in diameters of 5" through 12". A/W can also supply roughing and finishing cutters, hardware and replacement parts for most 5"-12" diameter bodies.

GEAR ROUGHING AND FINISHING CUTTERS
A/W Systems Co. manufactures new spiral cutter bodies in diameters of 5" through 12". A/W can also supply roughing and finishing cutters, hardware and replacement parts for most 5"-12" diameter bodies.

For more information contact:
A/W Systems Co.
Royal Oaks MI, 48067
Phone: (248)544-3852
Fax: (248)544-3922

CIRCLE READER SERVICE #154

EMUGE
Spantechnik

Clamping Technology

Clamping Technology features Emuge Corp's comprehensive program for precision mechanical, hydraulic and mechanical/hydraulic clamping products including arbors, chucks, diaphragm chucks, spindles, drawbars and machine operation measuring systems. Custom workpiece designs are used to illustrate a broad sampling of Emuge clamping solutions.

CLAMPING TECHNOLOGY
Clamping Technology features Emuge Corp's comprehensive program for precision mechanical, hydraulic and mechanical/hydraulic clamping products including arbors, chucks, diaphragm chucks, spindles, drawbars and machine operation measuring systems. Custom workpiece designs are used to illustrate a broad sampling of Emuge clamping solutions.

CIRCLE READER SERVICE #156

SU
RI 370

CNC FORM GEAR GRINDERS

The SU RI 370 CNC machine allows you to grind a large variety of parallel axis gears and worms. It is good for frequent change-over environments as well as medium and high volume production runs. Thanks to the ability to dress the grinding wheel onboard, the tool cost is very low. For an application study, contact SU America, Inc. at Ph: (248) 548-7177 E-mail: usasu@concentric.net

CNC FORM GEAR GRINDERS
The SU RI 370 CNC machine allows you to grind a large variety of parallel axis gears and worms. It is good for frequent change-over environments as well as medium and high volume production runs. Thanks to the ability to dress the grinding wheel onboard, the tool cost is very low. For an application study, contact SU America, Inc. at Ph: (248) 548-7177 E-mail: usasu@concentric.net

CIRCLE READER SERVICE #163

GEAR ANALYZER 3500 Series

A Clean and Portable Solution for Your Process Inspection Needs

ITW Heartland Model 3500 Gear Analyzer is designed for use in the gear laboratory or on the factory floor. It is suitable for either process inspection or final inspection. Measures composite, runout, size, nicks, tooth action, lead and taper. Measurement accuracy in microns.

ITW Heartland

ITW HEARTLAND
ITW Heartland Model 3500 Gear Analyzer is designed for use in the gear laboratory or on the factory floor. It is suitable for either process inspection or final inspection. Measures composite, runout, size, nicks, tooth action, lead and taper. Measurement accuracy in microns.

CIRCLE READER SERVICE #170

HUNK TENDO

HYDRAULIC CHUCKS

Schunk Inc. has expanded its stock of hydraulic chucks to include more CAT taper chucks, HSK chucks, Grinding chucks, New Flange-Mounted chucks, plus a greater selection of reduction sleeves. Schunk hydraulic chucks provide a Total Indicated Run-out (TIR) value less than .003mm and are guaranteed for one year. Custom designs are available.

HYDRAULIC CHUCKS
Schunk Inc. has expanded its stock of hydraulic chucks to include more CAT taper chucks, HSK chucks, Grinding chucks, New Flange-Mounted chucks, plus a greater selection of reduction sleeves. Schunk hydraulic chucks provide a Total Indicated Run-out (TIR) value less than .003mm and are guaranteed for one year. Custom designs are available.

Schunk Inc.
Morrisville, NC
(800)772-4865
CIRCLE READER SERVICE #159

DURA-BAR
CONTINUOUS CAST IRON

DURA-BAR
Continuous cast iron from Dura-Bar performs like free-machining steel but with 10% less weight. And Dura-Bar's superior vibration damping characteristics make for quieter running gears. Available in diameters from 5/8"-20" and lengths of 6'-20'. Contact Dura-Bar for the latest data on gear noise.

DURA-BAR
Continuous cast iron from Dura-Bar performs like free-machining steel but with 10% less weight. And Dura-Bar's superior vibration damping characteristics make for quieter running gears. Available in diameters from 5/8"-20" and lengths of 6'-20'. Contact Dura-Bar for the latest data on gear noise.

Phone: 800-BAR-MILL (227-6455)
Fax: 815-338-1549
E-Mail: sales@dura-bar.com
CIRCLE READER SERVICE #155

UNIVERSAL CENTER DISTANCE Gear Checker

Moore Products' Universal Center Distance Gear Checker permits easy monitoring of tight-mesh gear characteristics. Adjustable system promotes quick changeover; one gage inspects all parts. Advanced software permits quantitative analysis, provides process control and statistical analysis reports. Produces wide range of results including runout, sectional runout, average and maximum tooth-to-tooth action and more.

GEAR CHECKER
Moore Products' Universal Center Distance Gear Checker permits easy monitoring of tight-mesh gear characteristics. Adjustable system promotes quick changeover; one gage inspects all parts. Advanced software permits quantitative analysis, provides process control and statistical analysis reports. Produces wide range of results including runout, sectional runout, average and maximum tooth-to-tooth action and more.

