The Genesis™ series of gear production machines is the next generation in gear production technology. The Genesis 130H Hobbing and 130SV Shaving Machines are available today to deliver more speed, greater precision and, above all, reduced cost in day-to-day operation for gears as large as 130 mm diameter. Only Genesis offers:

- Workpiece load/unload times as short as 2 seconds.
- The ability to more effectively operate in wet or completely dry conditions (Hobber).
- New hobhead and shaving head designs to help guarantee reliability and reduce cycle times.
- A common platform that improves performance and simplifies installation and serviceability.
- A host of operator- and maintenance-friendly features making every Genesis machine easier to own and operate.

Only Genesis combines Gleason's long tradition of innovation and technology leadership. Put it to work today.

Visit www.gleason.com/genesis today to find out more.

Gleason Corporation

1000 University Avenue, P.O. Box 22970, Rochester, NY 14692-2970 USA Phone: 585/473-1000 Web site: www.gleason.com E-mail: sales@gleason.com

KEEPING THE WORLD IN MOTION™
Grinding News
Our focus on grinding and finishing

15

Gear Tooth Honing: Economical And Flexible
Präwema machines at Getrag Ford

24

Honing: The Secrets Of Hole Finishing
There's more to gears than just the teeth

28

Basics Of Harmonic Drive Gearing
Do you know how it works?

32

Upgrade Your Maag Gear Shaper
Options for upgrading the controls

38

Cover photo courtesy of Kapp Technologies.
We do.

See the BIG PICTURE?

How do we do this? Offer the highest quality machines, tools and processes and then back them up with a lifetime commitment of superior service. Leading the world in the technology of CBN, KAPP designed the first CBN profile grinding wheel in 1981. Since then we’ve continued to improve application capabilities, form accuracy and delivery time. That’s how we got to be THE BEST.

Our business is to help make your business succeed.

KAPP Technologies
2870 Wilderness Place  Boulder, CO  80301
Ph: 303-447-1130  Fx: 303-447-1131
www.kapp-usa.com  info@kapp-usa.com
One partner for all gear tasks.

Klingelnberg, Liebherr and Oerlikon. Three strong brands, which fulfill the promise of the Sigma Pool’s common logo. Unlimited system competence in all fields of gear technology—machines, tooling and application. At all times, in all places. More information at: www.sigma-pool.com

For the US market please contact:
Liebherr Gear Technology Inc.
1465 Woodland Drive
Saline, Michigan 48176-1259
 Fon: 001-734-429-7225
Fax: 001-734-429-2294
info@lgt.liebherr.com
**Samputensili’s Master Gears**

**PERSONALIZED TO CUSTOMER/DIN SPECIFICATIONS**

Samputensili has introduced a range of master gears used to determine work gear accuracy and setting masters to adjust checking equipment.

According to the company’s press release, the Samputensili software and manufacturing methods deliver products to customer specifications or DIN standards. Master gears allow checking of internal or external spur and helical gears with or without profile corrections.

When checking parts, the master gear flank rotates in contact with the work gear teeth and primarily checks meshing, center distance and runout, detecting any nicks. Setting masters, conversely, are usually static. Two master gears for different applications and consequently of different design can check the same workpiece correctly. The company’s production range includes master gears from module 1 to module 6 with outside diameters from 40–300 mm, tooth face widths from 4–100 mm and helix angles from 0–45°.

All master gears are produced in high speed steel or bearing steel without surface coating, depending on customer specifications. The company says it mainly uses powder metals, high speed steels ASP23 and ASP30.

**For more information:**
Samputensili S.p.A.
c/o Star SU LLC
5200 Prairie Stone Pkwy., Ste. 100
Hoffman Estates, IL 60192
Phone: (847) 649-1450
E-mail: sales@star-su.com
Internet: www.star-su.com

---

**Neeter Drive Gearboxes**

**TRANSMIT POWER UP TO 6,600 N-M**

The PowerGear range of bevel gearboxes from Neeter Drives is available in sizes 360 and 450 with an extended transmission range of 3,750 N-m for the 360 and 6,600 N-m for the 450.

Neeter Drive says these sizes extend the PowerGear range’s torque capacity by a further 3,400 N-m. This is complemented by uniform load distribution on the gear teeth that is set by optimizing the contact pattern during assembly. Both gearboxes are available with six gear ratios up to 5:1 as standard, and each design has solid and hollow shaft variants up to four-way shaft configuration.

According to the company, other advantages include a 98% industrial efficiency rating, a compact and rigid design, fretting-free torque transfer using a friction locked fit between shaft and bevel gear, and a lifetime lubrication guarantee.

Typical applications are angular torque transfer and torque distribution in single- or multiple-shaft configurations as well as in non-stationary applications where weight is a consideration.

**For more information:**
Neeter Drive
Power Jacks Group
Maconochie Rd., Fraserburgh
Scotland, U.K.
Phone: +(44) 1346-513-131
E-mail: sales@powerjacks.com
Internet: www.powerjacks.com

---

**UTS**

**ENHANCES INTEGRATED GEAR SOFTWARE PACKAGE**

Universal Technical Systems released a new upgrade for its Integrated Gear Software product line for greater ease of use.

According to the company’s press release, a new built-in DXF converter allows users to bring coordinates from IGS into a CAD system for 2-D or 3-D use. Other new features include the addition of the Ticona M15HP high performance engineering plastic material and further animation of gear rotation through the length of the active profile.

UTS says a new range analysis capability offers improved “what-if” analysis in less time. The new software quickly generates a table of results to help users arrive at the optimum design solution more quickly. The new range analysis facility is available in 80+ programs in IGS.

**For more information:**
Universal Technical Systems
202 W. State St., Ste. 700
Rockford, IL 61101
Phone: (800) 435-7887
E-mail: sales@uts.com
Internet: www.uts.com

---

April 2006 | Gear Product News | 5
Alpha Gear’s Newest Software

SIMPLIFIES SELECTING GEAR REDUCERS

The Cymex calculation software from alpha gear drives Inc. uses a database of company products and 6,000 motors from various manufacturers.

According to the company’s press release, users simply enter their application data, and the software will immediately calculate the most appropriate drive train. Users can experiment with different load cases, varying the parameters and testing the preferred drive systems in detail. The software then compiles comprehensive technical documentation.

Beyond the basic Cymex 3.0 Design Edition package, the Cymex 3.0 Motion Edition allows users to lay out a complete drive system with a mouse click. In the Motion edition, belt, volume, spindle, turntable and rack-and-pinion drives are pre-defined as standard applications.

Additionally, arbitrary general load cases can be computed. Along the drive system, it is possible to output data at every one of the six dial gages (torque, number of revolutions, mass-moment of inertia, translations, etc.) to optimize the drive.

For more information:
apha gear drives Inc.
1249 Humbracht Circle
Bartlett, IL 60103
Phone: (630) 540-5341
Internet: www.alphagear.com

Zero-Max’s Linear Actuators

CONVERT ROTARY MOTION INTO PRECISE LINEAR MOTION

The Roh’lix linear actuators from Zero-Max convert rotary motion to linear travel and carry loads at speeds up to 70° per second, depending on size. They are designed for positioning operations in different types of machinery and are an alternative to ball screws.

The actuators are built to handle thrust rated between 5–200 lbs., and loads can be attached to the Roh’lix carrier block using two cap screws. The product’s thrust capacity is adjustable, so the system will disengage if the present thrust is exceeded, providing overload protection if an obstruction is encountered.

The linear actuators consist of three replaceable precision ball bearings at each end of a two-piece aluminum carrier block. Mounted at an angle to the drive axis, the six bearings convert drive shaft rotation into proportional linear travel. With a minimum of 90% efficiency, the actuators can normally provide up to 100 million inches of linear travel. The movable Roh’lix carrier block travels on a smooth, threadless, hardened RC 58 shaft that requires no lubrication, Zero-Max says in its press release.

For more information:
Zero-Max
13200 6th Ave. N.
Plymouth, MN 55441
Phone: (763) 546-4300
E-mail: zero-max@zero-max.com
Internet: www.zero-max.com

PCB Piezotronics’

NEW ROTARY TORQUE SENSOR SYSTEM ASSESSES AUTOMOTIVE DRIVELINES

The rotary torque sensor system from the Force/Torque Division of PCB Piezotronics is designed for automotive driveline and power train dynamometers and other torque measurement applications requiring a robust torque transducer.

The Torkdisk features a telemetry system consisting of an on-board electronic module that converts torque signals into a high-speed 16-bit digital output. According to the company’s press release, styles are available that use a non-contact, maintenance-free design that eliminates the need for replacing worn brushes, as is the case with conventional slip-ring type rotating torque sensors.
Applications include dynamometer testing of gasoline and diesel engines, transmissions, transfer cases, differentials and drive shafts. Additional applications include torque studies on pumps, fans and electric motors. Rotary torque sensors are offered in capacities from 0.35 N-m to 25.4 kN-m full scale and maximum speeds to 15,000 rpm.

For more information:
PCB Piezotronics Inc.  
Force/Torque Division  
3425 Walden Ave.  
Depew, NY 14043  
Phone: (888) 684-0004  
E-mail: force@pcb.com  
Internet: www.pcb.com

Bison Gear
INTRODUCES LINE OF AC MOTORS

Bison Gear & Engineering introduced a new line of custom AC motors manufactured in its St. Charles, IL, facility.

Motors will be available in the 34 and 49 frame. The 34 frame (3.3”) OD will have a power range of 1/80 hp (10 W) to 1/10 hp (75 W) and will have a 1/2” standard shaft diameter. The motors will be available as PSC, split phase, three-phase and three-phase inverter style. Winding configurations are available as well. The company says its U.S. manufacturing location allows it to offer short lead times.

