Power Transmission Engineering®

AUGUST 2014

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- **Cut down installation time**
- **Increase reliability and durability of connections**

Features

- Complete connectors are built from components, including bases, inserts, hoods, couplers and covers
- Available in 3A, 6B, 10A, 10B, 16A, 16B, 24B and 32B sizes
- Heavy-duty metal housings in powder-coated die-cast aluminum alloy, or self-extinguishing thermoplastic
- Bulkhead and surface mounting housings with standard or automatic covers
- Single locking system (one lever locked on two pegs) or double locking system (two levers locked on four pegs)
- Silver or Gold crimp contacts
- Operating temperatures from-40°C to 125°C (-40°F to 257°F)
- IP66 degree of protection with enclosure when coupled
- NEMA/UL Type 1, 4, 4X, 12 protection when housings are coupled
- Conforms with EN61984, VDE 0110, VDE 0627, EN 175301-801, and UL 1977, UL50, UL50E standards
- UL and CE approvals

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AUGUST 2014

MDA, IANA and IMTS

FEATURE ARTICLES

TECHNICAL ARTICLES

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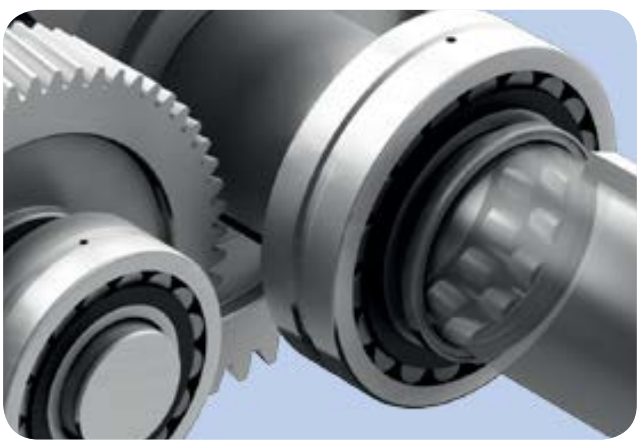
Power Transmission Engineering
VOL. 8, NO. 5

Cover image by David Ropinski

Gear up for higher reliability



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PTE Videos

Matt Frady, product business manager for **Baldor-Dodge Mounted Roller Bearings**, and **Kyle Sobke,** product business manager for Baldor-Dodge Mounted Ball Bearings illustrate some of the technology behind the design of mounted bearings (*www.powertransmission.com*).

www.youtube.com/watch?v=iBupv6Ke-28&list=UUDgYB8vETZ9o2nlGgX6s7Ww

LinkedIn: PMMI, owner and producer of Pack Expo International 2014, has announced that more than 30 leading packaging and processing professional associations from all over the world will be on hand at Pack Expo International 2014 (McCormick Place, Chicago; Nov. 2–5) in the Association Pavilion, on the Grand Concourse at the North Hall entrance. For more information, visit *www.packexpointernational.com*.

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Twitter: Catch up on the latest product and industry news items on the PTE Twitter feed (*https://twitter.com/PowerTransMag*) including information from companies like ETEL, Timken, Kluber Lubrication, Heidenhain, Bosch Rexroth and more.

Ask the Expert: Do you have a question about gears, bearings, motors, clutches, couplings or any other mechanical power transmission or motion control product? Submit your question here to our panel of experts at *www.powertransmission.com/asktheexpert.php*.

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Randall Publications LLC
1840 Jarvis Avenue
Elk Grove Village, IL 60007
Phone: (847) 437-6604
Fax: (847) 437-6618

EDITORIAL
Publisher & Editor-in-Chief
Michael Goldstein
publisher@powertransmission.com

Managing Editor & Associate Publisher
Randy Stott
wrs@powertransmission.com

Senior Editor
Jack McGuinn
jmcguinn@powertransmission.com

Senior Editor
Matthew Jaster
mjaster@powertransmission.com

Editorial Consultant
Paul R. Goldstein

ART
Art Director
David Ropinski
dropinski@powertransmission.com

ADVERTISING
Advertising Sales Manager & Associate Publisher
Dave Friedman
dave@powertransmission.com

China Sales Agent
Eric Wu
Eastco Industry Co., Ltd.
Tel: (86)(21) 52305107
Fax: (86)(21) 52305106
Cell: (86) 13817160576
eric.wu@eastcotec.com

Materials Coordinator
Dorothy Fiandaca
dee@randallpublications.com

CIRCULATION
Circulation Manager
Carol Tratar
subscribe@powertransmission.com

RANDALL PUBLICATIONS STAFF
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Randy Stott, Managing Editor

Why MDA Matters

Most of you probably think you know what IMTS is about—machine tools, cutting tools, and various manufacturing processes. And if you stick to the North, South and West halls, you'll be mostly right. But there's a substantial group of exhibitors in the East building that are dedicated to automation, motion control and mechanical components.

At IMTS 2012, the show organizers introduced the first installment of Industrial Automation North America (IANA), a show-within-a-show that significantly expanded the scope of the overall offerings at IMTS.

This year, that scope has been expanded even further, with the addition of the Motion, Drive and Automation North America show (MDA). Like IANA, MDA is brought to you by the Deutsche Messe Group, the same people who produce the Hannover Fair in Germany.

Because of its strong machine tool focus, IMTS has always attracted a number of exhibitors who sell various mechanical power transmission and motion control components. These manufacturers of ball screws, bearings, machine spindles, linear slides, servomotors and so forth were there mainly to sell to the other exhibitors. After all, the entire machine tool industry comes to IMTS, and machine tools are a prime application for precision motion control components.

But IANA and MDA are beginning to change all that—to attract an audience of their own. MDA adds a specific focus on gears, gear drives, bearings, couplings, brakes, lubricants, fluid power and electric motors—categories that have wide applications in industries far beyond just machine tools.

Don't get me wrong. This show has a long way to go before it rivals Hannover Fair as a show for mechanical components. You won't see a lot of big gearboxes, motors or couplings. In fact, you won't see many exhibitors specializing in large, heavy-duty applications—at least not yet. There is still a decidedly machine tool and automation focus to what's on display here. But the focus has grown enough that many other industries should start to take notice. Designers and developers of packaging machinery, medical equipment, vehicles and factory automation should have plenty of technology to explore.

I expect—and hope—that the visitor profile will also begin to change. In addition to the high volume of dedicated manufacturing professionals that IMTS already attracts, MDA and IANA should begin to attract design engineers, maintenance managers, purchasing professionals and more.

And that's the real reason I think MDA matters. Its addition to the IMTS lineup makes the show more relevant to readers like you.

If you're at the show, we hope you'll come and see us. We'll be at booth #N-7214. Please stop by to renew your subscription or chat with our editors and staff. When you visit the East building, we hope you'll take advantage of the free cell phone and tablet charging station outside the MDA and IANA pavilions. You'll see our name there, along with a QR code you can scan to quickly and easily renew your subscription.

I'll be spending a lot of time walking the aisles at MDA and IANA. If you happen to see me, please stop me to say hello. I'll be very interested in hearing your take on the changing face of IMTS.

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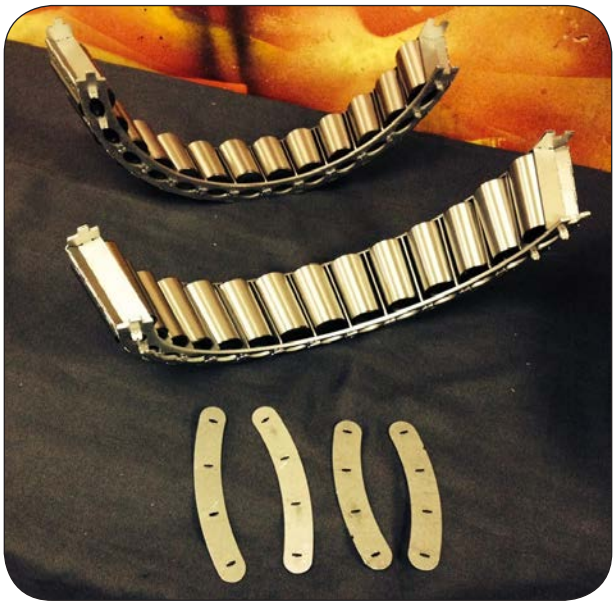
Industrial Origami, Inc. (IOI) has developed a high performance bearing retainer made exclusively from folded sheet metal. Thin sheet metal retainers improve bearing performance and extend bearing life in the most demanding applications. Using proprietary metal forming technology, IOI specializes in producing complex metal parts with precise geometries. Utilizing partnerships with world class bearing engineering teams, IOI has produced high performance retainers from thin sheet metal instead of machined and formed from thick metal plate.