CIRCLE READER SERVICE #179

LITERATURE MART



**DF1 Gear Testers...
Double Flank-Gear
Roll Testers**

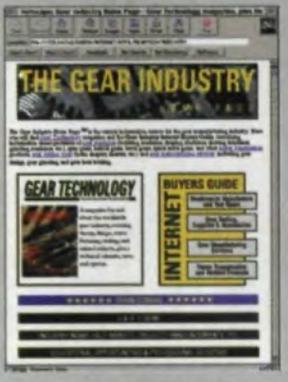
Mahr
The Master of the Spirit

DOUBLE FLANK GEAR ROLL TESTERS

New color brochure offers descriptions and specifications of Mahr DF1 Series gear measurement instruments and WinGear®, Windows®-based test and evaluation software. System provides automatic, push-button measurements and test analysis to DIN, ISO and AGMA standards. **Mahr Corporation**, 11435 Williamson Rd., Cincinnati, OH 45241. Phone: 1-800-969-1331. Fax: 513-489-2020.

CIRCLE READER SERVICE #157

HOW TO ESTABLISH A PRESENCE ON THE GEAR INDUSTRY HOME PAGE™



CYBERSPACE IS CALLING

A Company Page in The Gear Industry Home Page Internet Buyers Guide lets you sell your products or services to gear industry CEOs, engineers and managers around the world. This is the best Internet deal around. Call 847-437-6604 for a FREE brochure or send e-mail to people@geartechnology.com.

CIRCLE READER SERVICE #275

CAPABILITIES TO MEET ALL YOUR NEEDS



600H CNC
5 CNC Controlled Axis
Max. Work Diameter 24"
Max. Work Length to Spindle 148"
Max. Coarseness 4 NDP

25H CNC
4 CNC Axis
Max. Work Diameter 1"
Max. Work Length to Spindle 6"
Max. Coarseness 24 NDP



- **OEM-** Gear Hobbers, Shapers, Grinders and Inspection Machines
- **Remanufacture/Retrofit/Rebuild** of Your Barber-Colman Machines
- **Parts/Service/Repair** of Your Barber-Colman, Bourn & Koch Machinery

BOURN & KOCH
MACHINE TOOL CO.

2500 Kishwaukee St.
Rockford, IL 61104
Phone (815) 965-6013
Fax (815) 965-0019
E-mail: bourn&koch@worldnet.att.net
Web Site: www.bourn.koch.com

SEE US AT IMTS BOOTH #C2-5473

CIRCLE 172

The American Gear Manufacturers Association's

Fall Technical Meeting



October 25-27, 1998
Cincinnati, Ohio

**FOR THE BEST
LEARNING
EXPERIENCE
IN THE
INDUSTRY:**

Please contact
AGMA
1500 King Street, Suite 201
Alexandria, VA 22314
Phone: (703) 684-0211
Fax: (703) 684-0242
E-mail: ftm@agma.org
Website: www.agma.org

Learn the latest about:

- Effects of heat treat distortion
- New tests for evaluating lubricants
- Effects of surface finish on oil film
- Gear tooth friction in plastic gears
- Gear refurbishment
- Powder metallurgy gearing
- Worm gear lubrication
- Calibration of master gears on CMM's
- Bevel gear inspection

FIND

the answers to your technical questions.

HEAR

perspectives and solutions from international engineers.

QUIZ

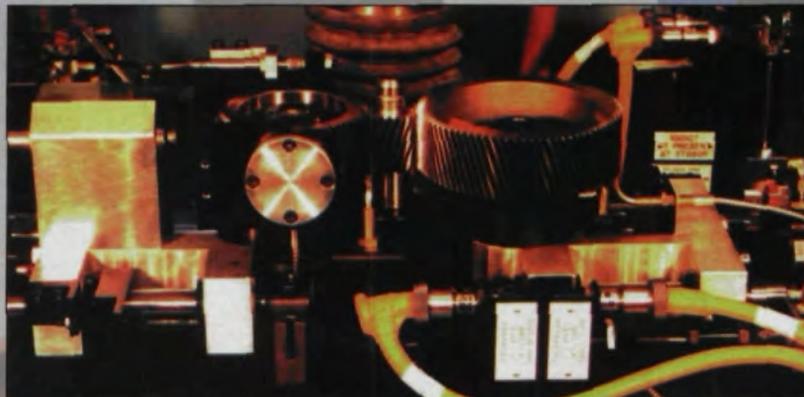
the experts on critical issues.

NETWORK

with the best minds in the gear industry.

When it comes to double flank inspection,

inspection,



High Speed Automatic In-Line Inspection

put your trust in the people who invented the process.

Since 1936, **ITW** has been the leader in double flank inspection.

ITW Heartland offers both automatic and process inspection for internal and external gears, both spur and helical. For complete details, contact the gear inspection experts by phone, fax or e-mail.

Sales & Service Offices Worldwide.



Portable Computerized
Process Inspection

ITW Heartland

A Division of Illinois Tool Works Company

1205 36th Avenue West
Alexandria, MN 56308

Phone: 320-762-8782

Fax: 320-762-5260

E-Mail: itwgears@gctel.com

CIRCLE 110

Visit our Web Site at: www.gctel.com/~itwgears/itwheart.htm

Welcome to our Product News page. Here we feature new products of interest to the gear and gear products markets. To get more information on these items, please circle the Reader Service Number shown. Send your new product releases to: *Gear Technology*, 1401 Lunt Avenue, Elk Grove Village, IL 60007, Fax: 847-437-6618.