For more information:
Bison Gear & Engineering  
3850 Ohio Ave.  
St. Charles, IL 60174  
Phone: (630) 377-6777  
Internet: www.bisongear.com
Haas Automation’s MACHINING CENTER UTILIZES IN-LINE, DIRECT DRIVE SYSTEM

The VF-6SS from Haas Automation is a high performance vertical machining center designed for high volume production and work necessitating high speed and short cycle times.

The machining center comes standard with a 12,000 rpm inline direct-drive spindle, ultra-fast tool changer and high-speed rapids. It also is equipped with a 40-taper spindle that uses an inline, direct-drive system to couple the motor directly to the spindle. According to the company’s press release, this yields less vibration, heat and noise than other drive systems, providing improved surface finishes, extreme thermal stability and quieter operation. The spindle’s 30-hp vector dual-drive system provides low-end torque and the required speed for high-speed machining operations.

Additional features include a high speed, 24 pocket side-mount tool changer that swaps tools in 1.6 seconds. To further reduce cycle and non-machining time, high pitch ball screws and high torque servo motors for rapids of 1,200 ipm on the Y and Z axes and 900 ipm on the X axis are provided. More standard features include an automatic chip auger system, programmable coolant nozzle, floppy disk drive, 1 MB of program memory, Visual Quick Code programming and a remote jog handle.

For more information:
Haas Automation
2800 Sturgis Rd.
Oxnard, CA 93030
Phone: (805) 278-1800
Internet: www.HaasCNC.com

Mitutoyo’s CMM INCORPORATES RECENT TECHNOLOGIES

The Legex 574 CNC coordinate measuring machine from Mitutoyo America combines state-of-the-art design, electronics, computing, sensors and materials to offer improved performance.

According to the company’s press release, accuracy of $MP_{E_X} = (0.35 + L/1000) \mu m$, a measuring range of X: 510 mm, Y: 710 mm and Z: 455 mm and a worktable loading capacity of 200 kgf make the machine suitable for a diverse range of applications.

The Legex is driven by MCOSMOS (Mitutoyo Controlled Open System for Modular Operation Support) software with modules supporting numerous CAD formats while providing in-line measurement, data feedback and process management.

In addition, the machine uses spheroidal graphite ductile cast iron for the chassis and air-damped spring isolators in order to attenuate vibration. A FEM (Finite Element Modeling) analysis optimizes its configuration to ensure geometric accuracy by minimizing the deformations caused by normal machine operation. Thermally stable components and real-time temperature compensation maintain accuracy when operating under temperatures from 64.4°–71° F. Available probes include contacting scanners as well as laser and vision.

For more information:
Mitutoyo America Corp.
965 Corporate Blvd.
Aurora, IL 60504
Phone: (630) 978-5385
E-mail: info@mitutoyo.com
Internet: www.mitutoyo.com
Mori Seiki’s

HIGH EFFICIENCY SHAFT
MACHINE ONE-THIRD THE
SIZE OF PREVIOUS MODELS

Mori Seiki released the NZ-S1500 2-
turret shaft lathe for shaft machining.

Workpieces that can be machined are
restricted to those with a maximum
machining diameter of $\varnothing 120$ mm and a
standard machining diameter of $\varnothing 60$–$20$
mm. According to the company’s press
release, the size of this shaft machine
was reduced to one-third of that of
the previous model. A symmetrical
construction in which two turrets are
aligned with the spindle, which is
mounted on the vertical bed, is used.
The machine’s 1,500 mm height allows
for easier chip discharging as well as
great visibility.

Other features include a vertical
protector that prohibits chip
accumulation, three-point support
construction, and a high speed
loader with rotary hand function.

For more information:
Mori Seiki Co. Ltd.
2-35-16 Meieki, Nakamura-ku
Nagoya City 450-0002
Japan
Internet: www.moriseiki.com

Baldor’s
Motors

OFFER LOW INERTIA

Baldor Electric Co. offers low inertia,
high efficiency, high cycle brake motors
with cast aluminum footless frames for
increased thermal dissipation.

According to the company’s press
release, a DC brake with integral rectifier
provides faster action than traditional
spring-set brakes, and the motors
feature a low inertia design best suited
for continuous start/stop applications. A die cast aluminum frame aids in heat dissipation. The brake coil is powered by an integral rectifier connected in the motor conduit box so it may be separately connected if the motor is used with an inverter.

Baldor brakes are available in ½–2 horsepower for applications including baggage conveyors and any other applications requiring frequent stopping.

For more information:
Baldor Electric Co.
5711 R.S. Boreham, Jr. St.
P.O. Box 2400
Fort Smith, AR 72901
Phone: (800) 828-4920
Fax: (479) 648-5792
Internet: www.baldor.com

Parker Bayside
COMBINES SERVO MOTOR AND HELICAL PLANETARY GEARHEAD

Each gearmotor in the Stealth line from Parker Bayside is a brushless servo motor and a helical planetary gearhead integrated into a single product.

According to the company’s press release, the motor magnets are attached directly to the input gear shaft, eliminating the extra couplings, shafts and bearings normally required. The servo gearmotor simplifies installation by eliminating potential configuration and assembly problems associated with conventional separate motor/gear packages. Available as both in-line and right-angle units with operations for metric/NEMA configurations and special output shafts, flanges and/or windings, the gearmotor can save space. Units are available with 160 VDC or 300 VDC windings and ratios from 5:1.

Why Grinding… …when you can Fässler Hone?

HMX-400

Fässler
Customised solutions

www.faessler-ag.ch

Fässler Corporation - 1200 W. Layton Avenue, Suite 300 - Milwaukee, WI 53207
Phone: +1 (414) 769-0072 - Fax: +1 (414) 769-8610 - E-mail: usa@faessler-ag.ch
to 100:1 for a variety of speed and torque ranges. Encoders, resolvers and brakes are offered as standard options without increasing the overall unit size.

For more information:
Parker Bayside
5500 Business Park Dr.
Rohnert Park, CA 94928
Phone: (707) 584-7558
Internet: www.parkermotion.com

Alpha Gear
INTRODUCES ECONOMY LINE OF GEARHEADS

The LP+/LPB+ value line of gearheads from alpha gear drives Inc. offer efficiency with low torsional backlash for less demanding applications.

According to the company’s press release, the gearheads are maintenance-free for their entire service life due to a unique lubrication concept.

The LPB+ offers the option of adding an integrated geared pulley drive system. The belt pulley eliminates the need for a right-angle gearbox, couplings and/or additional bearings.

The company says the gear reducers achieve a 95% efficiency at full load. The two-stage reducer restricts torsional backlash to 10 arc-minutes while the single-stage version operates at less than eight arc-minutes.

For more information:
alpha gear drives Inc.
1249 Humbracht Circle
Bartlett, IL 60103
Phone: (630) 540-5341
E-mail: mbilstein@alphagear.com
Internet: www.alphagear.com

Send us your product news!
Robin Wright, Assistant Editor
Gear Technology
1425 Lunt Ave.
Elk Grove Village, IL 60007
robin@geartechnology.com
Midwest Motion’s

GEARMOTOR ACCEPTS BATTERY POWER

The Model MMP-TM55-12V GP52-308 gearmotor from Midwest Motion accepts any 12-volt DC source including battery power and measures 2.14” in diameter by 7.75” long and has a keyed output shaft of 12 mm diameter by 25 mm long.

According to the company’s press release, easier mounting is possible with four face mount M5 threaded holes, equally spaced on a 40 mm diameter bolt circle. The gearmotor’s output is rated for 35 N-m continuous torque at 15 rpm and 70 N-m peak. The motor’s design requires 7.2 amperes at 12 volts DC to generate its full load output torque. Optional 24- and 36-volt windings are available. The design is rated at IP-54 protection level for operation in harsh environments.

Typical options available include servo motors with integral optical encoders, failsafe brakes, analog tachometers and planetary gearheads with ratios from 3:1 to 450:1 and standard or low backlash precision gearing.

For more information: Midwest Motion Products
10761 Ahern Ave. SE
Watertown, MN 55388
Phone: (952) 955-2626
E-mail: randy@midwestmotion.com
Internet: www.midwestmotion.com

United Grinding’s

NEWEST MACHINE TURNS AND GRINDS SHAFTS AND CHUCKED WORKPIECES

The Studer S242 from United Grinding is designed for the hard turning and grinding of high-precision applications for both shaft and chucked workpieces such as gear shafts, camshafts, turbocharger shafts and tool holders.
According to the company’s press release, a part can be fully machined with a single clamping, reducing machining time, idle time and logistics costs (fixturing and refixturing from one machine to another). Modular design for quick setup and changeover, state-of-the-art digital control and drive systems and step-by-step programming are designed for flexibility. Swing diameter is 185 mm and between-centers grinding length is 400 mm, with an 800 mm version coming late in 2006. Depending on the application, parts up to 1,000 mm can be machined, and the maximum workpiece weight is 25 kg.

A rigid longitudinal slide with two independently-controlled cross slides for the tool holders ensure short travels for combined machining and the flexible use of numerous tools. The left cross slide holds the wheel head while the rotating tool turret with eight tool positions—with an optional four driven tools for milling and drilling—is fitted to the right-hand cross slide. Highly dynamic axis drives with pre-tensioned linear guideways and linear measuring systems for in-process length positioning, length and diameter guarantee higher precision.

The Grantitan® S103 mineral inclined-bed machine base meets machine accessibility requirements, optimum chip discharge into the chip conveyor, effective vibration dampening and high thermal stability.

For more information:
United Grinding
510 Earl Blvd.
Miamisburg, OH 45342
Phone: (937) 859-1975
Internet: www.grinding.com
Out of This World Gear

The quality and precision of our broaches and gears have won customers worldwide (and beyond!) – from the smallest gearshop to NASA and the Mars Rover.

Precision manufacturing, modern equipment, advanced technology, and quality control, balanced with talented craftsmanship, means you get nothing but the very best.

Guaranteed the most rigid shank cutters and the highest quality level disk cutters made. Products that perform. Why use Broach Masters/Universal Gear? Because your parts matter!