Sheet metal retainers use optimized geometries, including hollow cross sections and multiple roller to retainer contact surfaces, to improve roller positioning and control. Through improved roller control and light weight designs, high performance sheet metal retainers dramatically reduce the forces between the roller and retainer during operation. Reduced forces allow retainers to use up to 50% less material resulting in lower torque and over all bearing weight. These benefits are available in multiple bearing types including tapered, spherical and cylindrical roller bearings.

Reduced material content and retainer forces have the added benefit of reducing the physical space in the bearing occupied by the retainer. The result is the option to add rollers to the same diameter of bearing helping to satisfy the ever increasing demands for load capacity and improved grease distribution. Depending on the application, a sheet metal retainer has the ability to add up to 7% more rollers in the same bearing. At the cost of a traditional bearing, the additional load capacity can approach that of 'pin' type retainer. Custom operation and maintenance features, such as inspection ports, can also be designed into a retainer.



IOI retainers are suitable for low to medium volume applications because sheet metal retainers require minimal tooling and capital investment to produce and to final assemble in the bearing. These innovative retainer designs require no welding or fasteners in assembly and enable qualified service maintenance in the field. Further facilitating final bearing assembly in most applications, the rollers are safely retained during assembly within the IOI retainer.

Sheet metal retainers are designed to be modular allowing any size of bearing retainer to be cost effectively produced with minimal capital investment and virtually no capacity constraints. Reliably scaling and supplying retainers without exponentially affecting cost is critical to meeting the demand for larger diameters and results in no effective limit to the retainer diameter. Additionally, modular designs offer the option to cost effectively use and combine multiple material types in a given retainer (brass, mild and high strength steel, etc).

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Baldor Electric

DELIVERS HT500 BELTS AND EXPANDS MOTOR LINE

Baldor Electric Company's Dodge HT500 synchronous drive system delivers high torque, low maintenance and potential energy savings with less overhung load than V-belts. HT500 belts also offer longer life in wet/oily environments than rubber made products. The companion to HT500 sprockets is the Baldor-Dodge HT500 high torque synchronous belt (8 mm & 14 mm metric pitch). The HT500 belt is made with polyurethane for harsh environment resistance and carbon fiber cords, providing higher torque carrying capacity than commonly known aramid fiber tensile cords made belts. A full line of stock, compact, power-dense Taper-Lock sprockets, fin fan QD sprockets, and Minimum Plain Bore (MPB) sprockets will also be available from stock. Baldor's made-to-order capability includes split-tapered options as well as a variety of tooth count, materials and plating to satisfy the requirements of any application. Baldor's sprockets are made with the modified curvilinear tooth profile for 8 mm and 14 mm pitches.

Additionally, Baldor recently announced a new line of energy efficient electric motors. The Large AC – GPM induction motor is available up to 1,500 hp. Large AC – GPM motors are available in stock ratings of 250 – 1,000 hp, 2300/4000 Volt, Totally Enclosed Fan Cooled (TEFC), foot mounted designs. Custom motors are available in 250 – 1,500 hp, 460, 575, 2300/400 Volt, TEFC, in foot mounted designs. The GPM product line of Large AC motors fits various industrial applications including pumps, fan, conveyors and compressors requiring high torque. Stock GPM motor features include all cast iron construction, drive end slinger, insulated opposite drive end bearing, winding RTDs, space heaters, provisions for bearing RTDs and a ground lug in the conduit box. The entire product line is suitable for use on variable frequency drives.

For more information:
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Miki Pulley

STEP-FLEX COUPLINGS REDUCE BEARING LOAD

Miki Pulley announces the introduction of its Step-Flex Coupling for direct sale to OEM's in North America. The Step-Flex is an altogether new class of shaft coupling. This design was conceived to eliminate resonance in stepper motor ball screw assemblies. The innovative two part elastomer element combination dampens vibration caused by the actuator carrier struggling to find its home position by making small adjustments in rapid sequence. With this construction, the hard (black) element is separated from the aluminum alloy hubs by a softer (green) elastomer. This maintains enough torsional stiffness for precise positional accuracy while still allowing for minimal angular and parallel misalignment, and absorbing vibration. The power-transmitting element, consisting of different hardness layers also achieves a reduction in counter force generated by misalignment. This can greatly reduce the load on the bearing – resulting in reduced heat load. Step-Flex applications include automation of all types where ball screws are used including packaging, semiconductor assembly, laboratory automation and medical equipment.

For more information:
Miki Pulley
Phone: (800) 533-1731
www.mikipulley-us.com

C&U Americas

OFFERS HYBRID CERAMIC BALL BEARINGS

C&U Americas, the North American subsidiary of The C&U Group, offers a wide range of hybrid ceramic ball bearings for electrical machinery and general industry applications. C&U hybrid ceramic ball bearings are engineered to maximize the benefits of precision steel ring construction and lightweight ceramic balls. The bearings are available in a variety of configurations with bores from 17 – 90 mm, ODs from 40 – 190 mm, and speed ratings as high as 21,600 rpm/min.

C&U hybrid ceramic bearings are constructed of steel rings and silicon nitride (Si3N4) balls, which are approximately 40% of the density of steel. This gives the bearings a lower inertia and better high-speed capability than standard bearings. The lower inertia results in less loading on the raceway and provides suitable performance during rapid acceleration and deceleration. The silicon nitride balls also have a lower coefficient of friction so they generate less heat at high speed,

greatly improving the life of the grease and the bearing. As a result, the bearings are less sensitive to temperature changes and high temperature operating conditions that can affect both running accuracy and internal clearance.

The silicon nitride used in C&U hybrid ceramic bearings is much harder than steel, which improves the overall stiffness of the bearings and makes them resistant to damage from contamination. C&U hybrid ceramic bearings are also less susceptible to false brinells. When a stationary bearing is subjected to external vibration, the metal-to-metal contact between the balls and raceways can result in abrasions known as false brinells. The wear particles created by false brinells can contaminate and breakdown the lubricant, causing increased noise and vibration.

These hybrid ceramic bearings are suitable for use in electric motors and generators that are prone to stray electric currents. The bearing design insulates the inner ring and the outer ring of the bearing, effectively preventing the flow of stray currents. This helps to avoid arc-pits and secondary damage that can result in increased noise and vibration, heat generation, lubricant breakdown, and premature failure of the bearing.

They can be used as direct replacements for existing hybrid ceramic bearings as well as conventional bearings in all applications. They are lubricated for life with Mobil Polyrex EM grease and sealed with low-torque, non-contact seals (-2RZ) to ensure optimum efficiency for torque-sensitive applications and adequate protection from contamination. Handling and mounting are identical to steel bearings, so standard installation tools and methods can be used.

C&U Americas offers a full line of bearing types and styles for use in original equipment manufacturing, aftermarket replacement, and MRO operations. The C&U portfolio includes over 30,000 types of bearings in a wide range of specifications and sizes ranging from 1.5 mm ID to 4,000 mm OD.

For more information:
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www.cubearing.com

Romax

ENHANCES PRODUCT PORTFOLIO

Romax Technology is enhancing its product portfolio with the launch of a number of new releases. Currently used by 14 of the world's top 15 car manufacturers, *RomaxDesigner* is Romax Technology's flagship product providing design, analysis and optimization for systems incorporating gears, shafts and bearings.The main enhancement delivered with *RomaxDesigner* 14.6 is customized reporting incorporating a flexible drag-and-drop report builder and the flexibility to create customized extensive reports. Report design templates can be saved and are reusable and sharable. The solution also allows intelligent grouping, filtering and formatting of data. These features will save time and reduce errors during the design process by limiting the amount of further post-processing that users have to do to generate reports.