Power Dry Cutting Revolutionizes Bevel and Hypoid Gear Production

Gleason Pfauter Hurth Worldwide Sales has introduced a new process for face hobbing and face milling bevel gears and pinions that reduces production time by 50-80% versus conventional methods. The "platform" for the new process, called Power Dry Cutting, is a Gleason PHOENIX 6-Axis CNC Cutting Machine equipped with advanced new tooling and an innovative chip disposal system. The system is capable of producing five times the surface speeds of conventional cutting, while at the same time producing parts without the use of coolant, so chips are dry and easy to recycle, parts are clean, and the work area is dry and safe. For more information, contact: Brian Cluff at Gleason Pfauter Hurth Worldwide Sales at (815) 282-3000, by fax at (815) 282-3075, via e-mail at sales@pfauter.com or on the Internet at www.pfauter.com.

Circle 301

Three-Zone, Electrically-Heated Belt Conveyor Oven From Grieve

No. 794 is a three-zone, electrically-heated belt conveyor oven from Grieve. This unit has a maximum operating temperature of 500°F and a work space of 30"W x 96"D x 24"H. The conveyor consists of an 18" long open belt loading zone, 36" long insulated unheated entrance vestibule, three 32" long insulated heat zones with independent recirculated airflow and temperature control,

12" long insulated unheated exit vestibule and 60" long open unloading zone. The No. 794 also features aluminum steel interior and exterior, as well as 4" thick insulated walls, a three-pen, 10" dia. circular chart recorder and a 24" x 1" x 1" flatwire conveyor belt with 1/2 hp motor drive and variable speed from 1.5 to 4.3 inches per minute. A cus-

tomerspecified, multi-color paint finish was also supplied by Grieve on this conveyor oven. For more information, please contact Frank Calabrese, National Sales Manager, The Grieve Corporation, at (847) 546-8225, by fax at (847) 546-9210, or send messages via e-mail at bandc@interaccess.com.

Circle 302



THE PURDY CORPORATION

Aerospace Manufacturing Technologies For The 21st Century

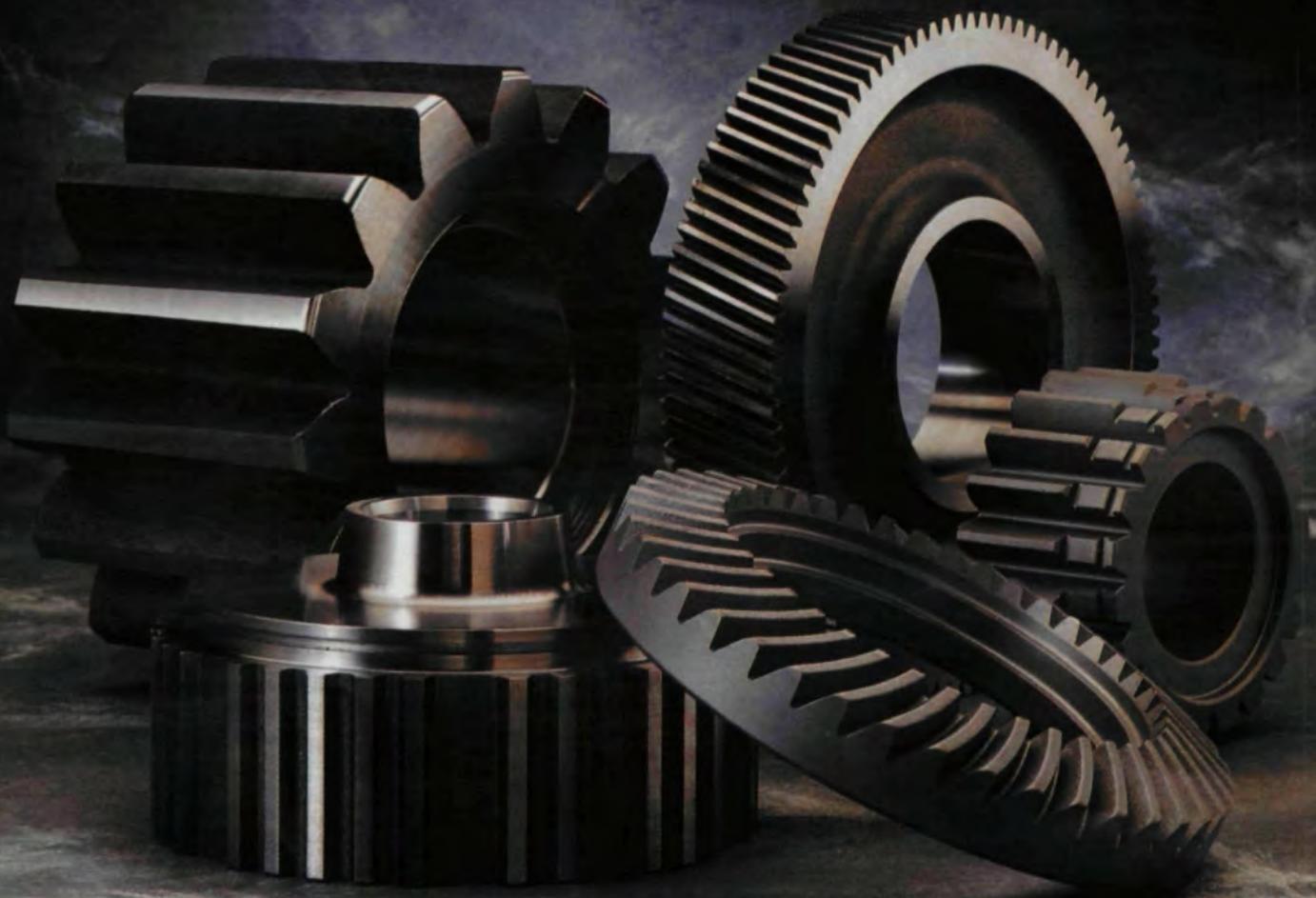


**AH-64
Longbow Apache
Attack Helicopter
Main Rotor
Transmission**

586 Hilliard Street, P.O. Box 1898, Manchester, CT 06045-1898 U.S.A.
Telephone: 860 649-0000 • Fax: 860 645-6293
Home Page: <http://www.purdytransmissions.com>
E-Mail: sales@purdytransmissions.com