As a complete source for all your tooling and production needs. Broach Masters/Universal Gear will supply you with the highest quality products and services that you and your customers expect. Experience the difference!

Manufacturers of:
- Broaches
- Spline Broaches
- Fine Pitch Gear Broaches
- Form Broaches
- Serration
- Bearings
- Shaper Cutters
- Disk Shapers
- Shank Shapers
- Hex and Square Cutters
- Special Form Cutters
- Inspection
  - Master Gears
  - Go–No Go Gages
  - Posiloc Arbors
  - “Quick Spline” Software

Call 530 885-1939 or visit www.broachmasters.com

The Broach Masters, Inc.
U.G.C.
MADE IN U.S.A.

Made in USA
1605 Industrial Drive
Auburn, CA 95603
Phone (530) 885-1939
Fax (530) 885-8157
Web: www.broachmasters.com
Three Processes, One Machine:
Hobbing, Worm Milling, Gear Grinding in the Gear Jet

Promoting flexibility, Lambert-Wahli Ltd. has combined hobbing, worm milling and gear grinding in one machine, the Gear Jet, creating two models to cover a range of production environments.

The 1600 CNC model was designed for job shops making various types of gears in low- to high-volume production. “1600” refers to the number of workpiece spindles, 1, and maximum workpiece length, 600 mm. The 2100 CNC was designed for shops dedicated to making a few types of gears in high-volume production. It has two workpiece spindles and a maximum workpiece length of 100 mm.

The Gear Jet can hob and grind external spur, helical and straight bevel gears, as well as external worm wheels. It can also mill worms. The hob assembly swivels 175°, from −50° to +125°, which allows the machine to hob and worm mill in the same enclosure. Also, using electroplated CBN wheels, the Gear Jet performs both generating grinding and form grinding. “Mostly it’s generating,” says Stefan Mori, Lambert-Wahli’s president.

The Swiss company manufactures CNC worm and thread milling machines as well as CNC and non-CNC hobbers. The Gear Jet is a recent addition to its offerings, having been introduced first in Europe in April ’05.

The combination machine manufactures gears with diametral pitches ranging from 8–350. Mori says it can mill worms with modules ranging from “very fine, very small” to 3. He adds that the machine can hob gears with two parameters to DIN 1–2 quality: total composite error and tooth-to-tooth error. He prefers not to disclose how the Gear Jet hobs such quality for those parameters, but he says the ability involves the accuracy of the machine’s electronic gearbox, which he describes as having no backlash.

Mori adds the Gear Jet’s main advantages include fast changeover, high rigidity, high torque and an advanced user interface. He explains: High rigidity contributes to longer tool life and greater gear accuracy because there’s less vibration, and high torque allows the Gear Jet to take advantage of hob rigidity and hob materials such as carbides and powder metals.

All Gear Jet spindles are direct-driven, except for the worm milling spindle, which is belt-driven. Maximum speed for the hob spindle is 15,000 rpm, for the workpiece spindle 9,000 rpm and for the worm milling spindle 10,000 rpm. The Gear Jet’s maximum feed rate is 48 m per minute.

Both models can be either manually loaded or autoloaded. When manually loaded, their maximum workpiece diameter is 160 mm. When autoloaded, it’s 120 mm. The 2100 is commonly an autoloaded machine, though. Its two workpiece spindles allow it to cut a gear on one spindle while loading a gear blank on the other. Thus, loading time isn’t part of the 2100’s cycle time.

Another feature is Lambert-Wahli conversational programming software. However, the Gear Jet is capable of open programming, so a gear manufacturer can use non-Lambert-Wahli software for his hobbing, milling and grinding. “With us, it’s completely open,” Mori says. “There’s no black box.”

The machine has an integrated network card as well, so it can be connected to a local area network (LAN) computer system.

For more information:
Lambert-Wahli AG
Industriestrasse 24
CH-2553 Safrern
Switzerland

Phone: +(41) 323-56-0272
Fax: +(41) 323-56-0271
E-mail: sales@lambert-wahli.ch
Internet: www.lambert-wahli.ch
Pagani, Cima and Samputensili are three companies that have successfully blended skill in mechanical engineering with a passion for speed to help develop the kind of sports cars little boys (even the grown-up kind) dream about.

Cima S.p.A. was founded in 1942 to manufacture hobbing machines. To inspect and test the quality of these machines, the company also began manufacturing gears as a job shop. In the 1990s, however, Cima discontinued its production of hobbing machines to concentrate on and develop gear manufacturing as its core business. In 2005, the company realized revenues of 25 million euros with 130 employees. Cima primarily sells automotive and motorcycle gears, but it also has customers in aerospace and other industries that require high quality gears up to module 5 with a maximum outside diameter of 350 mm.

Whether it be prototype work and small batch production or volumes of around 50,000 parts per gear drawing, Cima grinds the gears that are mounted in gearboxes for the most powerful engines. Because of the demands on these gears, nothing is left to chance. Strict classes of tolerance, surface roughness, lead and involute crowning, tip relief and root fillets are all realized with Samputensili single-profile wheels or CBN or ceramic worm wheels, depending on the application. That attention to detail means less strain on mechanical components, reduced noise levels and better performance in the sports cars.

On these machines, Cima grinds the gears that are mounted in gearboxes for the most powerful engines. Because of the demands on these gears, nothing is left to chance. Strict classes of tolerance, surface roughness, lead and involute crowning, tip relief and root fillets are all realized with Samputensili single-profile wheels or CBN or ceramic worm wheels, depending on the application. That attention to detail means less strain on mechanical components, reduced noise levels and better performance in the sports cars.

The collaboration between Cima and Pagani began eight years ago, when the
owner of Pagani, Horacio Pagani, proposed that Cima design and produce an entire gearbox, including the box, assembly and setup.

This challenge was accomplished so well that Cima now manufactures around 50 of these six-speed + reverse gearboxes per year, 15 of which are for the Pagani Zonda F, a technological torpedo housed in a carbon-fiber shell. The Zonda F was on display in March at the Geneva Auto Salon in Switzerland.

For more information:
Cima S.p.A.
Via Cairoli 8
40050 Villanova di Castenaso - BO
Italy
Phone: +(39) 051-603-2511
Fax: +(39) 051-605-3292
E-mail: salesdept@cimaingranaggi.it
Internet: www.cimaingranaggi.it

Samputensili
c/o Star SU LLC
5200 Prairie Stone Pkwy., Suite 100
Hoffman Estates, IL 60192
Phone: (847) 649-1450
Fax: (847) 649-0112
E-mail: sales@star-su.com
Internet: www.star-su.com
Tifco Gage & Gear: MASTERS OF PRECISION

Bill Miller, Kapp Technologies, and Tony Tonello, Tifco Gage and Gear

Tifco Gage and Gear of Livonia, MI, is known for its precision components serving the gear industry. A wide segment of the market—from automotive to aerospace—depends on Tifco's know-how and highly skilled technicians.

As quality levels have increased worldwide in the auto industry, quality specifications for master gears and setting masters have increased in precision, making a tough job ever more difficult.

To keep up with those requirements and provide increased capacity, Tifco recently took delivery of a Kapp VUS55P gear grinding machine (Fig. 1).

With the new machine, Tifco has completed its first set of internal helical gear setting masters certified to a DIN 2 overall geometric quality with a size tolerance of +/- 0.005 mm between balls (Fig. 2).

For the 1.2-module helical master, this equates to an involute form tolerance of 1.6 µm. Due to a common tendency in the master gear industry, customer specification of the lead tolerance was effectively DIN 1 quality! Under AGMA's 2000-A88 standard, the quality requirement for lead tolerance was effectively class 14.

To explain this more clearly, a typical master gear lead tolerance band is shown as a “V” shape with a focal point at one face, effectively creating a tolerance of zero. This does not lend itself to analytical evaluation and classification, because a trace with even a small deviation will not pass through the focal point. This tolerance band was typically used along with mechanical lead measuring instruments that claimed an accuracy of 0.0002” (0.005 mm). The trace was smoothed by natural filtering of the recorder device and the deviation was compared with the tolerance band subjectively.

Even though computerized lead and involute instruments have been in use for more than 20 years and ISO and DIN standards have provided guidance for master gear quality and application, it is not uncommon to see tolerance bands rather than quality class or grade specified. This may be viewed as a reflection of the methods and machinery available to many companies designing and/or producing the master gears for industry. (As a note to designers and manufacturers, the new AGMA 2015 standard is a welcome and modern classification reference.)

The quality levels were certified by Tifco with modern CNC gear measuring equipment without filtering of the traces. The tolerance bands were created to allow the trace to pass through (Fig. 3).

The internal helical size-setting masters were produced on the new VUS55P using Kapp’s CBN plated wheel technology (Fig. 4).

Quality and durability requirements demanded a P/M high speed steel material hardened to 61–64 HRc. Use of CBN enabled the grinding of the gear teeth into the solid from through-hardened condition. As with any high quality gear, the datum must be equally high quality. Pre-heat treating the material also made it possible to produce the final datum on the blank with less distortion. Tifco manufactures its own clamping devices to necessary precision to establish and maintain the axis of the gear during the entire process.

The VUS55P produces teeth by discontinuous indexing. That means each tooth form is ground separately. Sometimes this is referred to as the single index method. This method requires especially strict control of all variables to achieve the tooth-to-tooth quality for master gears. Temperature stability of machine elements is provided by refrigeration of the
coolant oil. Stability is enhanced by continuous circulation of coolant oil across the machine bed, slides and spindles. Physical location of the machine in a central area away from drafts and doors aids in achieving best results.

The VUS55P is equipped with an integral dressing device mounted directly on the tailstock slide so it is always aligned and ready for use for either external or internal gear jobs. The dressing software enables virtually any special form or gear modification. The software allows the special forms to be entered point by point or via downloading externally generated coordinates. The measuring probe and software enable the machine to iterate towards a perfect solution automatically. The iterative approach is called “GMG” or grind-measure-grind. This compensates for deviations due to dresser shape and other variable conditions at the moment.
of grinding and is a valuable aid to shorten setup times. The Kapp machine is designed with measurement in mind. All position measuring scales are of resolutions typical of CMM equipment (0.0001 mm).