Simon White, *RomaxDesigner* product manager commented: "This new report generating functionality enables users to get results that are customized to support their internal reporting processes. It means clients can drastically reduce the amount of data manipulation and get the key results they need in minutes not days." This is accompanied by a new ver-

Altra Couplings

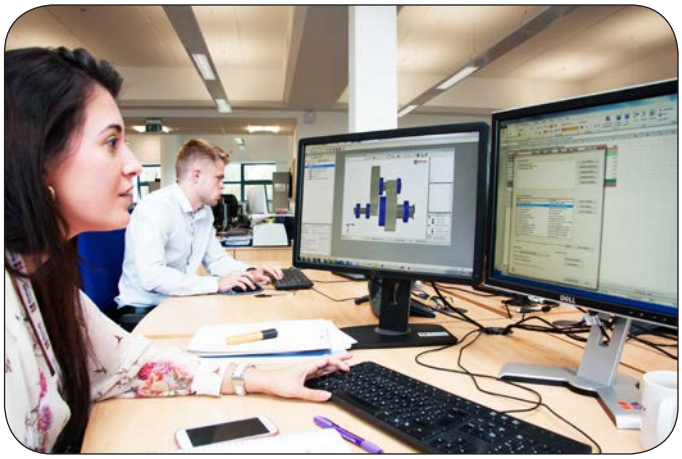
INTRODUCES OLDHAM CLUTCH COUPLING

The Oldham clutch-coupling from Huco Dynatork provides system protection and misalignment compensation in one, compact device. It combines two, time-served Huco Dynatork designs, the first of which is the Oldham coupling that has been an important part of the company's range since the mid-80s.

The Huco Dynatork lateral offset coupling Oldham is precision engineered throughout and comprises two hubs with inward facing tenons. These engage with matching slots spaced at 90° in a central lightweight torque disc. As the coupling rotates, the disc compensates for any parallel shaft offset by sliding the commensurate distance along each tenon in turn.

Quality of motion is a function of the carefully controlled relationship between the tenons and the torque disc. The disc is precision molded from high grade engineering polymers and, being easily replaced at low cost, is the sacrificial element in the drivetrain; radiation and heat resistant torque discs are also available.

If severely overloaded the torque disc will break, acting as a mechanical fuse, thereby protecting associated equipment from damage. A re-



sion of *Concept* (*release R3.0*) which includes improved gear design capability and improved modeling of synchronizers and planetary gear sets. *Concept* offers rapid modelling and analysis of transmissions and drivelines for gear design, system layout design and component sizing and rating.

Romax's *CAD Fusion* (*release R1.1*), which brings seamless integration with CAD tools for improved modelling efficiency, robustness and collaboration is also benefiting from new important features for those who work with 2-D CAD models. The new release of *CAD Fusion* allows intelligent importing of 2-D CAD

placement torque disc quickly restores the drive without the need to dismantle the drive system. The new Huco Dynatork clutch-coupling marries the ability of the Oldham to compensate for angular and radial misalignment with a proven slip clutch mechanism that maintains constant tension with no sudden shocks to damage fragile products. As well as tension control the clutch provides repeatable cushioned torque for protection during overload. Seven sizes complete this new range with bores from 12 mm to 30 mm and torque up to 56 Nm. Fixed torque versions are also available to order.

For more information:
Huco Dynatork
Phone: +(44) 1992 501900
www.huco.com

drawings to reduce modelling time and errors.

These upgrades will further help users of Romax's suite of software tools in supporting a Right First Time product development process, ultimately leading to faster time-to-market and improved product quality.

For more information:
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Heidenhain Corp.

LINEAR ENCODERS ENSURE RELIABILITY AND ACCURACY

For use on machine tools, Heidenhain Corporation's newest absolute LC 185 and LC 485 sealed linear encoders are now available as a complete family. This includes providing options of all the most common encoder interfaces such as EnDat 2.2 with or without incremental signals, Fanuc, DRIVE-CLiQ and Mitsubishi interfaces. The dual sealing lips on the LC 185 provide an extra layer of protection against contamination, and both encoder extrusions ensure high vibration resistance, making them extremely reliable and accurate.

These LC 185/485 encoders improve upon the LC xx3 series, as they now provide suitable replacements for the LC 183/483 sealed linear encoders already in the market. The LC 185/485 series product introduction had opened in 2012 with the safety-related purely-serial EnDat 2.2 (up to 16 MHz) encoder version, and is still an important option today.

As mentioned, the LC 185 features an optimized sealing design with two successive pairs of sealing lips. When compressed air flows into the scale housing, the air flows in between the sealing lips to prevent contamination of the DIADUR graduation which is responsible for the positioning accuracy. The resolution of the LC 185 and the LC 485 is 5 nm with an accuracy grade of 3 µm.

The LC 485 has an improved design which allows existing customers to upgrade their slim-line linear encoders from incremental to absolute without drilling or tapping new mounting holes. The laser etched ID label adds a touch of elegance and a sense of durability that customers have come to expect from Heidenhain sealed linear encoders.

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INDUSTRIAL AUTOMATION NORTH AMERICA and MDA NA @IMTS 2014

By Jack McGuinn, Senior Editor

It's not a show title that rolls off the tongue, but the Industrial Automation North America and MDA NA @IMTS 2014 show nevertheless may well be one to remember.

Following a very successful 2012 launch with record attendance, Industrial Automation North America at IMTS is well on its way to becoming North America's leading trade show for process, factory and building automation. To make it easier for manufacturers to find the best solutions for all of their manufacturing needs, show organizers are also bringing motion control, power transmission and fluid technology under the tent — i.e. — Motion, Drive & Automation North America (MDA NA) @IMTS 2014. The International Manufacturing Technology Show (IMTS) is the largest industrial trade shows North America, boasting more than 1,900 exhibitors and 100,000 visitors. It is held every two years in September at McCormick Place, Chicago. And if the good numbers continue, the two automation shows may become fixtures as well.

WHAT TO KNOW IF YOU GO

(*Editors' Note: The following information was correct and current as we went to press. But — things change — so you may wish to call ahead to confirm certain dates and times.*)

Fact Sheet

Name of Shows: Industrial Automation North America and MDA NA @IMTS 2014

Venue: McCormick Place, Chicago, IL U.S.

Show Dates: September 8 (Mon.) – 13 (Sat.), 2014

Attendee Hours

East & West Buildings: 9:00 a.m. – 5:00 p.m.
North & South Buildings: 10:00 a.m. – 6:00 p.m.

Registration. **On-site** registration **only** is available **Monday, Sept. 8** through **Saturday, Sept. 13**, **8:00 a.m. – 5:00 p.m.**, in all four buildings of McCormick Place.

The Event

Back in 2012, IMTS teamed up with Deutsche Messe AG to co-locate the first-ever Industrial Automation North America show. Industrial Automation North America showcased products and solutions for production automation, complementing the focus of the show on manufacturing technology, metalworking and precision manufacturing. Exhibit space sales *and* attendance exceeded expectations and, as part of the agreement to extend the partnership to IMTS 2014, Industrial Automation North America will occupy additional space. The 2014 introduction of Motion, Drive & Automation North America (MDA NA) further expands the range of technologies and solutions you'll find at IMTS by bringing together the power transmission, motion control and fluid technology sectors. The show list of markets and product categories below is ready proof.