CIRCLE 122

DON'T MESH WITH ANYTHING LESS



PRESRITE NEAR-NET GEARS ARE NEAR PERFECT

If you want the best gears money can buy, invest some time with Presrite. We've already invested millions to build a world-class gear forging plant. A dedicated facility equipped with a state-of-the-art gear lab, high-capacity presses, and the latest in sophisticated machinery.

The results are gear-making capabilities that are second to none. We hot-forged gears economically to near-net shapes. Because we can meet such tight tolerances, there's little or no hobbing required. The inherent strength of the forging is maintained while costly roughing and finishing operations can be eliminated.

See why customers around the world—in all types of industries—have come to rely on Presrite for high-quality forged gears. Contact us today for more information or a quote.

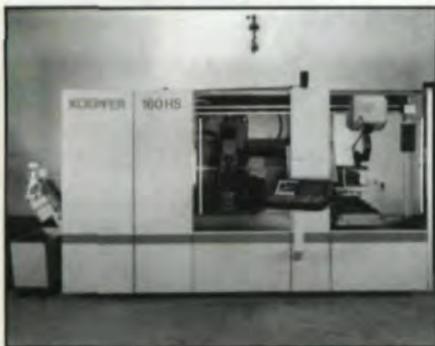


Presrite Corporation

3665 East 78th Street, Cleveland, Ohio 44105

Phone: (216) 441-5990 • Fax: (216) 441-2644

We're as NEAR as the NET! Visit our Web site at www.presrite.com.



Koepfer Introduces High Speed, Eight-Axis CNC Hobbing Machine

The Koepfer Model 160 machine has been designed to provide an optimum gear cutting system for shaft, pinion and gear work up to 60mm, 2.36" diameter. The machine includes eight axes of CNC control. In addition to the normal hobbing control axis, the Model 160 includes the tailstock and gantry loading arm positions, which reduce setup time and improve overall efficiency. A unique slant bed design provides ideal chip flow and allows the user's choice of dry or wet hobbing. The cutter spindle is capable of speeds up to 5,000 rpm with the work spindle designed for 1,000 rpm. These high spindle speeds allow optimum utilization of coated carbide cutting tools even when hobbing parts of small diameters or with low numbers of teeth. The Model 160 includes current technology such as polymer bed, preloaded linear guide ways, ceramic bearing direct drive cutter spindle and digital drives with optical couplings. For more information contact Jennifer Scherer, Sales & Marketing Administrator, Koepfer America, L.L.C. at (847) 931-4121, by fax at (847) 931-4192.

Circle 303

Oilpure Technologies at IMTS

At IMTS in September, OilPure Technologies, Inc., Kansas City, Missouri—Booth C 2 - 5374—will be exhibiting products that emphasize a proactive approach to maintenance of clean oil in metalworking. The MB-50 oil purifier, with capacity up to 50 gph, provides oil purification that is customized to the individual application. Its proprietary chemical filtration process results in purified oil

equal in quality to the original oil. The Vacuum Jet Dehydrator provides a low cost capability of removing water from metalworking oils, in one pass removing dissolved water down to 100 ppm. The OilPure Water Sensor detects leakage of water into all types of petroleum-based and synthetic oil-based industrial oils and can be calibrated to the sensitivity range of the operation. For more information contact

Oilpure Technologies, Inc. at (716) 429-5000, or by fax at (716) 429-5005.

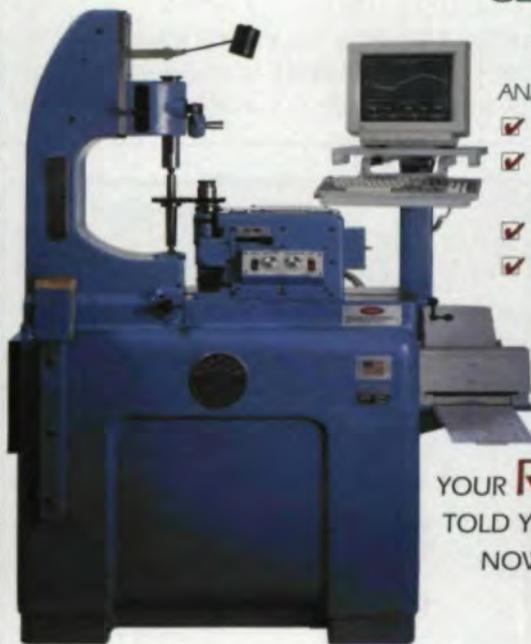
Circle 304

Lexair Direct Mount Collet Chucks

Lexair's direct mount collet chucks bolt directly to the lathe spindle nose and can be used on any spindle that incorporates a draw tube type actuator. They feature a simple pull back design and are

**TURN YOUR
"RED LINER"
AROUND**

WITH OUR COMPOSITE
GEAR
ANALYZER®



ANALYZED RESULTS:

- TOTAL COMPOSITE VARIATION
- MAXIMUM TOOTH TO TOOTH COMPOSITE VARIATION
- TEST RADIUS
- RUNOUT

YOUR **RED LINER** NEVER TOLD YOU THE COMPLETE STORY NOW YOU WILL GET EVERY DETAIL.