Dressable wheels come in nearly infinite specifications to suit any work material, and the master gear is no exception. The advantage of dressable wheels for rapid setup in this case, however, was offset by a high dressing frequency and a process with unnecessary extra variables and resultant lesser quality. CBN wheels were optimally designed for rough and finish grinding to eliminate the dressing variables. This resulted in a very reliable quality on the first piece. A size-setting master has an additional degree of difficulty because the size must be controlled so closely. The additional advantage of CBN in this case was the elimination of wear in the final grinding pass. Even though Tifco has applications like the setting masters, which are ideal for CBN wheels, Kapp’s optional dressable wheels allow the same machine to be used for grinding internal or external prototype gears and small lot applications (Fig. 5).

With the Kapp software for gear measurement, the setup time required to achieve the first good piece is shortened considerably. The Kapp dressing and measuring program enables involute modifications of nearly any type, including tooth twist (bias) of the flank form along the tooth length. Tifco has long specialized in the form grinding process required for precise involute control over master gears. Now Kapp provides a high technology system for reliable setup and production times on all types of gears, splines and special forms to gage quality.

Gages are what frequently comes to mind with Tifco. However, the “Gear” part of the name has become a bigger business, in fact. Naturally, the gears produced by Tifco are specialty gears beyond what can be routinely produced at commercial gear shops. One such critical application for Tifco customers is pump gears made from a CPM10V material (Fig. 6).

The basic gear data is 13 teeth, 4.7 NDP and 30° NPA. This poses a unique challenge for CBN grinding wheels. The material has an extreme low machinability, but it has been ground for years on Kapp machines successfully with CBN plated wheels. These gears introduce several other challenges for gear grinding. The quality required is DIN 2 for profile form (ff) and DIN 3 for total profile (F). Achieving the high geometric quality level is complicated by the fact that one flank of the pump gear is relieved along the entire length except for a 10 mm band that requires a precise involute form. The opposite flank requires the precise involute form over the entire tooth length. The consequence is a non-symmetrical grinding force which can lead to unwanted deviations where the forces change (Fig. 7).

The 16 micro-inch $R_a$ surface finish specification demands a fine-grit abrasive and risk of influence from high hydrody-
namic forces while grinding. These challenges are met with an HSS grinding wheel body and a wheel spindle with high stiffness. The workholding secures the pump gear with positive drivers. A special grinding process technology is applied on the Kapp grinder to optimize wheel peripheral speed, feed rate, stock removal and coolant flow, to ensure that the wheel cuts evenly with high hydrodynamic forces. Grinding of one flank at a time is sometimes employed in cases like this. However, where possible, this is avoided due to the cycle time penalty. Again, the temperature variable exists not only for the machine elements but for the workpiece itself. A balance is achieved between grinding speed and feed to minimize temperature increase of the workpiece.

Figure 5 — External grinding setup on a Kapp VUS55P.

Figure 6 — Typical aerospace pump gears.

Figure 7 — Aerospace pump gears with asymmetrical flank relief.
Form grinding any gear with only 13 teeth also requires precise axis positioning and centering of the wheel to avoid deviation of involute angle. The center line of the CBN wheel is established during the replating process. Even still, very slight temperature influences to the work area can render a deviation beyond acceptable limits. The Kapp GMG technology is useful in this case to correct the deviation by automatically finding the true center position of the wheel. In the end, Tifco was able to achieve a total cycle time which is many times faster than previous methods. Reliability of the process allows consistent production rates even under these extraordinarily challenging conditions. This is most important to enable volume increases in production.

Tifco is prepared for the future, where high performance components are made from increasingly advanced P/M materials. Tifco is equipped with various grinding arm sizes to cover most possible geometries of internal helical gears. The small grinding arm uses wheels with diameters of 50–60 mm, and the larger arm can use up to 130 mm diameter wheels. Any type of dressable abrasive wheels may be used on the Kapp grinder, including 3SG, 5SG, aluminum oxide and CBN. Dressable grinding wheel bond hardness, grit density, size and hardness are all variables of the grinding process. The learning curve for Tifco is shortened due to its long experience with single index form grinding via dressable wheels. Still, the availability of the CBN plated tool from Kapp provides huge versatility and allows selection of the best of both technologies on one machine.

For more information:
Kapp Technologies
2870 Wilderness Place
Boulder, CO 80301
Phone: (303) 447-1130
Fax: (303) 447-1131
E-mail: info@kapp-usa.com
Internet: www.kapp-usa.com

Tifco Gage & Gear
33067 Industrial Rd.
Livonia, MI 48150
Phone: (734) 525-8000
Fax: (734) 525-8400
E-mail: info@tifcogagegear.com
Internet: www.tifcogagegear.com
NEW & IMPROVED!
www.powertransmission.com

- Easy access to all current articles
- Latest news, updated as it happens
- Improved buyers guide format
(Try Our New “Find-It” Wizard)

Now Live!
The need to increase operational efficiencies is a daily requirement in the highly competitive global automotive manufacturing environment. This is clearly seen at the transmission development and manufacturing facilities of Getrag Ford Transmissions in Köln, Germany, and Halewood, England. At those factories, high volume production is required, but so is flexibility.

Originally, the Köln plant was set up as a high-volume, fully automated manufacturer. However, the increasing size of the Getrag Ford customer base—Ford, Jaguar, Mazda and Volvo, to name few—along with ever-changing volumes and product mixes between five- and six-speed manual transmissions as well as automatic transmissions create the need for greater flexibility.

Today, Getrag Ford’s plants in Halewood and Köln are set up in manufacturing cells to make transmissions in smaller volumes—approximately 50,000 units per year. But getting to that point required changes in philosophy as well as machining processes to allow Getrag Ford to manufacture a spectrum of parts with up to four part changeovers daily.

Knoy adds that the cycle times and costs of gear honing are equivalent to gear shaving, but honing produces a higher quality gear.

Choosing this course of action was a relatively high-risk proposition for Getrag Ford, considering the tenacity of today’s global competition. In the current market, the basic prerequisite for a partner is 24-hour service with guaranteed product reliability.

Despite those demands, there have been no significant problems since the installation of these processes in January 2004, according to Schulte.

Continued
In fact, the new setup has piqued the interest of many potential customers. According to a Getrag Ford spokesman, the combination of shaping and gear honing enables the company to have a tighter control on delivery and allows it to be more competitive in the world market, even with a product being manufactured in high-cost countries like England and Germany.

**A Direct Comparison Proves the Point**

Schulte says he is generally reserved in the comparison of different gear production processes. All relevant technical criteria have to be taken into consideration. Those criteria include the amount of material removed, production quality and manufacturing-induced deviations, tooling costs, personnel costs, machining costs and scrap costs.

Keeping all that in mind, Schulte says, “The modern gear shaping and honing processes—carried out as individual stepped processes—are comparable on the cost side to the costs of conventional shaping [alone]. Chiefly, the high precision Präwema honing process makes for a very logical compromise between quality and cost. The Priwema honing machines’ remarkably high process stability and robustness of the machine construction provide a convincing argument for this case.”
Combined with the improvements mentioned above, this has allowed Getrag Ford’s average cycle time to be reduced from 60 seconds to 30 seconds during the time period from 1999–2005.

Despite these improvements, the expectations of engineers and management at Getrag Ford Transmissions are high, and they are convinced that there are many more possibilities for process optimization.

For more information:
Präwema Honing Machines
c/o American Wera Inc.
4630 Freedom Dr.
Ann Arbor, MI 48108
Phone: (734) 973-7800
Fax: (734) 973-3053
E-mail: info@american-wera.com
Internet: www.american-wera.com

Tyrolit Gear Honing Tools
c/o Koepfer America LLC
635 Schneider Dr.
South Elgin, IL 60177
Phone: (847) 931-4121
Fax: (847) 931-4192
E-mail: csanderson@koepferamerica.com
Internet: www.koepferamerica.com

A German-language version of this article appeared in the March 2005 issue of the magazine Werkstatt und Betrieb. It has been translated and expanded here for Gear Product News.
Gearing manufacturers spend a lot of time worrying about gear teeth. It’s their specialty, after all. They have specialized equipment and technical expertise that aren’t found at just any manufacturer.

But an often-overlooked, yet incredibly important, part of the manufacturing process is the quality of the gear bore.

Without proper bore size, cylindricity and surface finish, all a gear manufacturer’s hard work on the gear teeth could go to waste, especially in parts that use the inner diameter for a bearing surface or that require close tolerances for shaft or bushing fits.

That’s why many gear manufacturers use honing to finish the bores. The advantages of honing include proper functioning of bearings, increased life of the gears or bearings, increased accuracy of the powertrain and lower noise levels.

**What’s Honing?**

Honing is an abrasive process that uses a rotating tool to machine metal from the interior diameter of a bore or cylinder. One of the most common uses of honing is bore sizing and finishing the cylinders of automotive engine blocks. But any application that requires precise control over the size and shape of an inside diameter could be a candidate for honing.

Traditional honing tools use abrasive stones mounted in an expanding mandrel. As the tool rotates, the tool—or in some cases the part—reciprocates rapidly. In modern machines, the expansion of the mandrel is CNC-controlled to ensure precise honing of the bore.

Traditional honing stones use bonded abrasives, from aluminum oxide up to...
CBN or diamond, depending on the application. Because the bonded matrix wears down during production, new, fresh abrasive grits are constantly exposed. Also, because the stones are on an expanding mandrel, the size of the bore is automatically adjusted.

Traditional honing has the largest range of applications, says Rich Moellenberg, custom products manager with Sunnen Products Co. “It is compatible with almost all part materials. If the surface finish of the bore is important to the performance of the gear, such as a transmission pinion gear, the manufacturer will choose traditional honing.”