INDUSTRY MARKETS/KEY PRODUCT CATEGORIES

INDUSTRIAL AUTOMATION

- Industrial Automation Systems
- Assembly & Handling Systems, Linear Positioning Systems
- Robotics
- Industrial Image Processing Systems
- Control Systems, PLC, SCADA
- Sensors and Actuators
- Industrial PCs
- Communication, Networks and Field Bus Systems
- Embedded Systems
- Measuring and Test Systems
- Industrial Automatic Data Capturing and Identification Systems
- Laser Technology
- Automation Services
- Industrial Building Automation Systems
- Safety and Security Systems
- Electrical Systems
- Electronic and Opto-Electronic Components
- Electric and Electronic Test and Measuring Equipment
- Lighting Equipment
- Industrial IT & Software
- Operating Systems
- Database Systems, DBMS
- Program Development Systems
- Virtual Reality Systems
- Multimedia Software
- Speech Recognition Software
- Video Conferencing Systems
- Internet & Communication Software
- Manufacturing Execution Systems (MES)
- Product Life Cycle Management Software (PLM), Computer Aided Design (CAD)
- Enterprise Resource Planning Software (ERP)
- Customer Relationship Management Software (CRM)
- Computer Aided Facility Management Systems
- Supply chain & demand chain management systems
- Human Resources Software
- Quality Management Software
- Industrial IT Services & Outsourcing
- Industrial IT & Software, Others
- Microsystems Technology
- Microsystems Components
- Modular Micro-Systems
- Micro Sensors
- Micro Actuators
- Micro & Fiber Optics
- Micro Assembly
- Micro Joining Technology
- Micro Reaction Technology
- Design and Modeling of Micro-Systems
- Micro Engineering
- Rapid Micro Product Development

MOTION, DRIVE & AUTOMATION

- Linear Drives, Gears, Motors & Mechanical Transmission Systems
- Linear Motion Systems
- Gears
- Electronic Motors & Frequency Inverters, Motor Drives
- Chain Transmissions
- Couplings and Brakes
- Fasteners
- Springs
- Bearings
- Floating Bearings
- Rolling Bearings
- Hydraulics & Pneumatics
- Oil Hydraulics
- Pneumatics
- Condition Monitoring and Vibration Reduction
- Sealing Technology & Lubrication
- Seals
- Lubrication Systems
- Lubricants
- Production Equipment
- Equipment for Bearing Production and Machining
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Industrial Automation NORTH AMERICA

MDA NORTH AMERICA

Pre-Show Q & A with

Larry Turner, CEO,

Hannover Fairs USA, Inc.

***Power Transmission Engineering* (PTE): We're asking the question two years late — but what circumstance or set of circumstances led to the decision in 2012 to co-locate with IMTS?**

Larry Turner (LT): There had been discussions between our parent company, Deutsche Messe, and AMT for a number of years. Key executives have been going to our events in Hannover and Worldwide for a number of years so the relationship was there. There was a discussion in 2010 between Deutsche Messe and AMT where both parties came to the same conclusion that co-locating our premier events alongside of IMTS made sense and provided added value for the attendees at IMTS. No one set of circumstances.

PTE: It appeared that the robust attendance at 2012's show almost took many people by surprise; indeed, the 2012 registration reached 100, 200 — the highest show-to-show IMTS increase ever recorded. How much of that do you think can be attributed to the co-location of the Industrial Automation North America show? With the addition this year of the Motion, Drive & Automation show, what kind of attendance do you expect this year — both overall and particularly for your two shows?

LT: While I would like to take credit for the entire 20,000+ increase in attendance in 2012 we only contributed to a part of the increase. The attendance increase from 2010 to 2012 was due in part by our efforts but also pent up demand in the industry. Manufacturing led the way out of the recession and the timing of the 2012 show was perfect. We believe that approximately 25% of the increase was due to Industrial Automation North America based on the number of new titles in the registration system, badge scans by our exhibitors and the overall number of attendees that visited the Lakeside Building.

We have high hopes for this year. I spoke with executives at AMT in early/mid-July and registrations were trending approximately 20% higher than the same time in 2012. We feel there are a number of things that should provide another strong show including the addition of Motion Drive and Automation (MDA) North America, the additional activity AMT and we have put into attendee development, and the strong economy. Our events specifically, we are looking to increase attendance by approximately 20% over the 2012 event for Industrial Automation and MDA North America.

PTE: I'm sure it gets bigger every two years, but how pervasive do you believe social media will be in this year's IMTS — for both exhibitors and attendees?

LT: During the 2012 event social media was very active. IMTS had a social media feed in the hall and the activity was very strong. This year we believe it will be even greater. On our end, we are bringing our social media firm to the show so they can do live streams each day of the event and monitor activity associated directly with MDA and Industrial Automation North America.

PTE: What are the hottest applications today that advances in automation technology have made possible?

LT: In Germany, the term Industry 4.0 is being used where it represents the fourth industrial revolution. In the United States, we use the term Smart Manufacturing or Advanced Manufacturing. The direction is moving towards highly flexible mass production, methods of self-optimization, self-configuration, self-diagnosis of machines and equipment in the manufacturing environment. We are in the early stages of this evolution and Industrial Automation and Motion Drive and Automation exhibitors are key to this transformation in the manufacturing process.

PTE: Are the 3-D printing and additive manufacturing technologies applicable in your industries? If so please briefly explain.

LT: In our show in Hannover these technologies are a part of Hannover Messe, but not in our area of MDA and Industrial Automation North America. These technologies are included in the IMTS exhibit show floor. **PTE**

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MDA, IANA and IMTS 2014

The following exhibitors are suppliers of products or services that may be of interest to readers of *Power Transmission Engineering*. The Booth numbers include a letter indicating the building location (N=North, S=South, E=East, W=West, C=North Building, Hall C).

Alphabetical Company Listings	
COMPANY	**BOOTH**
ABTech Inc.	E-5048
Andantex USA Inc.	E-5146
Aerotech Inc.	N-6442
Aidro Srl	E-4947
Argo - Hytos Inc.	E-5040
AS Aston Seals Spa	E-4953
Assofluid - Italian Fluid Power Association	E-4848
Atlanta Drive Systems, Inc.	N-6046
B&R Industrial Automation	E-4901
Baldor Electric Company	E-5748
Beckhoff Automation LLC	E-4905
Belt Technologies Inc.	E-4958
Berarma Srl	E-4943
Bimba Manufacturing Company	E-5030
Bolenz & Schaefer GmbH	E-4864
Bosch Rexroth Corporation	E-5283
Calmotion LLC	E-5041
Cast Steel Solutions USA LLC	E-4895
Cheng Dai Co., Ltd.	E-4539
Chieftek Precision Co., Ltd. USA	E-4489
Commex Srl	E-4852
Continental Hydraulics, Inc.	E-4850
CPM Spa	E-4945
Delta Products Corporation - Industrial Automation Business Group	E-4972
Delta Products Corporation - Fan and Thermal Management Business Group	E-4972
Desch Canada Ltd.	E-4950
DMM Technology Corp.	E-5050
Dontyne Gears Ltd.	N-6778
Elettrotec Srl	E-4842
Elmo Motion Control, Inc.	E-4971
EMI Solutions Pvt Ltd.	E-4748
EZO SPB-USA, LLC	E-4941
Fagor Automation Corporation	E-5224
Festo Corporation	E-4865, E-4936, C-869
FMC Hydraulic	E-5079
Gear Technology magazine	N-7214
German Group Stand	E-4955
Germany Trade & Invest	E-4955

Alphabetical Company Listings	
COMPANY	**BOOTH**
G H Binroth Co.	E-5068
GMT Global Inc. Changhua Branch	E-5092
GRW High Precision Bearings LP	E-4959
GTEN Ball Screw Technology Co., Ltd.	E-5096
G. W. Schultz Tool, Inc.	W-1163, E-4992
Harbin Bearing Manufacturing Co., Ltd.	E-4894
Hardinge Inc.	S-8738
Harmonic Drive LLC	E-5566
Hawe Hydraulics	E-4930
HPB Motion Control Co., Ltd.	E-4836
ICB Greenline, L.L.C.	E-4963
IC Flow Controls, Inc.	E-5026
igus Inc.	E-5677
Isutami USA Inc.	E-5057
Italian Trade Agency	E-4848
Italnord Flex Srl	E-4844
Jiang Su Krius Machine Tool Accessories Co., Ltd.	E-4995
Jinn Woei-Tsay Co., Ltd.	E-4937
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Leadshine America, Inc.	E-4988
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Lynch Fluid Controls Inc.	E-4932
Mach Motion	E-4992
MecVel Srl	E-4951
Meridian Laboratory	E-5066
Meter Spa	E-4854
MFP Seals, A Division of Martin Fluid Power	E-5052
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Modular Assembly Technology Co., Ltd.	E-4993
Napoleon Engineering Services	E-5803
National Fluid Power Association	C-871
Neugart USA Corp.	E-5085
Nippon Pulse America	E-4885
NSK Americas	E-5157
oelheld U.S., Inc.	N-7475
Omative North America	E-5059