PC-20 CGA®

A Proven Design with Today's Technology



PROFILE ENGINEERING INC.

100 River Street
Springfield, VT 05156
802-885-9176
Fax 802-885-6559

CIRCLE 119



LeCOUNT

EXPANDING MANDRELS

WANTED?

MORE ACCURACY

MORE EXPANSION

MORE VERSATILITY

LONGER LIFE

AND LESS COST?



THE ANSWER FOR 150 YEARS.

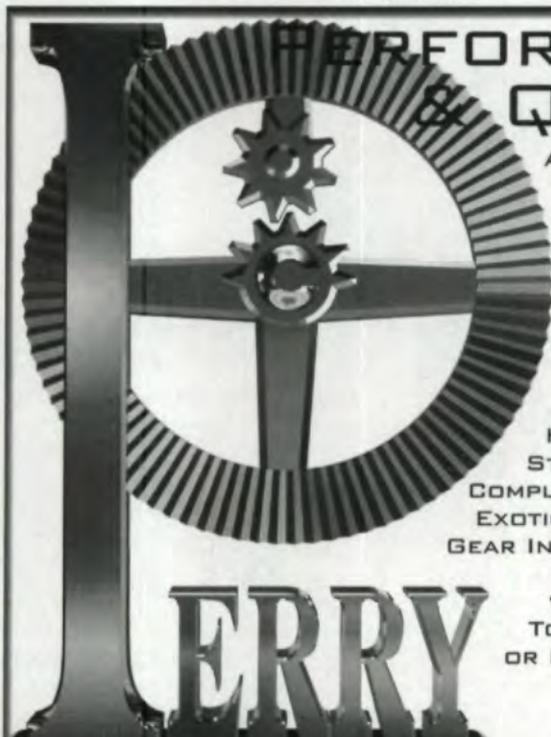
LeCOUNT, Inc.

12 Dewitt Dr. • PO Box 950 • White River Jct., VT 05001 U.S.A.

Tel: (800) 642-6713 or (802) 296-2200 • Fax: (802) 296-6843 E-mail: lecount@sover.net

Website: <http://www.sover.net/~lecount/> (includes product specifications)

CIRCLE 130



PERFORMANCE & QUALITY

- AEROSPACE SPLINES
- HELICAL SHAPING
- CROWN SHAPING
- CNC SHAPING
- FACE GEARS
- GEAR HOBBING
- SPLINE HOBBING
- KEYSEATING
- CNC TURNING
- CNC MACHINING
- HELICAL BROACHING
- STRAIGHT BROACHING
- COMPLETE MACHINE SHOP
- EXOTIC ALLOY MACHINING
- GEAR INSPECTION SERVICES
- PROTOTYPE GEARS
- WITH FAST DELIVERY
- TOOTH CUTTING ONLY
- OR COMPLETE TO PRINT

*CONTACT US
FOR A PROMPT
QUOTATION.*

*YOU'VE FOUND:
THE
GEAR & SPLINE
EXPERTS*

ERRY

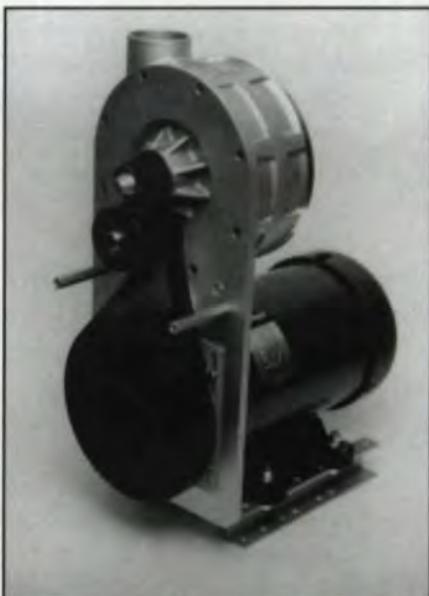
TECHNOLOGY CORPORATION
P.O. Box 21 / 29 Industrial Park Road
New Hartford, CT. 06057
Phone: (860) 738-2525
Fax: (860) 738-2455

CIRCLE 134

PRODUCT NEWS

especially suited for clamping small diameter workpieces. Their compact size increases tool clearances and reduces strain on spindle bearings. The 360 degree rigid clamping feature allows increased machine speeds for bar feed applications. These chucks are well suited for heavy roughing and drilling. They are available in types 5C, 16C, 3J, 20C and 25C. A threaded nose is standard on all 5C chucks to provide step chuck capability. For more information, contact: Lexair, Inc. at (606) 255-5001, or by fax at (606) 255-6656.

Circle 305



New Sonic Blower Model With Automatic Belt Tensioner Assembly

Sonic Air Systems announces the introduction of the Sonic-70 and Sonic-100 blower models with automatic belt tensioners for use in critical and industrial parts and products drying. Sonic's new automatic tensioning system eliminates periodic belt maintenance and adjustments and extends belt and blower longevity. The design achieves linear belt speeds up to 9200 fpm and loads up to 20 hp. The tensioning assembly allows for backside idling of the drive belt creating more wrap around the blower pulley and reducing the overhung load on both the blower and motor bearings. The result of the increased wrap with lower load is a reduction in the normal slip rate of the previous drive system and a reduction in operating temperatures of the belt, pul-

PRODUCT NEWS

leys and bearings. Aside from the elimination of regular maintenance, belt and bearing life is increased over the manual adjustment process. Replacement belts can be installed in less than five minutes, a savings of 15-20 minutes over the SAS-700 and SAS-1000 blowers. For more information about Sonic's advanced belt tensioner, contact: Sonic Air Systems, Inc. at (714) 870-2700, by fax at (714) 870-0100 or on the Internet at www.SonicAirSystems.com.