Traditional honing is performed on either vertical or horizontal machines designed for rapid reciprocation of either the tool or the part. Generally, a single, rotating spindle carries the expanding mandrel with the abrasive stones.

Electroplated tools offer some alternatives for honing, especially in higher volume applications. For example, the patented Krossgrinding® system from Sunnen applies diamond-plated abrasive to an expanding mandrel. These tools are “typically the most accurate honing tool, but do not necessarily offer the lowest perishable cost per bore,” says Moellenberg.

Krossgrinding tools are expanded under CNC control, and bore diameter size can be changed in 0.0001 mm increments, with repeatability within 0.0001 mm, Moellenberg says.

Both conventional honing and Krossgrinding tools are capable of removing relatively large amounts of stock. Also, they produce a “crosshatch” surface finish pattern, which helps hold lubrication. This crosshatch pattern is also essential if the bore of the gear acts as an outer bearing race, Moellenberg says.

Another type of electroplated honing tool is designed for sizing or finishing the bore in a single pass or stroke. Instead of being mounted on an expanding mandrel, the tool itself is a solid substrate, with the abrasive material (usually diamond or CBN) plated directly onto the tool. Examples include the Single-Pass tools from Engis and the Single-Stroke Honing tools from Sunnen.

These tools are used for removing only a small amount of material, but productivity rates are extremely high. When the application is right, this is the least expensive method of honing, with per-part costs of about $0.01.

The single-pass honing process provides a number of advantages, says Bob Marvin, Engis product manager.

The first advantage of single-pass tools is good precision. "In fact, this process can hold quality to better than a 2 Cpk in production," Marvin says.

Also, the single-pass process offers high productivity without complicated tooling. With this type of tooling and machine, productivity can be as high as 600 parts per hour, Marvin says. Although conventional honing can achieve similar high production rates, it requires parts like gears to be stacked in order to do so. This requires complicated fixturing and can result in a loss of accuracy.

Finally, the cost of $0.01 per part is what is most attractive, Marvin says. “This is at least half the cost of conventional honing and much less than grinding. The long tool life also promotes less downtime and overall lower cost per piece.”

Moellenberg agrees that single-stroke tooling has its advantages. However, he points out that the process has a more narrow range of applications, compared to traditional honing. It is difficult to use plated diamond abrasive tools with materials that typically develop a “long chip” when machined. Some materials also react with the nickel plating that holds the diamond abrasive to the honing tool. Examples include 300 series stainless steels or 8620 steel. With those materials, the honing chips tend to stick to the nickel, embedding in the part and causing galling. However, if the application is right, Moellenberg says, it’s the least expensive method of honing for both the perishable tooling cost and the machine investment.
In some cases, the single-stroke tools can be used in conjunction with a honing machine that incorporates a rotary index table and multiple spindles, so that multiple tools with increasing diameters can be used in succession. This allows the manufacturer to increase the amount of stock removed without increasing cycle time.

**Where Does Honing Fit In?**

In most cases, honing is a finishing process, used after heat treating to put the final size on an inside diameter. Generally, this means it’s done after the gear teeth are cut.

But in some cases—particularly for higher precision gears—honing is performed before the teeth are cut. “The accurate bore in the gear blank makes the gear blank very accurately fixtured in the gear hobbing machine,” says Moellenberg.

“This produces superior gear teeth to the bore centerline tolerance.”

Often with such high precision gears, Moellenberg says, the bore is honed, the teeth are cut, the part is heat treated, and then the part is finish honed to remove any heat treat distortion.

Many gear parts have interior features, such as internal splines, keyways or holes for set screws. Although these interrupted cuts often are more demanding and cause problems for many abrasive processes, they can be honed with the right tooling.

“These types of gear bores are typically honed for bore diameter and bore geometry tolerance,” Moellenberg says.

Engis has one customer that uses the single-pass process to hone the inside diameter of a component with an internal spline. This creates a good locating surface for a subsequent gear tooth grinding operation, Marvin says.

“Internal recesses or splines can have a negative effect on processes such as grinding, hard turning and conventional honing,” Marvin says. “This is due to the cutting insert or honing stone hitting the edges of the cutout during the cutting. The single-pass process does not have this problem because the tool is self-centering in the bore and has full contact with the bore around the periphery of the tool.”

No matter the application, though, both Marvin and Moellenberg agree that honing is a crucial step in manufacturing precision gears.

For more information:
Engis Corp.
105 W. Hintz Road
Wheeling, IL 60090
Phone: (847) 808-9400
Fax: (847) 808-9430
E-mail: kwerner@engis.com
Internet: www.engis.com

Sunnen Products Corp.
7910 Manchester Avenue
St. Louis, MO 63143
Phone: (314) 781-2100
Fax: (314) 781-2268
E-mail: bdavis@sunnen.com
Internet: www.sunnen.com
USE THE BUYERS GUIDE
Get information from the industry’s leading suppliers

• Gear Machines
• Cutting Tools & Grinding Wheels
• Software
• Non-Gear Machinery
• Gear Blanks & Raw Material
• Lubricants
• Inspection Equipment
• Workholding & Toolholding
• Heat Treating
• Services
• Gear Drives
• Gears

VISIT Gear Technology ONLINE
Your No. 1 source for gear-related information online

• Sign up for E-GT
• Read the latest news
• Renew your subscription
• Request info from our advertisers
the basics of
Harmonic drives were invented in the late 1950s and have been a major part of the motion control industry since then. In that time, several innovations, improvements and adaptations have been made, allowing harmonic drives to become a primary choice for applications requiring precise positional accuracy and repeatability.

They are now available as fully housed gearheads, actuators complete with motor and encoder, or in custom configurations with special materials, greases or customer-specific designs that allow for easy adaptability.

Since they were invented, one aspect of harmonic drive gearing has remained constant: their principle of operation. Most people in industry are familiar with the term harmonic drive and have either heard about them or seen them in passing, but few understand how they work or why they’re capable of high ratios, zero backlash, and high torque-to-weight ratios.

Harmonic Drive Gearing—Do You Really Know How it Works?
The operating principle of harmonic drive gearing is one of the most misunderstood of all gearing technologies.

The mechanism is comprised of three components: wave generator, flexspline, and circular spline (Fig. 1).

Wave Generator. The wave generator is actually an assembly of a bearing and a steel disk called a wave generator plug. The outer surface of the wave generator plug has an elliptical shape that is carefully machined to a precise specification. A specially designed ball bearing is pressed around this bearing plug, causing the bearing to conform to the same elliptical shape as the wave generator plug.

The wave generator is typically used as the input member, usually attached to a servo motor.

Flexspline. The flexspline is a thin-walled steel cup with teeth machined into the outer surface near the open end of the cup. The large diameter of the cup allows it be radially compliant, yet remain torsionally stiff.

The cup has a rigid boss at one end to provide a rugged mounting surface. During assembly, the wave generator is inserted inside the flexspline in the same axial location as the flexspline teeth. The flexspline wall near the brim of the cup conforms to the same elliptical shape as the bearing. Effectively, the flexspline now has an elliptical gear pitch diameter on its outer surface.

The flexspline is usually the output member of the mechanism.

Important: Although the steel flexspline flexes during normal operation, there is no concern about fatigue failure. The stresses developed are far below the endurance limit of the material. Thus, the flexspline will achieve infinite life when used according to catalog ratings. This is explained better in Figure 2.

Circular Spline. The circular spline is a rigid circular steel ring with teeth on the inside diameter. The circular spline is usually attached to the housing and does not rotate.

The teeth of the circular spline mesh with the teeth of the flexspline. The tooth pattern of the flexspline (which is now elliptical—as a result of conforming continued
to the wave generator’s elliptical shape) engages the tooth profile of the circular spline along the major axis of the ellipse. This engagement is like an ellipse inscribed concentrically within a circle. Mathematically, an inscribed ellipse will contact a circle at two points. However, the gear teeth have a finite height. So there are actually two regions (instead of two points) of tooth engagement.

In fact, up to 30% of the teeth are engaged at all times on the major axis. The pressure angle of the gear teeth transforms the output torque’s tangential force into a radial force acting on the wave generator bearing. The teeth of the flexspline and circular spline are engaged near the major axis of the ellipse, and disengaged at the minor axis of the ellipse (Fig. 3).

**Here’s the Trick...**
The flexspline has two fewer teeth than the circular spline. So every time the wave generator rotates one revolution, the flexspline and circular spline shift by two teeth. The gear ratio is calculated by

\[
\text{gear ratio} = \frac{\text{# Flexspline Teeth}}{\# \text{Circular Spline Teeth}}
\]

Since the flexspline has two fewer teeth than the circular spline, the term \((\# \text{Flexspline Teeth} – \# \text{Circular Spline Teeth})\) = -2. For example, if the flexspline has 200 teeth, the circular spline has 202 teeth. The gear ratio will be calculated as \(200/(200–202) = -100\). The negative sign indicates that the input and output rotate in opposite directions.

**Principle of Operation**
As the wave generator is rotated by the primary power source, it imparts a
continuously moving elliptical form or wave-like motion to the flexspline. This causes the meshing of the external teeth of the flexspline with the internal teeth of the circular spline at their two equidistant points of engagement. This meshing progresses in a continuous rolling fashion. It also allows for a full tooth disengagement at the two points along the minor axis of the wave generator.

Since the flexspline has two fewer teeth than the circular spline and because full tooth disengagement is made possible by the elliptical shape of the wave generator, each complete revolution of the wave generator causes a two-tooth displacement of the flexspline in relation to the circular spline. This displacement is always in the opposite direction of the rotation of the wave generator (Fig. 4).