MDA NORTH AMERICA

Industrial Automation NORTH AMERICA

Alphabetical Company Listings	
COMPANY	**BOOTH**
Omlat S.r.l.	E-4846
Omlat USA, LLC	E-4846
Omnitrack Ltd.	E-5083
Oriental Motor USA Corp.	N-6295
Panasonic - Industrial Component Sales	E-5084
Power Transmission Engineering magazine	N-7214
QingDao QianShao Precision Instrument Co., Ltd.	E-4892
Rockwell Automation	E-4979
Rodriguez GmbH	E-4963
Rollon Corporation	E-4606
Schmidt Technology Corporation	E-4956
Schneeberger, Inc.	E-5268
Schunk, Inc.	W-2000
Sekwang Hi-Tech	E-5034
Sercos	E-4865
Sesame Motor Corp.	E-4832
Setco	N-6534
Siemens Industry Inc.	E-5010
SKF USA Inc.	E-5185
Smalley Steel Ring Company	N-6300
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Sommer Automatic, Inc.	E-5038
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Wepon Bearings, Inc.	E-5088
Wittenstein	E-4879
Yaskawa America, Inc.	N-6600
ZF Friedrichshafen AG	E-4868

Listings by Booth Number	
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Sesame Motor Corp.	E-4832
HPB Motion Control Co., Ltd.	E-4836
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Festo Corporation	E-4865
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EZO SPB-USA, LLC	E-4941
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CPM Spa	E-4945
Aidro Srl	E-4947

MDA NORTH AMERICA
Industrial Automation NORTH AMERICA

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Schunk, Inc.	W-2000

Wall to Wall Technology

IMTS 2014 promises the latest products and services in PT and motion control

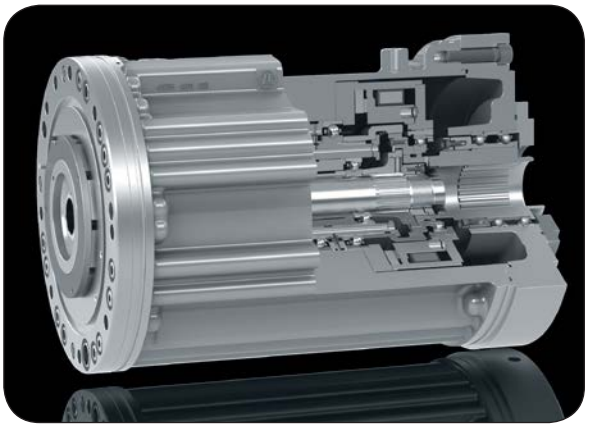
With the addition of Industrial Automation North America (IANA) as well as Motion, Drive & Automation North America(MDA NA), IMTS 2014 has greatly expanded its range of manufacturing technology services. These co-located shows complement the metalworking solutions found at IMTS by bringing in key suppliers from around the world.

MOTION, DRIVE & AUTOMATION NORTH AMERICA

This event will feature technologies and solutions for the power transmission, motion control and fluid technology sectors together. Meet face-to-face with key suppliers from around the world and see first-hand the best new technology available. Here are some highlights:

ZF

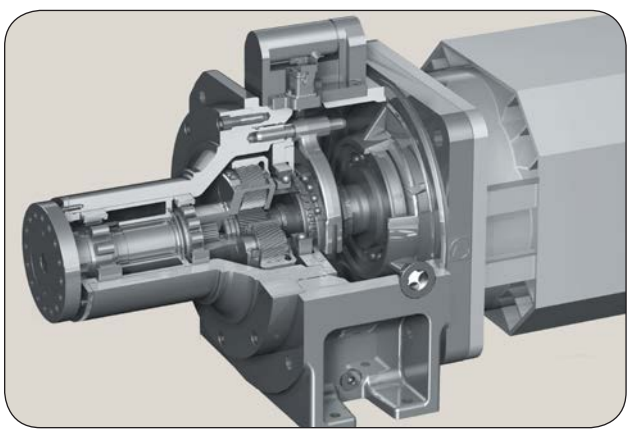
Booth E-4868



ZF has pooled its comprehensive knowhow for the new hollow shaft drives from the Duoplan model range. Consequently, the ZF-Duoplan 2K 150 HS that was already presented in 2012 features a top speed of 18,000 revolutions per minute with up to 24 kilowatt (kW) drives with 600 newton meters (Nm) of nominal output torque. Now, two further versions for higher performance ranges are almost ready for the start of production at ZF: The 2K 280 HS/HWG is predestined for up to 44 Kw or 1,400 Nm and, thus, scores with a maximum of 16,000 revolutions. In addition, there is the 2K 380 HS/HWG that excels with up to 12,500 revolutions with 60 Kw motors or 1,900 Nm engines.

The special features of the ZF hollow shaft drives can be attributed to the innovative design for which there is a patent pending: The extremely compact planetary gear set is only active when it is actually required. In the event of high speeds in direct drive (gear ratio 1:1), it remains decoupled which drastically reduces the rotating masses. The resulting advantages over conventional planet or spur gear drives go far beyond high rotation speeds: They range from the short ramp-up times to the excellent efficiency and the low temperature level of a maximum of 37 degrees to vibration values that always remain below one millimeter per second.

The ZF hollow shaft drives increase the spread between the torque and the speed for machine tools, irrespective of whether they are operated with a DC or AC drive. In doing so, the new Duoplan variants increase the bandwidth of possible applications and consequently improve the workload of each machine. Furthermore, they can be vertically or horizontally docked in a direct manner to highly dynamic spindle motors in a flange design that enable shorter cycle times. For the first time, the ZF two-speed drives are therefore also an option for machines that were previously only suitable for direct drives. A further advantage: The hollow shaft design allows pushrods for release units or even coolants to be passed through the drive. As it is the case with all other products from the Duoplan family, these innovations are also maintenance-free and particularly durable.



The new Duoplan 2K 450 and 2K 600 two-speed manual transmissions now complete ZF's product range as latest innovations. The transmissions that can be delivered as of now are designed for nominal input torques of 450 or 600 Nm and thus complete the 2K series which already covers torques up to 300 and over 800 Nm.

ZF now offers more than ten different transmission variants for several applications and installation positions with the expanded product range. With their help, motors with installation dimensions of 100 to 280 millimeters axle height can be operated; the range of the transferred power is between 19 and 120 Kw, the range of the nominal input torques is between 120 and 1,200 Nm.

For mechanical engineering companies, this extensive range of transmissions offers the advantage to further increase their efficiency and their cost-effectiveness, because an optimally adjusted motor/transmission unit also reduces energy consumption.

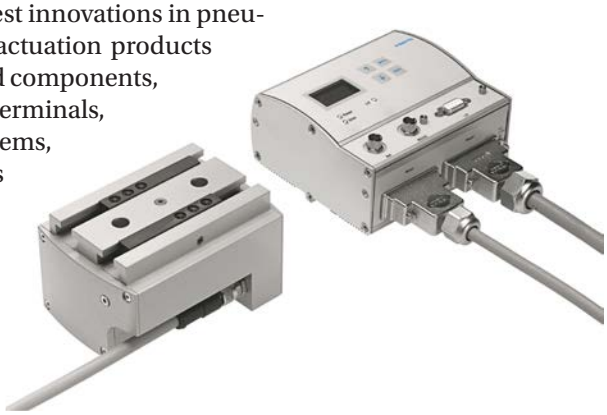
In addition, there are the proven advantages of the shiftable two-speed transmission: If hard materials are to be machined, the ZF Duoplan 2K transmissions transfer high torques at low rotational speeds. If soft materials must be processed, the ZF machine drives supply high speeds in the upper speed range. These and many more innovations will be on-hand as ZF displays its products and technologies at Booth E-4868 in the Motion, Drive and Automation show taking place at IMTS 2014 in Chicago.

For more information:
ZF North America Inc.
Phone: (734) 416-6200
www.zf.com/us

FESTO CORPORATION

Booth E-4865, E-4936, C-869

Festo will be showcasing the HGPLE electric gripper in an end-of-arm-robotic-tooling demonstration at IMTS. The HGPLE electric gripper operates using position control or force control, and can switch between the two modes on the fly. At the show, the HGPLE gripper will pick and place a work piece using force control. Between picks, the electric gripper operates using position control for fast, precise positioning of the gripper fingers. The demo shows how utilizing both force and position speeds up changeover between different sized work pieces. Festo will also be featuring the company's latest innovations in pneumatic and electric motion actuation products including safety systems and components, actuators, valves and valve terminals, drives, air preparation systems, and advanced controllers and architectures.