Circle 306



Weiler Corporation Announces Expanded Tiger Disc Line

Weiler Corporation, an ISO 9001 certified manufacturer of industrial power brushes, abrasives and maintenance products, introduces their new, expanded line of Tiger Disc abrasive flap discs. The broadened Tiger Disc offering includes a wide selection of abrasive flap discs to help provide solutions for many diverse applications. Included in this line is a selection of specialty products, including; BobCat, primarily used for grinding and finishing curved and irregular surfaces; the standard Tiger Disc which offers a variety of styles and grit sizes to solve a wide range of surface finishing applications; and introducing Weiler's latest addition, the Econoline, designed to produce a high cut rate at a value price. For more information about Weiler's expanded Tiger Disc abrasive flap disc line, please contact your local Weiler distributor or contact Weiler Corporation at (888) 600-5857 or on the Internet at www.weilercorp.com.

Circle 307

Tell Us What You Think...

If you found this article of interest and/or useful, please circle 216.

KOEPFER MZ120

FINE PITCH WORM MILLING AND HOBBING



Introducing KOEPFER's newest machine: the MZ120. This machine is designed for fine pitch worm milling and hobbing applications. The MZ120 is a full CNC machine controlled by GE Fanuc. In line

with KOEPFER tradition, the MZ120 can be equipped with a variety of flexible automation systems.

The MZ120 is the ideal combination of a high speed worm milling and hobbing machine.

KOEPFER AMERICA, L.L.C.

635 Schneider Drive, South Elgin, IL 60177
(847) 931-4121 phone (847) 931-4192 fax

SEE US AT IMTS BOOTH B1-6961

CIRCLE 171

powertransmission.comTM

- The power transmission industry at the click of a mouse
- More than 250 top suppliers
- Everything from actuators to worm gears

geartechology.comTM

- All the products & services you need for gear making
- Gear Technology online
- Hot products & news, cool gear sites, lively features
- Log on today

CLASSIFIEDS

SERVICE

PFAUTER-MAAG CUTTING TOOLS LIMITED PARTNERSHIP

PICK UP AND DELIVERY
IN MANY AREAS

- HOB SHARPENING
- SHAVING CUTTER GRINDING
- TIN, TiCN, & TiAlN
COATING SERVICES
- CUSTOM HEAT TREAT SERVICE

PFAUTER-MAAG CUTTING TOOLS

1351 Windsor Road, P.O. Box 2950
Loves Park, IL 61132-2950
Phone (815) 877-8900
Fax (815) 877-0264

CIRCLE 149

GEAR TOOTH GRINDING

- Spur • Helical
- Herringbone (with groove)
- Capacity up to 63" O.D.,
1 D.P., 16" face

AGMA Certification Inspection

Delivery to Meet Your Requirements

Midwest Gear Corp.
2182 E. Aurora Rd.
Twinsburg, OH 44087
Phone 330-425-4419
Fax 330-425-8600

Direct your inquiries to
Ron Humphrey, General Manager

CIRCLE 148

GEAR TOOTH GRINDING SERVICES

- Cost effective gear tooth grinding specialists
- Gear manufacturers are our only customers
- Prototype and production quantities
- Capacity to 27.5" P.D., 3.5 D. P.
- Able to match delivery to your requirements
- All service to AGMA standards with Certified Gear Inspection Equipment

PRO-GEAR COMPANY, INC.

23 Dick Road Depew, NY 14043
Phone (716) 684-3811
Fax (716) 684-7717

CIRCLE 150

HOB SHARPENING SERVICE

Star Cutter Co.



• THIN FILM COATINGS

West Branch Industries
Subsidiary of Star Cutter Co.
2083 W. M-55, West Branch, MI 48661
1-888-Resharp • 1-888-737-4277
Phone: (517) 345-2865 • FAX: (517) 345-5660

CIRCLE 151

ALLIED GEAR COMPANY

*Manufacturers of
Cut Tooth Gears and Sprockets*

Spur and helical gears to 80" O.D.
Bevel gears to 36" O.D. and 1 1/2 DP.
Internal gears to 36" P.D. and 3 DP.
Worm gears to 48" O.D. and 2 DP.
Sprockets to 80" O.D. and 2 1/2" pitch.
Spline shafts to 120" long.
Crown shaving to 24" O.D.
Gear tooth grinding to 24" O.D. and 2 D.P.
Thread grinding to 14" O.D. and 40" long.
Internal and external cylindrical grinding.