For example, if the wave generator is rotating in a clockwise direction, the two-tooth per revolution displacement of the flexspline will be in a counterclockwise direction, and vice-versa. In this way, a basic three-element harmonic drive component set is capable of functioning as a speed reducer. Input from a main power source through the wave generator is at a high speed, but the two-tooth per revolution displacement causes the flexspline to rotate at a considerably slower speed than the wave generator.

continued
The reduction ratio which results can be calculated by dividing the number of teeth on the flexspline by two. For example, if a fixed circular spline has 202 teeth and an output flexspline has 200 teeth, the ratio would be 200/(200–202) = –100:1*

*The negative sign indicates that the input and output are turning in opposite directions.

Other Configurations
In addition to acting as a speed reducer, a wide variety of configurations can be achieved with harmonic drive gearing by changing which element (among the wave generator, circular spline and flexspline) acts as the fixed element, input element and output element (Fig. 5).

Advantages
The advantages of harmonic drive gearing over other, more conventional gear trains are apparent. A simple three-element construction combined with the unique harmonic drive principle puts extremely high reduction ratio capabilities into a very compact and lightweight package. This remarkable union of simplicity of construction with an operating principle that is unique, also enables backlash to be held to a minimum.

Zero Backslash. The unique design and operating principle yield some very convenient benefits. The tooth engagement motion (kinematics) of the harmonic drive gear is very different than that of planetary or spur gearing. The teeth engage in a manner that allows up to 30% of the teeth to be engaged at all times (60 teeth engaged for a 100:1 gear ratio). This contrasts with maybe six teeth for a planetary gear set, and one or two teeth for a spur gear set.

In addition, the unique kinematics allow the teeth of a harmonic drive gear to be engaged on both sides of the tooth flank. Since backlash is defined as the difference between the tooth space and tooth width, this difference is zero for harmonic drive gearing.

Consistent Performance. As part of the design, the gear teeth of the flexspline are preloaded against those of the circular spline at the major axis of the ellipse. They are preloaded such that the stresses are well below the material’s endurance limit. This has an important benefit.

In conventional gearing, wear results in an increase in backlash over time. In harmonic drive gearing, as the gear teeth wear, the elastic radial deformation acts like a very stiff spring to compensate for space between the teeth that would otherwise cause an increase in backlash. This allows the performance to remain constant over the life of the gear.

High Positional Accuracy. The combination of harmonic drive gearing principle and manufacturing technology allows positional accuracy of 30 arc-seconds (0.008°). All three gearing components (wave generator, flexspline and circular spline) are held concentric at all times. In addition, the tooth height, pitch circle and tolerances are controlled to millionths of an inch. These factors, when combined with the 30% tooth engagement, allow for sustained accuracy far better than other gearing technologies.

High Torque-to-Weight Ratio. Harmonic drive gearing offers higher torque-to-weight and torque-to-volume ratios than other gearing technologies. The lightweight construction and single-stage gear ratios of up to 160:1 allow the gears to be used in applications requiring minimum weight or volume. Small motors can exploit the large mechanical advantage of a 160:1 gear ratio to create a compact, lightweight and low-cost package.

Affordable Precision. Harmonic drive gearing offers many performance advantages as compared to conventional gearing technologies. Yet, its simple and elegant design allows manufacturing costs to be roughly equal to that of other precision motion control technologies. This provides an attractive cost/benefit proposition for most motion control applications.

Anthony Lauletta is manager of marketing communications with Harmonic Drive LLC. On Jan. 1, Harmonic Drive Technologies/Nabtesco of Peabody, MA, and HD Systems of Hauppauge, NY, merged to form a new joint venture, Harmonic Drive LLC. Harmonic Drive remains committed to providing the highest quality harmonic drive gearing and motion control products combined with world class customer service and support. The new company will employ over 90 people and be headquartered in Peabody, MA.

For more information:
Harmonic Drive
247 Lynnfield St.
Peabody, MA 01960-4904
Phone: (978) 532-1800
E-mail: info@harmonic-drive.com
Internet: www.harmonic-drive.com
Immediate Opportunities in Challenging Aerospace Careers.

The Purdy Corporation is a leader in manufacturing flight critical Jet engine and rotor components including gears, gear boxes and transmissions for OEMs and the United States Government. Aerospace manufacturing opportunities offering stability, job satisfaction and growth are available in the following areas of expertise;

- Gear Management - Aerospace Manufacturing
- CNC Programming (Unigraphics) - Gear Box Housings, High Speed Machining,
- Gear Engineering - Process, Planning & Manufacturing
- Gear Machining - Spiral Bevel and Parallel Axis • ID/OD Grinding
- Gear Metrology • Gear Box Assembly and Testing

Excellent benefit and relocation packages. An Equal Opportunity/Affirmative Action Employer.

Take your career to a whole new level, contact us at 860.649.0000 Ext. 226 or e-Mail to finance@purdytransmissions.com

TEAM APACHE
Proud Supporters of America’s Military.

THE PURDY CORPORATION
60 YEARS OF EXCELLENCE
www.purdytransmissions.com
586 Hilliard Street, Manchester, CT 06042, USA • Phone 860-649-0000, Fax: 860-645-6293
For much of this century, a lot of people have owed their livelihoods to Dr. Max Maag. After years of development, the Maag Gear Wheel Co. shipped the first of many spindle-type gear shapers in 1958. The Maag design represents a more practical alternative to hobbing for manufacturing many types and styles of large gears. In fact, even today, there are coarse-pitch, large diameter and narrow-gap double helical gears that can only be manufactured on a Maag-style machine.

Because of the machine’s precision capabilities, versatility and production efficiency, many manufacturers have found it important to protect their investments and keep their Maag gear shapers in tip-top condition—especially since the machines are no longer made. By the time the last new Maag gear shaper was installed in 1990, the control technology had changed dramatically. Also, the robust nature of the Maag gear machines that once captivated gear makers eventually became their curse, as the mechanical components greatly outlived the electrical controls. Retrofit became a part of the gear maker’s vocabulary as a path to continued productivity in the future.

A full CNC solution involves installing synchronized servo motors on the table rotation, table translation and cutter box motions and removing all the unnecessary equipment formerly associated with these motions. The significant roadblocks one faces going down the full CNC path include the natural tendency not to disturb a functioning system and the ability to find a control system integrator possessing the intimate knowledge of the inner workings of the Maag gear shaping process.

There are a number of technological reasons for choosing a full CNC retrofit; however, it can be difficult to make a justifiable business case to support this decision. During the justification process, someone always points out that the Maag will not run any faster after a retrofit. Those who attempt to make it run faster, often end up burning the tooling out faster, which wipes out savings realized by the increased speed. In addition, the savings in reducing the setup time that a CNC solution would
bring become insignificant when one considers the ratio of setup time to run time. Without the prospect of increased production or significant setup time reduction, Maag projects are not usually high on the appropriations list.

But you don’t have to do a full CNC retrofit. A number of less expensive retrofit options exist, from a complete control system upgrade to an individual ram drive replacement. Since 1992, Nova personnel have retrofitted two SH-250s with new control systems, reusing only the original drive motor, and one SH-250 with a new control system and a new drive motor. Nova has also integrated new drive controllers into two SH-450s and one SH-250/300, each time replacing energy-hogging motor-generator sets. In every retrofit case, whether a complete or partial upgrade was installed, the Maag shapers either met or exceeded the production rates of the machines prior to the start of the projects.

Maag gear makers usually struggle to justify making improvements to their shapers, but there are good reasons why upgrades make sense. Replacing outdated motor-generator sets provides a continuous payback due to reduced energy consumption. Another reason might be avoiding downtime spent trying to troubleshoot a relay logic control system. A major reason to consider an upgrade would be the impending demise of the ram drive motor or motor-generator set. Normally, the cutter box motion should be steady with a smooth turnaround. If there is any jerkiness in this motion, it might indicate a developing problem with the ram drive system. An emergency full overtime repair of these components can be very costly both in terms of direct expenditures and loss of planned production time. Funds might be better spent towards updating equipment on a preplanned schedule. Downtime waiting for the arrival of specially manufactured or repaired parts can support the case.

A much overlooked opportunity to retrofit a Maag is when it is moved, since the machine is down and usually rewired anyway.

Another viable business case could be made for an upgrade when gear shapers might be underpowered. This condition would exist when a shaper originally built to finish previously gashed blanks was now being used to rough cut. In that case, increased throughput could be realized with a power upgrade. In the late 1990s, the power of these machines could be increased by replacing the 32 kW DC ram motor with a 70 kW modern flux vector AC motor. Even though this combination produces about 15% less torque than an original 70 kW Maag DC motor (commonly used on roughing machines), there still is a significant improvement over a 32 kW motor. Today, new motor technologies can offer solutions to overcome the shortcomings of the flux vector motor.

The control system of a Maag shaper consists of an electronic control unit
and a relay logic section. Since the initial introduction of the first spindle-type machine, the control system has evolved through many stages to a full PLC-based implementation. The last machines produced by Maag used Modicon equipment. The original intent of the PLC initiative was to provide a degree of separation between the logic and the hardware. A secondary benefit was the capability to use software tools for troubleshooting. With this system, since the logic (software) rarely changes, new hardware elements can readily replace obsolete elements.

Nova has continued the development of the Maag control system by migrating it to a PAC (Programmable Automation Controller) platform. With this technology, it is possible to install a control system to adequately operate the shaper in present time, but also provide the potential to add full CNC capabilities as future needs arise. The PAC solution additionally provides capabilities for display of machine status, storage of part production setups and diagnostic information. These systems are designed using a Fieldbus digital I/O protocol that allows locating the physical inputs and outputs on the machine. This eliminates the gaggle of wires running through the flex conduits back to the main control. The updated control will free up at least half of the real estate in the former control cabinet.

From a gear maker’s view, the upgraded machine changes very little. The pendant controls are exactly the same. The main operator panel is modified to allow the installation of an electronic display. This display/data entry keyboard annotates machine status and fault information. Because of the modular nature of the Nova solution, a ram-drive-only retrofit can be implemented on an existing Maag control system and be completely compatible with a future PAC upgrade. This interim ram drive upgrade would be seamless as far as the operator is concerned.