For more information:
Festo
Phone: (800) 993-3786
www.festo.com

WITTENSTEIN

Booth E-4879

Wittenstein Alpha announced the new SC+, SPC+, TPC+ product family earlier this year as a new development to offer performance in low ratio right angle applications. As line speed requirements continue to increase, the ability to run lower ratios to achieve higher output speeds becomes crucial. The SC+ uses a high-speed bevel design with reduced output friction to achieve speed increases of up to 30 percent for enhanced throughput. Using the 2:1 ratio offers designers increased output speed while maintaining inertia reduction.

Using new materials, innovative gearing designs, and improved lubrication, the SC+, SPC+, and TPC+ are the coolest on the market, leading to longer lifetime and increased speed to achieve maximum machine performance. This product family offers an improved synchronous running accuracy, delivering the highest results in printing and imaging systems. Enhanced drivetrain accuracy delivers the best resolution for

vision scanning and 3-D imaging systems.

The SC+, SPC+, and TPC+ gearbox family is based on a newly designed right angle spiral bevel gear set. The family is intended to be a modular set to provide different ratios and output configurations: The SC+ contains the spiral gear set in a single stage design with output shaft configuration, and is available in 1:1 and 2:1 ratios. The SPC+ contains the spiral bevel gear set, but is also equipped with an SP+ shaft style planetary output stage, providing ratios to 20:1. The TPC+ contains the spiral bevel gear set, but it also equipped with a TP+ flange style planetary output stage, providing ratios to 20:1.

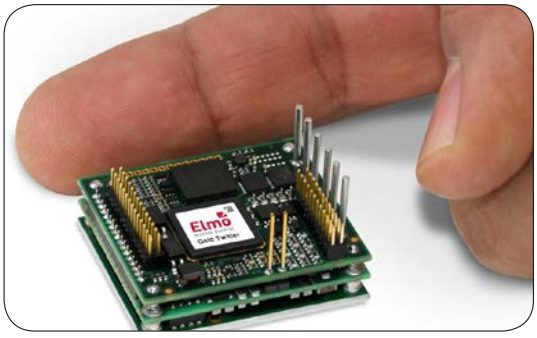
For more information:
Wittenstein
Phone: (630) 540-5341
www.wittenstein-us.com

INDUSTRIAL AUTOMATION NORTH AMERICA

IANA made its North American debut in 2012 co-located with IMTS. Featuring factory, process, and building automation, this event is distinguishing itself as the place to see the automation industry's most innovative solutions and technologies. Here are some highlights:

ELMO MOTION CONTROL

Booth E-4971



Elmo Motion Control, a leading provider of advanced and cost-effective motion control solutions, will exhibit its flagship Gold Twitter, the smallest, high-power servo drive on the market today at Industrial Automation North America (IANA) at IMTS.

Weighing at just 18 grams (less than 1 ounce), and less than 13 cm3 in volume, the Gold Twitter delivers up to 4,000W of qualitative power, ultra high current of 50A/100V with advanced servo capabilities and support for EtherCAT and CANopen fieldbus communication standards for deployment in any industrial application. Gold Twitter is compliant with international safety and EMC standards.

The Gold Twitter is an excellent solution for applications that require ex-

tremely high servo performance but are limited in space. In addition, the Gold Twitter is mountable, thus ensuring high servo performance and savings in hardware and cabling.

Based on the premise that "the best way to dissipate heat is not to generate it in the first place," the Gold Twitter incorporates Elmo's proprietary FASST (Fast and Soft Switching Technology) resulting in >99% efficiency with negligible EMI.

"I'm proud of Elmo's ingenuity and innovation. I am not aware of any servo drive in the industry that approaches the Gold Twitter's power and size density," said John McLaughlin, manager of Elmo USA.

Elmo will also be debuting at IMTS, the superb Gold Drum HV, a compact high voltage servo drive that delivers up to 65,000 W of continuous power and runs optimally on any servo motor, supporting "any feedback" sensor in single, dual and gantry loop configurations.

Easily set up and tuned using Elmo Application Studio II (EASII) software, the Gold Twitter, Gold Drum HV, and Elmo's product line of Gold servo drivers operate as a single or multi-axis control solution in a distributed configuration real-time network.

Elmo recently released its free advanced online EASII Experience RPS system providing users with the ability to build and practice advance servo control, multi-axis solutions and EtherCAT networking. It allows building up a complete application online with no need to purchase or install any hardware or operating system.

For more information:
Elmo Motion Control Ltd.
Phone: (603) 821-9979
www.elmomc.com

B&R INDUSTRIAL AUTOMATION

Booth E-4901

With the X20c series, B&R is setting new standards for protection against harsh environmental conditions. The "coated" variants of the compact controller and I/O modules are protected against condensation and corrosive gases by a special coating on the electronics module. This makes these modules suitable for use in corrosive environmental conditions.

The coating on the electronics module protects the components and circuit board from the effects of condensation and corrosive gases. The effectiveness of protection against condensation is checked using the test specified in BMW GS 95011-4, and protection against corrosive gases using the 4-part corrosive gas tests specified in EN 60068-2-6, test method 4. The tests are carried out in a fully accredited in-house testing laboratory and in certified external testing facilities. B&R places even higher demands on the modules than what is specified in the standards and also subjects equipment to additional, more stringent testing.

At sea and in icy temperatures

The X20 modules with coated circuit boards are completely compatible with existing models with respect to functionality. Their introduction represents the third time that B&R has extended the range of applications in which the X20 system can be used. The operating temperature range for all X20 modules was recently expanded to -25°C to +60°C. The X20 System has also received certification for maritime applications from Germanischer Lloyd (GL), which is particularly demanding. To discuss these and other B&R products, visit Booth E-4901 during the Industrial Automation North America (IANA) show at IMTS.

For more information:

B&R Automation
Phone: (770) 772-0400
www.br-automation.com

BECKHOFF AUTOMATION

Booth E-4905

To substantially boost the performance of multi-touch industrial displays via an all-in-one HMI and automation device, Beckhoff Automation has released the new CP22xx Panel PC series. Designed for cabinet installation, the CP22xx series combines the advantages of a modern multi-touch interface with high-performance multi-core processors for automation and control applications. With the company's extensive range of Control Panels and Panel PCs, along with TwinCAT automation software, Beckhoff offers the ideal portfolio to efficiently solve all PLC, motion and HMI tasks in a machine or factory. Equipped with powerful multi-core CPUs – Intel Celeron, Core i3, i5 (all with 2 cores) or i7 (4 cores) of the 3rd and 4th generation – the CP22xx Panel PCs achieve maximum computing power for the most demanding industrial applications. Adding to the flexibility of the CP22xx series is a range of available screen sizes from 12- to 24-inch, so the most challenging control and HMI tasks can be solved while precisely matching the devices to application-specific requirements. Widescreen display orientations in landscape and portrait formats are also available, adding even more variety to the product lineup.

The CP22xx features a free Mini-PCI slot for factory-installed cards, 2 GB DDR3-RAM (extendable to 16 GB), a hard disk, a CFast card or SSD, an on-board dual Ethernet adapter with 10/100/1000Base-T connection and an on-board SATA RAID-1 controller (Intel® Rapid Storage Technology). The equipment also includes a serial RS232 interface and four USB 2.0 ports as well as up to four further optional Ethernet ports.

The new generation of Beckhoff Panel PCs for control cabinets and control consoles offers a scalable range of active and passive panels providing a uniform, high quality appearance on the machine and in the plant. Multi-finger touchscreens (PCT) are available in display sizes from 7- to 24-inch, in 16:9 (widescreen), 5:4 and 4:3 formats and in landscape and portrait mode. In addition to the CP22xx series, the product family encompasses a highly scalable selection featuring various display sizes and Panel PCs in different performance classes to match any application:

- CP26xx: compact Panel PC series with ARM Cortex A8, 1 GHz
- CP27xx (available soon): fanless Panel PC series with Intel Celeron ULV 827E, 1.4 GHz
- CP29xx-0000: Control Panel with DVI/USB extended interface (up to 50 m distance from the PC)
- CP29xx-0010 (available soon): Control Panel with CP-Link 4 via standard CAT-7 cable (up to 100 m distance from the PC)

For applications that require mounting arm installation, the Beckhoff CP3xxx series is also available with all-round IP 65 protection, offering a similarly extensive range of multi-touch Panels and Panel PCs.