Call for our brochure

Phone 773-287-8742 • Fax 773-287-4720
Chicago, IL

CIRCLE 142

HOB SHARPENING (612) 425-5247

HSS & Carbide up to 5" Dia.
Straight Gash,
Sharpened & Inspected
Per AGMA STANDARDS
Quick Turnaround



KORO SHARPENING SERVICE
9530 - 85TH AVENUE NO. • MAPLE
GROVE, MN 55369

CIRCLE 147

Rates—Line Classified: \$35 per line, 8 lines per inch, \$270 minimum. Classified Display (3" min.): 1X—\$620, 3X—\$575, 6X—\$545. Additional per inch: 1X—\$210, 3X—\$200, 6X—\$190. *Gear Technology* will set type to advertiser's layout or design a classified ad at no extra charge. **Payment:** Full payment must accompany classified ads. Send check or Visa/MasterCard/American Express number and expiration date to *Gear Technology*, P.O. Box 1426, Elk Grove Village, IL 60009. **Agency Commission:** No agency commission on classified ads. **Materials Deadline:** Ads must be received by the 20th of the month, two months prior to publication. **Acceptance:** Publisher reserves the right to accept or reject classified advertisements at his discretion.

**TO ADVERTISE
IN THE
CLASSIFIED SECTION
CALL PAT FLAM AT
847-437-6604**

SERVICE

SHAVING CUTTER REGRIND SERVICE



**FAST TURNAROUND
LOW PRICES
HIGH ACCURACY
PROTOTYPE PROFILE DEVELOPMENT**

SU AMERICA, INC.

8775 Capital Ave., Oak Park, MI 48237
Ph: 248/548-7177 Fax: 248/548-4443

E-mail: usasu@concentric.net

**ALSO, CALL US ABOUT
HOB SHARPENING**

CIRCLE 174

HELP WANTED

MANUFACTURER'S REPRESENTATIVE

Progressive Midwest aerospace/aircraft gear mfg. seeking aggressive representation. Looking for representation in the area of hardened and precision ground gears and gearshafts to AGMA Class 11-15. If you are looking for the opportunity to represent a quality conscious, progressive company, look no further!

**FOR MORE INFORMATION CONTACT:
Tifco Gage & Gear
29905 Anthony Drive
Wixom, WI 48393
(Fax) 248-624-1260**

HEAT TREATING

Contour Induction Hardening Specialists

Spur, helical and bevel gears
Our gear hardening equipment includes 3 NATCO submerged process machines and 4 AJAX CNC-controlled gear scanning machines. We can tool to meet any production need. Call for a company brochure.

American Metal Treating Company

1043 East 62nd Street
Cleveland, OH 44103
(216) 431-4492
Fax: (216) 431-1508

CIRCLE 144

HELP WANTED

**JOIN A WINNING TEAM WHERE PEOPLE
ARE SHAPING TOMORROW'S FUTURE TODAY!**

SUNDSTRAND AEROSPACE, a leading supplier of technology based aerospace components and systems, has an immediate opening for a person who has a desire to work in a **Self-Directed Work Team Environment**.

GEAR MACHINIST

- Gear Shaping and Hobbing
- Reishauer and Kapp Gear Grinding
- Broaching

Minimum Three Years Experience Required.

EXCELLENT BENEFITS PACKAGE INCLUDING HEALTH AND LIFE INSURANCE, VACATION, 401K WITH COMPANY MATCH, HOLIDAYS, PENSION, WELLNESS CENTER AND 100% EDUCATIONAL REIMBURSEMENT.

Interested candidates can obtain an application which must be completed with detailed salary history. Submit completed application and resume by October 31, 1998 to:



**SUNDSTRAND
AEROSPACE**

2480 West 70th Avenue, Denver, CO 80221
Out of state inquiries call our main Guard Office at 303-426-2800 for application. An Affirmative Action, Equal Opportunity Employer.

Engineer

MANUFACTURING ENGINEER

IIT Research Institute, a nationally recognized contract R&D organization, has an immediate opening for a Manufacturing Engineer in its CHICAGO location.

Requirements include bachelor's degree in mechanical engineering, industrial engineering, metallurgy or related discipline (advanced degree preferred); at least 15 years relevant experience; knowledge of and experience with government manufacturing technology programs as well as government contracting processes; demonstrated capability to build programs; knowledge of precision gear industry. Knowledge of defense helicopter community a plus. Experienced program manager with P/L responsibility preferred.

Complete benefits package available including full tuition reimbursement. Please forward resume along with salary history/requirements to: IIT Research Institute, Human Resources Dept. ME, 10 W. 35th Street, Chicago, IL 60616. E-mail: hr-chgo@iitri.org. Equal opportunity/affirmative action employer.



IIT RESEARCH INSTITUTE

**GOT A GEAR
QUESTION?**



**NEED AN
ANSWER
FAST?**

Put it in the
Question & Answer
section on

The Gear Industry Home Page™.

One of the hottest departments
on the GIHP™ is the Q & As.

Launch your question into
cyberspace and let your
peers answer it.

www.powertransmission.com

**FINDING GEAR MANUFACTURERS
HAS NEVER BEEN EASIER.**

**Just log on at
geartechology.com.**

**It's the best spot for gearing
on the Internet.**

Back in the Good Old Days

Gear Technology's bimonthly aberration — gear trivia, humor, weirdness and oddments for the edification and amusement of our readers. Contributions are welcome.

Come with us now to those thrilling days of yesteryear...OK, this is not the Cisco Kid, but we do have a little game for you. Guess the year the following advertisements and excerpt were printed—they all appeared in a single issue of *Machinery Magazine*. Fax us at (847) 437-6618 or e-mail people@geartechnology.com with your answer and if you are the first to guess the year we'll print your name in the next Addendum and declare you the winner.

On Advertising: Seeing the Market Whole

"We have been looking over the mechanical world with the sales manager, noting that (1) the modern market for shop equipment is universal, and is rapidly increasing in volume and extent; (2) that customers are found in industries of almost every description; (3) that the buyers are not office men, but practical shop men who originate the orders and specify makes and brands as well as sizes wanted.