Nova designs and builds the systems in Milwaukee, WI. This location provides a geographical center point for the dispatch of service engineers if needed for further maintenance. After shipment to the final destination, either plant personnel or an electrical contractor familiar with the site does the installation. This has worked well because it allows a local presence and familiarity with the hardware. Following the installation, a factory-trained engineer would commission the retrofit. In some cases, owners elect to separately contract the services of a gear shaper expert to check and resolve any mechanical issues. In the case of a ram drive power change, it is highly recommended that such an expert be involved because the overload clutch will have to be adjusted.

A Maag gear shaper is a symphony of gears, levers, motors, pumps and control units all playing together in perfect harmony. A successful retrofit will keep the parts playing together perfectly.

For more information:
Nova Systems Inc.
11629 W. Dearbourn Ave.
Milwaukee, WI 53226
Phone: (414) 771-4800
Fax: (414) 771-4847
Internet: www.novasystemsinc.com

Kenn Anderson is vice president of engineering at Nova Systems Inc. and is responsible for troubleshooting problems with motors and electronic controlling devices and for management of technical personnel. Prior to that, he was engineering/plant manager for Dietz Electric Co. in Milwaukee, WI.
Name:
Bob Sakuta, President of Delta Research and Tifco Gage and Gear, Livonia, MI.

About your career in the gear industry:
“My dad started the company in 1952. I began working here when I was 10 or 12. Then I went off to college, got a business degree and became a ‘big shot’ at a large corporation, but it was a hollow experience. So I came back to the family business and have been here ever since.”

What keeps you going?
“I love building things...the creativity of the business. The people who work here–they're family.”

Your equipment and technology?
“We have millions worth of gear cutting and grinding machines, inspection equipment, machining centers, broaching and spline rolling... to name a few. We usually buy two of everything, just to have a backup. Recently, we installed a completely automated gear production cell that runs 24/7 and produces 3,000 gears a day for a customer in Japan. I'm constantly on the hunt for new equipment and technology.”

The future of the gear industry?
“I have a vision to make Livonia the gear capital of the world! A cooperative effort with other gear designers and producers that would provide the innovation and production capabilities to supply major OEM's and compete globally.”

Your thoughts on Gear Technology magazine:
“It's a great magazine. I've been reading it my whole career. It gives me ideas on how to make better gears. It helps me find the equipment I need to build the best gears.”

Gear Technology. The magazine gear industry buyers rely on.
Suzlon Energy

ACQUIRES HANSEN TRANSMISSIONS

Suzlon Energy Ltd. of India has acquired gearbox manufacturer Hansen Transmissions of Belgium from Allianz Capital Partners for 465 million euros. The acquisition is part of Suzlon's growth strategy in the wind turbine manufacturing market.

“Hansen will be run as an independent business unit,” says Tulsi R. Tanti, president of Suzlon’s board of directors. “The acquisition enables Suzlon to integrate gearbox technology in the development of wind turbines.”

Hansen has two production sites in Belgium, including a new factory dedicated to the production of wind turbine gearboxes. Hansen is able to produce gearboxes for 3,600 megawatts of wind turbines annually.

In addition to its wind turbine manufacturing, Hansen also has a strong presence in the industrial gear drive market, manufacturing and assembling more than 3,000 industrial gearboxes per year for applications such as water treatment, material handling and cooling towers.

“The acquisition confirms Suzlon’s trust and confidence to further develop Hansen,” says Matts Lundgren, CEO of Hansen. “We will continue to manage Hansen as an independent business unit and strive to exceed customer expectations.”

Ajax Tocco

ACQUIRES ASSETS OF TWO COMPANIES, MERGES OPERATIONS WITH GERMAN FOUNDRY

Ajax Tocco Magnethermic purchased the assets of Lectrotherm and Premelt Systems, both of Canton, OH. Ajax Tocco Magnethermic GmbH also merged operations with Foundry Services of Hemer, Germany.

According to Ajax’s press release, Foundry Services will continue operation in its current location and expand into an existing Ajax Tocco service center in Sinsheim, Germany.

Lectrotherm specializes in aftermarket repair and replacement of melting furnaces and electromagnetic stirring fixtures. In recent years, the company has expanded to provide capital equipment to non-traditional induction markets.

Premelt Systems designs and services integrated metal scrap cleaning and processing systems to the aluminum wheel industry worldwide.

Timken

SUPPLIES TWO MILLIONTH SPECIAL BEARING ASSEMBLY TO ZF

The Timken Co. delivered its two millionth special bearing assembly to the Saarbruecken, Germany, production plant of ZF, a leading global supplier for automotive driveline and chassis technology.

The product is a two-row flanged pinion bearing assembly referred to as a “TDOF.” ZF and Timken have been working together for years on providing higher performance with fewer components. The assemblies were first featured in ZF’s four-speed inline automatic transaxles and continued to evolve with the five-speed version. It is currently used in the six-speed automatic transmission cluster for front-wheel, standard or all-wheel-drive solutions and torques up to 750 Newton-meters. ZF’s transaxles are featured in dozens on engine-transaxle combinations for a variety of different car platforms.
Star SU and Winco Industries

ACQUIRE MARKETING AND MANUFACTURING RIGHTS FOR BENCERE PRODUCTS

Winco Industries has acquired the marketing and manufacturing rights to a patented series of padded adjustable reamers and fine boring tools.

The patents, held by Bencere Ltd. of Oxfordshire, England, are for R-Max padded adjustable reamers and Quattro-Cut padded fine boring tools. Star SU will become the exclusive marketer of both products in North America and Winco the exclusive marketer in South America.

Star SU R-Max reamers can be utilized for close tolerance reaming of ferrous and non-ferrous parts. Production tolerances of 0.01 mm or less can be expected. The patented single clamping screw simplifies fine adjustments to size and back taper. Automotive and heavy equipment component part manufacturers utilize these tools for operations such as engine cam and crank reaming in both cast iron and aluminum blocks and cylinder heads. Additional applications, such as steering gears, housings, hydraulic pumps, control valves and cylinders, air conditioning, compressors, brake calipers and master cylinders, also typically require precision reaming.

Metaldyne

SELLS FORGING BUSINESS, HIRES NEW VP

Metaldyne entered into an asset purchase agreement with Forming Technologies related to the acquisition of Metaldyne’s North American forging business.

According to Metaldyne’s press release, it expects $129 million and the assumption by the buyer of $7.5 million in outstanding indebtedness of the forging business as well as assumption of all working capital items and specific liabilities.

Metaldyne’s North American forging business includes its operations in Royal Oak, Fraser, Detroit and Troy, MI; Canal continued
Balzers

ASSUMES COATING OPERATIONS OF GOLD STAR COATINGS

Balzers announced plans to take over the PVD coating operations of Gold Star Coatings, a subsidiary of Star Cutter Co.

According to Balzers’ press release, the transaction will be completed by April 30. Balzers will assume the function of coating partner for the tool resharpening services sold by Star and SU. In addition, Balzers will open an in-house coating center in the gear tool manufacturing operation of Star Cutter Co. in East Tawas, MI.

The existing coating center of Gold Star Coatings in Richmond, IN, will be expanded to become a significant regional site for Balzers. The activities of Gold Star’s West Branch, MI, facility will be integrated into three existing Balzers coating centers in Michigan. In the future, Balzers will have a network of 14 sites in the U.S. and Canada for contract coating as well as three in-house coating centers located on customer premises.

Kent Connell, president of Balzers, said, “We are very excited with the possibility of working much closer with Star SU and Star Cutter Co. than we have in the past. They are doing a great job in offering customers a complete package of tool management and maintenance. We are happy to be the primary source for coating tools in this package. We are also excited to add the Gold Star customers to our portfolio and pledge ourselves to do everything possible to provide them with outstanding service and excellent quality.”

Ikona Industries

SHIPS FIRST GEARBOX MANUFACTURED IN-HOUSE

Ikona Industries is moving a number of projects from the initial design and prototype stages into commercialization.

Laith Nosh, president and CEO, said, “This month marks a significant milestone for Ikona as we shipped the first commercial gearbox application completely designed and manufactured in-house by Ikona Industries. The application, a satellite antenna base pedestal, is essentially a gearbox that provides rotation and tilt for a mobile satellite base station. The application represents approximately $110,000 in revenue and is soon to be followed by the shipment of identical units in the coming weeks.”

Formerly known as Ikona Gear, the company recently announced its name change to Ikona Industries Inc.
Balzers Inc. opened a coating center in Houston and has begun coating production of cutting, forming, molding tools and precision components. This is the fourth center to open in the past 12 months.

The Houston location will service the South Central region, including Texas, Oklahoma, Arkansas and Louisiana. According to the company’s press release, the center will provide full service coating solutions not only for standard coatings like titanium nitride but also advanced, high performance coatings and pre- and post-treatment capabilities.

According to Balzers’ press release, the new Houston center will primarily serve the cutting tool industry, as well as the die casting, stamping, forming, mold and die markets for application in oil field services, aerospace, machine tools and high-wear machine components.

Balzers
OPEN NEW COATING CENTER

FLYING INTO CHICAGO?
VISIT US NEXT TO O’HARE AIRPORT

Visiting on business? Attending an auction? First or last — visit Cadillac Machinery

We have 50,000 square feet with literally hundreds of all types of modern gear equipment. See our website for a complete inventory of our gear machine tools, most with photos, and an individual inventory of our gear tooling and accessories.

Fax or E-mail your requirements:
Ph: 847-437-6600
Fax: 847-437-6618
sales@cadillacmachinery.com
www.cadillacmachinery.com

CADILLAC MACHINERY CO., INC.
MH1 Lunt Ave., Elk Grove Village, IL 60007 USA

HELP WANTED
Immediate Openings

for
Shaping and Hobbing Set-Up Technicians

Three years experience preferred

Generous Benefits Package

Small and friendly firm located in the heart of God’s country in a rural setting between Milwaukee, Madison and Chicago.