For more information:

Beckhoff Automation
Phone: (952) 890-0000
www.beckhoffautomation.com

IMTS

The following booths will be of interest to *Power Transmission Engineering* readers that are not part of the MDA or IANA co-located programs:

ETEL

Booth N-6436

ETEL will exhibit its full range of torque motors at this year's IMTS 2014 show in Chicago's McCormick Place (September 8-13). Offering four series of direct drive ironcore torque motors, ETEL boasts one of the most comprehensive ranges of such motors in the industry and will be exhibiting at Booth #N-6436 in McCormick's North Hall.

Useful in many machine tool applications such as machining centers, milling/turning machines, rotary tables/milling heads, and multi-spindle and transfer machines, ETEL's patented motor designs can be found in over 20 countries. Within ETEL's TMK, TMB, TML and TMM series there are more than 100 models to choose from, allowing almost any relevant requirement to be successfully met.

All ETEL motors benefit from ETEL's patented anti-cogging design along with a compact coil construction enabling an exceptional peak force density in the magnetic gap with minimum torque ripple.

Of the series, ETEL's TMB torque motors are one of the most popular torque motors in its range, with a cage for water cooling. TMK motors are a unique type of very high speed torque motors for the most demanding applications. The TML and TMM are cageless variants of the famous TMB design. These variants are well suited when no water cooling is requested.

ETEL takes pride in their policy of full disclosure about their motor performances. It is standard for all data sheets to list its specifications at its highest operating temperature so that no special design is required to reach them, ensuring the user is able to utilize every bit of power that the motor is able to achieve.

For more information:
ETEL S.A
Phone: (800) 233-0388
www.heidenhain.com

FIXTUREWORKS

Booth W-1686

Fixtureworks, a supplier of workholding and machine tool components, fixturing accessories and material handling products will showcase its extensive product lineup during IMTS 2014, Featured in the exhibit will be Fairlane Products full line of fixturing accessories including grippers, rest pads, Swivots swivel/pivoting positioning components, Quick Release ball-lock pins, rollers and bumpers. Included in the Fairlane Products lineup are the new Urethane Covered Bearing Rollers. These covered bearings have a smooth urethane surface that is cast directly to a precision sealed ball bearing. They provide smooth, quiet and non-marring operation with excellent abrasion resistance and durability. They are available with hardness ranging from 35 to 95 durometer in 1'to 3' diameters.

The exhibit will also feature the company's full lineup of manual clamps from Imao, OK-Vise and Mitee-Bite. Clamps that provide quick and secure fastening for repetitive machining operations and are suitable for easy load/unload of workpieces. The clamps come in a variety of sizes from heavy-duty to mini, clamping-force options from as little as 2 to over 2,200 lb. and configurations that include swing, pull, snap, hook, toe and side.

In addition, also on exhibit will be Kipp spring plungers, rest and riser pads, levers, handles, knobs, and hand wheels; Imao supports and stops, risers, T-nuts, sliding mounts, springs, supports, grid plates and blocks; OK-Vise single and double wedge clamp designs; Mitee-Bite low-profile edge clamps; and Modern Industries mPower product line which includes quick change precision locating and mounting systems and modular tooling, plates and columns.

For more information:

FixtureWorks
Phone: (888) 794-8687
www.fixtureworks.net

SKF

Booth E-5185

The SKF Separator Filter Dryer (SFD) system introduces an ideal solution for removing water, contaminants, and oil vapor from compressed air and help realize improved pneumatic equipment performance, reduced need for maintenance, increased uptime, and higher productivity. The compact unit is engineered to dry compressed air for pneumatic applications directly from a compressor's reservoir tank or at a point of use, eliminating the need for most external filters.

This innovative technology can be applied to serve pneumatic applications in a wide range of industries; including cement and concrete, aggregates and mining, food and beverage processing, and others where an uninterrupted supply of clean, dry compressed air is critical.

The three-in-one SFD system incorporates a dual-cartridge design, which channels air flow through one desiccant cartridge, while regeneration occurs in the other. Standard units operate between 100-180 psi and will accommodate flow rates ranging from 20 to 800 CFM. The system can serve in high or low ambient temperatures and performs without the use of a refrigerant, a condensate
drain line, or a heat exchanger to clean and maintain.

The SFD system is offered in three models: Micro Logic Timer (MLT), Programmable Logic Control (PLC), and Pneumatically Controlled (PC). All install easily on a wall or directly to a compressor's top plate for plugging into standard 120 VAC. Units can be serviced without disassembling or removing them from their mounting position. Custom solutions can be developed and tailored to specific application requests.

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BOSCH REXROTH

Booth E-5283

Intelligent and scalable CNC controls combined with, high-performance electric and hydraulic drive technologies by Bosch Rexroth improve the productivity and precision of machines — across all cutting and forming applications. Rexroth offers proven technology; industry-specific control functions; and more user-friendly, open programming tools that help optimize machining time and improve operational flexibility and precision production. At IMTS, Bosch Rexroth will exhibit several notable products and systems designed to boost energy efficiency, improve controls programming, and integrate safety into machinery. A special machining demonstration will show how Rexroth's award-winning Open Core Engineering system offers greater freedom and flexibility for automation programmers. Other products in the booth include Rexroth's IndraMotion MTX CNC, a new IMS-I Integrated Measuring System and the Sytronix Variable-Speed Pump Drives for Machine Tools.

For more information:
Bosch Rexroth
Phone: (800) 739-7684
www.boschrexroth.com

DONTYNE GEARS

Booth N-6778

Dontyne Gears is a newly formed company set up to help in the development of gear systems. DG naturally uses the versatility of Dontyne Systems software to optimize design for production and performance, but also has access to the highest level of small and large volume machining equipment to produce such components. These components can be inspected on high quality gear inspection equipment and tested in test rigs ranging up to 160 mm centers. Proximity and collaborative links to Design Unit and Offshore Renewable Energy Catapult (formerly NaREC) in the North East of England ensure a solid knowledge base for R&D projects of the highest caliber and the possibility of larger scale development programs. DG will help define and implement a test program for standard gearing and custom gear forms. The company will also consider collaborations with machine tool manufacturers and tooling companies in the development of equipment and processes using various production methods and materials. IMTS is a chance to get to know the personnel and discuss potential collaboration.

For more information:
Dontyne Gears
namerica@dontynesystems.com
www.dontynesystems.com

No Time to Kill for Barge Operation

Nugent Sand Eliminates Downtime with Force Control Oil Shear Brakes

The scene is serene and picturesque. Sunshine reflects off the light chop of the Ohio River, as a barge winds its way into view. While those driving along Louisville's River Road may be inclined to reach for a camera to capture this idyllic scene, the mood at Nugent Sand Company is anything but tranquil. Workers here have a goal to send the deck barge – emptied of its contents – along its way quickly so they can be ready for the next arrival which will be along shortly. There is no downtime for either men or machine. That is why the facility switched from traditional dry friction brakes to MagnaShear Oil Shear Brakes from Force Control Industries.

Photos courtesy of Force Control

All day long, deck barges loaded with 1,100-1,200 tons of aggregate arrive at Nugent Sand Company's Louisville facility. When the barge approaches the unloading zone, lines from a WW Patterson winch are attached fore and aft. Powered by a 7½ hp Baldor motor, each line is tightened or loosened to "jog" the barge into place – and position the vessel within reach of the dockside excavator's 5-yard clamshell bucket. To keep the excavator arm swing to a minimum (and thus speeding the process), each motor and brake is subjected to numerous start/stop cycles for each barge unloaded. However, the motor is only as good as the brakes that stop it – and friction pads on their dry friction brakes were failing all too often - every six weeks or so.

When that occurred, crew members had to replace the pad – a process which required at least an hour and cost $300 in parts each time. In addition to the raw cost of repair parts, a towboat was launched to replace the winch operation with an alternate means of "jogging" the barge into position. Although the time required to position the barges with the boat is comparable to positioning with the winch, the cost is much greater. "When we have a boat in the water we have an hourly fuel burn of about $30/hour" said Engineering Director Damon Hughes, "plus maintenance and shipside repairs. The operating cost of the dry brake is just too high."