"Fortunate the sales manager who has the gift to visualize this boundless field, its unlimited possibilities, its manifold, increasing opportunities, its definite objectives. If he sees it all, his advertising plans will show it, his copy will demonstrate it. If he finds inspiration in so vast a market, there will be intelligence, method, conviction, force, and possibly power, in his advertising. His copy is read not only in America, but in Europe, Asia, Japan, China, India, Australia, New Zealand, Africa, South America. It is read wherever the wheels of industry revolve. It is read for business.

"American metal-working tools admittedly lead the world, and descriptions of them are eagerly read and studied by engineers everywhere. How anxious the sales manager should be to see that these intelligent, interested, responsible men are fully and accurately

informed about the tools which it is his mission to market.

"The sales manager who sees with his mind's eye the engineering world of readers will endeavor earnestly to make every advertisement convey some definite data, idea or suggestion. To do less than this is to trifle with serious business and real opportunities. Ask any foreign dealer representing American tools for his opinion of the value of good copy in reaching the foreign engineer, interesting him, arousing his curiosity.

"The modern advertising method developed by *Machinery*, which shows the machine demonstrating high efficiency under actual shop conditions, makes a lasting impression on an engineer no matter where he is. He sees the tool doing the work and reads the authentic figures of production. He, too, wants results, and his competitors want them. Once he knows the best he is not likely to be satisfied with anything less. Advertising copy carefully planned to definitely and specifically inform the engineering reader, and persistently carried on month after month and year after year, builds a granite foundation under a business. In time this is called Good Will, and sometimes it is the most valuable asset that a business retains."

Thanks to Roland Ramberg of The Gear Works-Seattle, Inc. for letting us raid his library.

Did you guess? Did these machines and that bit of sage advertising wisdom appear in 1910, 1925, or somewhere in between? If you think you know, fax or e-mail us by September 30, 1998 and maybe your answer will appear in the next Addendum. Also, if you or someone you know owns a working machine from this period, let us know. If so, we may work up a story on it for The Gear Industry Home Page.



140,000 Gears in Stock for Immediate Delivery
This does not include our large stock of Pinion Wires, Racks, Ratchet Wheels, Chains, Ball Bearings, Universal Joints and Gear Gages.
Our 1916 catalog contains complete specifications of the 1400 sizes of Stock Gears.
BOSTON GEAR WORKS
NORFOLK DOWNS QUINCY, MASS.



**Manufacturers of
AUTOMOBILE GEARS and
MACHINE TOOL BUILDERS**
Are you prepared to meet the increasing demand for **Spiral Type Bevel Gears**?
We build Spiral Type Bevel Gear Generators and Spiral Type Bevel Gears. Factories especially designed for the work.
They are adaptable only to manufacturing in quantity and are not recommended for jobbing.
Spiral Type Bevel Gears are absolutely quiet. They fill a special need. For general use we still advise the purchase of our standard bevel gear planers.
GLEASON WORKS
MANUFACTURERS OF GEARS AND GEAR CUTTING MACHINERY
ROCHESTER, N.Y.



NEWARK
MACHINES FOR
**Smooth Running
Gears**
Write for Catalog
**NEWARK GEAR CUTTING
MACHINE COMPANY**
GEAR SPECIALISTS
Our No. 3-36" Spur Gear Cutting Machine
69 Prospect St., Newark, N. J.

The Addendometer: If you've read this far on the page and enjoyed it, please circle 225.

IN YOUR SEARCH

S t a r

FOR GRINDING

C N C

SOLUTIONS

G r i n d e r s

Look No Further Than The Stars.

Star Cutter Company has been making cutting tools for more than 75 years. During that time we've learned a thing or two about grinding. And, we've learned how to build five and six axis CNC grinders that are among the most accurate in the world.

Star grinders excel at manufacturing and sharpening cutting tools and our engineers are continually exploring new frontiers in grinding technology.

Whether you manufacture or sharpen tools, or have another grinding need, look no further. Star has a solution.

Call Today 616-264-5661 or Fax 616-264-5663

 **IMTS 98**

Booth B1-7182

Star Cutter Company • Elk Rapids Engineering
210 Industrial Park Drive • P.O. Box 728 • Elk Rapids, MI 49629

Since 1927
 **Star**
STAR CUTTER COMPANY

Pfauter-Maag Cutting Tools – where the world goes for quality

Manufacturers everywhere need new cutting tool technology that can produce parts faster, more accurately and less expensively than ever before. That's why more companies worldwide turn to Pfauter-Maag Cutting Tools.

At Pfauter-Maag Cutting Tools, we have people and plant resources unavailable anywhere else in the world.

We can find the absolute best tooling approach for your application and help put it to use more productively than you might have believed possible.

So turn to Pfauter-Maag Cutting Tools for the best in

gear hobs, shaper cutters, shaving cutters, bevel gear cutting blades and heads, form-relieved milling cutters, CBN grinding wheels, heat treat services, and sharpening services.

Pfauter-Maag Cutting Tools CORPORATION

1351 Windsor Road
Loves Park, IL 61111 USA
Web Site: <http://www.pmct.com>

Phone: 815-877-8900
Fax: 815-877-0264
E-Mail: Sales@pmct.com

 **IMTS 98** BOOTH NO. B1-7150

CIRCLE 102



Proudly Announcing . . .

ISO
9001
Registered