Send Resumes to
Mr. Everett Hawkins
Forest City Gear Company
11715 Main Street, P.O. Box 80
Roscoe, IL 61073

HELP WANTED
Immediate Openings

for
Shaping and Hobbing Set-Up Technicians

Three years experience preferred

Generous Benefits Package

Small and friendly firm located in the heart of God’s country in a rural setting between Milwaukee, Madison and Chicago.

Send Resumes to
Mr. Everett Hawkins
Forest City Gear Company
11715 Main Street, P.O. Box 80
Roscoe, IL 61073

Balzers Inc. opened a coating center in Houston and has begun coating production of cutting, forming, molding tools and precision components. This is the fourth center to open in the past 12 months.

The Houston location will service the South Central region, including Texas, Oklahoma, Arkansas and Louisiana. According to the company’s press release, the center will provide full service coating solutions not only for standard coatings like titanium nitride but also advanced, high performance coatings and pre- and post-treatment capabilities.

According to Balzers’ press release, the new Houston center will primarily serve the cutting tool industry, as well as the die casting, stamping, forming, mold and die markets for application in oil field services, aerospace, machine tools and high-wear machine components.
WE BUY & SELL GEAR EQUIPMENT
Since 1950
Anywhere in the world
See Complete List of individual tools
and photos at www.cadillacmachinery.com

GLEASON BEVEL EQUIPMENT
Straight Generators 3", 24, 24A, 104, 725 — to 1975
Cutter Sharpener #12, 13A, 496, 532, 538, 545, 563 — to 1981
Grinders 29, 105, 120, 463 — to 1968
Testers #4, 6, 13, 14, 17M, 61, 512, 519 — to 1970
Lappers #15, 500 HL, 503, 514, 516 — to 1996
Cutter Inspection/Setting #15, 527, 528, 563 — to 1981
Quenching Presses #529 Automatic (250 mm), 529 Manual (400 mm), 537 (711 mm)

GEEAR SHAPERS
Barber Colman 10-4, with Tilt, as late as 1973
Fellows No. 7, 1973
Fellows 10-2, 10-4, 1977 Tailstock Available

GEEAR TESTERS
Lead—Goulder 3H 1973
Involute—Fellows 24M, ITW 3412B, 3424B, as late as 1981
Combination Lead/Involute—Maag SP60, PH100, as late as 1981, M & M #3012, ‘00

TESTERS ROLLING
Beaver 2203 3"
Hofler ZW400, 16" 1990
ITW 2203 3"
Parkson 9N, w/ & w/o worm attachment
Parkson 15N 15"
Parkson 24'/30", w/ & w/o worm attachment
Quaker 2-2/2"

GEEAR MILLERS
Barber Colman 16-16, 1966
Hurth KF32a, AMT 4 - 150 Heads,
AMT 4 - 240 Heads, with & without extension, as late as 1980
Hurth LK/F33, 40" Travel, 97" CC, 1970

GEEAR GRINDERS
Kapp AS203, AS305, AS305B

THE STANDARD OF THE GEAR INDUSTRY
Since 1950

Phone: 847-437-6600 • Fax: 847-437-6618
sales@cadillacmachinery.com
www.cadillacmachinery.com
Quality Spiral Bevel Tools
A/W Systems Co. is your quality alternative manufacturing source of spiral gear roughing and finishing cutters and bodies. We can also manufacture new spiral cutter bodies in diameters of 5" through 12" at present. A/W can also supply roughing and finishing cutters for most 5"-12" diameter bodies. Whether it’s service or manufacturing, consider us as an alternative source for cutters and bodies. You’ll be in for a pleasant surprise.

1901 Larchwood Troy, MI 48083
Tel: (248) 524-0778 • Fax: (248) 524-0779

Gear Manufacturing
CNC Gear Grinding
CNC Gear Analysis
CNC OD/ID Grinding
www.gearmanufacturing.com
Complete Precision Gears Under One Roof...
Ph 800-773-GEAR Fax 714-792-2870

Heat Treating

Cutting Tools

“GEARS FOR A YEAR”

Puts your message here

... and in Gear Technology

... and Online at
geartechnology.com
or powertransmission.com

Call Ryan King at
(847) 437-6604

www.gearproductnews.com

The complete issue, every issue, always available online

Plus

• Subscriptions
• Advertising Information
• FREE Buyers Guide Listings

Bookmark Us Today!
A/W Systems Co.  
Page 47  
(248) 524-0778

Arrow Gear Co.  
Page 13  
(630) 969-7640  
www.arrowgear.com

B&R Machine & Gear Corp.  
Inside Back Cover  
(731) 456-2636  
inquiry@brgear.com  
www.brgear.com

Bourn & Koch  
Page 22  
(815) 965-4013  
bournkoch@worldnet.att.net  
www.bourn-koch.com

The Broach Masters Inc.  
Page 14  
(530) 885-1939  
www.broachmasters.com

Cadillac Machinery Co. Inc.  
Pages 43, 45, 46  
(847) 437-6600  
sales@cadillacmachinery.com  
www.cadillacmachinery.com

Clifford-Jacobs Forging Co.  
Back Cover  
(217) 352-5172  
sales@clifford-jacobs.com  
www.clifford-jacobs.com

Comtorgage Corp.  
Page 9  
(401) 765-0900  
kgadolf@comtorgage.com  
www.comtorgage.com

Fässler Corp.  
Page 10  
(414) 769-0072  
usa@faessler-ag.ch  
www.faessler-ag.ch

First Gear  
Page 17  
(260) 490-3238  
www.first-gear.com

Forest City Gear  
Page 45  
(866) 623-2168  
www.fcgear.com

Gear Consulting Group  
Inserted Card  
(259) 523-4993  
gearconsulting@aol.com  
www.gearconsultinggroup.com

Gear Manufacturing Inc.  
Page 47  
(800) 773-4327  
www.gearmanufacturing.com

Gear Technology magazine  
Pages 31, 41, 47  
(847) 437-6604  
ryanking@geartechnology.com  
www.geartechnology.com

gearproductnews.com  
Page 47  
(847) 437-6604  
editors@gearproductnews.com  
www.gearproductnews.com

Gleason Corp.  
Inside Front Cover  
(585) 473-1000  
dmelton@gleason.com  
www.gleason.com

James Engineering  
Page 21  
(303) 444-6787  
www.james-engineering.com

Kapp Technologies  
Page 3  
(303) 447-1130  
info@kapp-usa.com  
www.kapp-usa.com

Kleiss Gears Inc.  
Page 47  
(715) 463-5995 x105  
kleiss@kleissgears.com  
www.kleissgears.com

Koepfer America LLC  
Page 7  
(847) 931-4121  
sales@koepferamerica.com  
www.koepferamerica.com

LeCount  
Page 17  
(800) 652-6713  
sales@lecount.com  
www.lecount.com

Leistritz Corp.  
Page 22  
(201) 934-8262  
staff@leistritzcorp.com  
www.leistritzcorp.com

Magnum Induction  
Page 47  
(810) 364-5270  
tom@magnuminduction.com  
www.magnuminduction.com

Midwest Gear & Tool Inc.  
Page 21  
(586) 779-1300  
midwestgear@bgglobal.net

powertransmission.com  
Pages 13, 23  
(847) 437-6604  
clark@powertransmission.com  
www.powertransmission.com

Precision Gage Co. Inc.  
Page 43  
(630) 655-2121  
sales@precisiongageco.com  
www.precisiongageco.com

Presrite Corp.  
Page 12  
(216) 441-5990  
www.presrite.com

Process Equipment Co.  
Page 11  
(800) 998-4191  
msdsales@processeq.com  
www.gearinspection.com

The Purdy Corp.  
Page 37  
(860) 649-0000  
www.purdytransmissions.com

Sigma Pool  
Page 4  
(734) 429-7225  
info@lgt.liebherr.com  
www.sigma-pool.com

United Tool Supply  
Inserted Card  
(800) 755-0516  
unitedtool1@aol.com
CUSTOM
BEVEL GEAR MANUFACTURING

Per Your Specifications and/or Sample
Providing Inverse Engineering to Make a Clone of Your Sample

- Spiral Bevel Gears: 66" PD
- Straight Bevel Gears: 80" PD
- Spurs Helicals Spline Shafts
- Gearbox Repair/Rebuilds
- In-House Steel Material Warehouse
- Full Heat Treating Services
- EDM Wire Burning

BREAKDOWN SERVICES

B&R

Machine and Gear Corporation

4809 U.S. Highway 45 Sharon, TN 38255
Toll Free: (800) 238-0651 Ph: (731) 456-2636 Fax: (731) 456-3073
E-mail: inquiry@brgear.com Internet: www.brgear.com

Family owned and operated since 1974
THE CLIFFORD-JACOBS ADVANTAGE:
FAST ESTIMATES. READY RESOURCES.
FREE PART WAREHOUSING.

TODAY'S MACHINERY ALLOWS NO WIGGLE ROOM FOR MEDIOCRITY.
Your custom gears demand the highest quality forging. That's why, at Clifford-Jacobs,
we maintain a standard of excellence that is second to none.

We turn around estimates quickly—routinely within days. Our in-house die shop and
substantial inventory of raw materials can shave weeks off projected delivery time.
Our part warehousing service minimizes overhead costs. And our delivery performance
is consistently one of the best in the custom forging industry. Making us a #1
quality-rated supplier wherever we do business.

We've been forging partnerships of value for nearly 90 years. From energy exploration
to aerospace design, we've had our part in America's progress.

CALL US TODAY TO LEARN MORE – 217-352-5172

P.O. Box 830
Champaign, IL 61824-0830
217.352.5172  fax: 217.352.4629
sales@clifford-jacobs.com

CLIFFORD-JACOBS FORGING