Additionally, there are other "soft production deficiencies" when using a towboat rather than the winches. Ideally, the towboat will move other barges into position so that when the vessel currently being unloaded is emptied it can be efficiently sent downstream and replaced with anther full barge. However, devoting all of their time to the barge being unloaded prevents the crew from pre-positioning other barges which slows the process in general. Also, the pilot and deckhand are prevented from doing any of their normal maintenance and cleaning when they are engaged in constantly repositioning the barge being unloaded.

In an industry with razor sharp margins any unintended cost or cost increase can mean the difference between black ink and red. So Hughes began researching alternatives. Luckily, the solution was right under their nose – literally. About six years ago, when seeking an alternative to high brake failures and maintenance requirements, they replaced a Stearns dry friction brake on one of the Baldor motors with a MagnaShear MSB6. "We've had that brake for years, and have not had to do anything to it," recalls Hughes. "Other than changing the oil annually, there are no adjustments, no repairs and the operating costs are dramatically lower."

How Oil Shear Technology Works

Normal dry brakes employ a sacrificial surface – a disc or pad – to engage the load. Having no good way to remove the heat caused from engagement between the disk and plate, this material

must absorb the heat. These extremely high temperatures will eventually degrade the friction material. As the friction surface wears away and begins to glaze it causes the ensuing torque fade – and ultimately in pad failure. Oil-shear technology plays a major role in ensuring that the oil shear brakes at Nugent Sand Company can operate continuously. The MagnaShear MSB6 brake consists of a multiple stack of friction discs and drive plates of a size and number needed to produce the required torque and absorb the energy. Transmission fluid is pumped through the inner hub pushing the fluid through the friction stack and back into the housing. As the plates and discs are compressed together the fluid film is put in a state of shear and will transmit torque between the two parts. The torque transmitted is directly related to the pressure applied to squeeze the stack together.

In addition to transmitting torque, much of the heat generated is developed within the fluid in shear which is removed from the stack and replaced by cooled fluid. This keeps the friction surfaces cooled eliminating fade and severe friction material degradation due to excessive heat.

Along with torque transmission and heat removal, the fluid also serves to continually lubricate all components such as bearings and splines – thus extending their service life. With elimination of wear comes elimination of repair and rebuild, allowing MagnaShear brakes to operate for years before any repair or parts replacement is required. This means increased "uptime" and availability for barge spotting for Nugent's Louisville facility – while driving operating costs down since.

Eliminating the $330 out of pocket costs (for repair parts and fuel burn for the positioning vessel) every six weeks means that the MagnaShear Oil Shear Brake pays for itself in less than a year. Further, stocking brake pads is a thing of the past, so less cash is tied up in parts inventory. As important to the team at Nugent, is the reliability of the Oil Shear Brakes. "We never have to worry about the Force Control Brakes" said Hughes. That allows him and his crew to focus on getting the present barge unloaded in a timely fashion in order to make room for another one. **PTE**

For more information:
Force Control Industries
Phone: (800) 829-3244
www.forcecontrol.com

Critical Factors for Proper Product Selection and Sizing

By Greg Cober, Altra Industrial Motion Product Training Manager

"Well begun is half done," a quote that most reference materials attribute to Aristotle, certainly applies when selecting mechanical power transmission products. A selection process that is well thought out at the start can ensure that the product selected will be properly sized and appropriate to the application at hand.

Different manufacturers have different names for them: service factor, safety factor, overload factor, load factor, etc. They all do basically the same thing: they factor or adjust for the hours of usage and the nature of irregularity, shock or vibration in the application. For our purposes, we will use the term "service factor," as that seems to be most common across the widest range of power transmission product types.

Table 1: Service Factors for Gearing (Source: Boston Gear)

Service Factor	Operating Conditions
.8	Uniform — not more than 15 minutes in 2 hours.
1.0	Moderate Shock — not more than 15 minutes in 2 hours. Uniform — not more than 10 hours per day.
1.25	Moderate Shock — not more than 10 hours per day. Uniform — more than 10 hours per day.
1.50	Heavy Shock — not more than 15 minutes in 2 hours. Moderate Shock — more than 10 hours per day.
1.75	Heavy Shock — not more than 10 hours per day.
2.0	Heavy Shock — more than 10 hours per day.

Heavy shock loads and/or severe wear conditions may require the use of higher service factors. Consultation with factory is recommended in these applications.

Service factors are used as a multiplier applied to the product's horsepower or torque rating. For example, a 1 hp motor used in an application with a 1.5 service factor will be seen as having a design hp or 1.5 hp for selection purposes.

Use of the proper service factor for an application ensures that the product selected will provide the desired life in the application as well as tolerate the levels of shock or vibration that are

Table 2: Service Factors for Overrunning & Backstopping Clutches

Formsprag and Stieber Overrunning Clutches Clutches are suitable for many different power transmission applications. Please refer to this table for the proper service factor for your application. Typical prime movers are listed at the left, types of loads across the top, and your service factor opposite the typical prime movers. When torsional or linear vibration is present, use an FSO series clutch and increase the service factor at least 50%. For severe vibration, a greater service factor increase is necessary. To conform with couplings manufacturer's recommendations, use a minimum service factor of 1.5 on all Clutch Couplings.		**Overrunning & Backstopping Applications Service Factors** **Driven Equipment Load Classifications**			
		Light Steady Loads Starting torque is equal to or slightly greater than running torque.	**Moderate Loads** High starting torque or above average running torque.	**Medium Loads** Starting torque is approximately double running torque.	**Heavy-Duty Loads** High starting torque, shock loading, light torque reversals during drive.
					
		Centrifugal pumps, uniformly loaded conveyors, light-duty fans and flowers, liquid mixers and agitators, centrifugal compressors, lobe and vane type flowers, gear pumps, textile machinery, woodworking machinery.	Hot oil pumps, heavy-duty centrifugal pumps, cooling towers, slurry agitators, boiler feed pumps, hoists, conveyors	Dredge pumps, dynamometer drives, light-duty hammermills, lineshafts, paper-converting machinery, rotary kilns, rotary or screw-type pumps for high viscosity fluids.	Mine ventilating fans, reciprocating pumps or compressors, papermaking machinery, heavy-duty hammermills, ore crushers, pulverizing mills.
Prime Mover	Steam, gas or air turbine	1.00	1.50	1.50	2.50
	AC electric motor	1.25	1.50	1.50	2.50
	DC electric motor with DOL start AC electric motor	1.25	1.50	1.75	3.00
	Gasoline, natural gas, propane or other spark ignition engine	3.0	3.0	Consult Formsprag	Consult Formsprag
	Diesel	Consult Formsprag	Consult Formsprag	Consult Formsprag	Consult Formsprag

DOL = Direct on Line; Source: Formsprag Clutch; Stieber Clutch

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Greg Cober is product training manager for Altra Industrial Motion, a producer of a wide range of electromechanical power transmission products.

anticipated in the application. A few examples will illustrate this point.

The service factors for open gears such as spur gears, helical gears or worm gears will typically be provided by the manufacturer as shown in Table 1.

Looking at Table 1, we can see that the service factors for gear sizing address two key variables: the number of hours per day the product will be used, and the variability of shock and vibration there is in the application. For example, a liquid mixing tank motor that has a slow acceleration to full speed and very low variation in load would be considered a uniform load application. However, a stamping press or die cutter drive could easily be considered a heavy shock load application. These factors must be considered when selecting gears, since each situation will apply different levels of stress and wear on the required gearing.

Some products, such as overrunning clutches, will require consideration of not just the nature of the load but the type of prime mover as well. As can be seen in Table 2, there can be an additive nature of an irregular load combined with the prime mover that will generate spikes as well. A basic AC motor will provide a much smoother output to an application than a diesel engine might, and these differences can have a significant impact on the clutch's performance.

Products such as V-belt drives will require a combination of all three factors: variability of the application load, the hours of service and the output nature of the prime movers. Other belt considerations include factors for the use of such devices as idler pulleys and how they are mounted.

When considering service factors, it is important to think about not just how a product might be used in the immediate future but further ahead as well. Note again in Table 1 that there is one factor for a uniform load at 10 hours or less per day and another that is 25% higher for more than 10 hours per day. Market demand may require that the system run only one shift now, but in the future that might change to require a two- or even three-shift operation. The gearing unit that provides perfectly acceptable life in one instance may become a maintenance headache in a higher usage situation. Worse, upsizing may require more than just a change in one component.

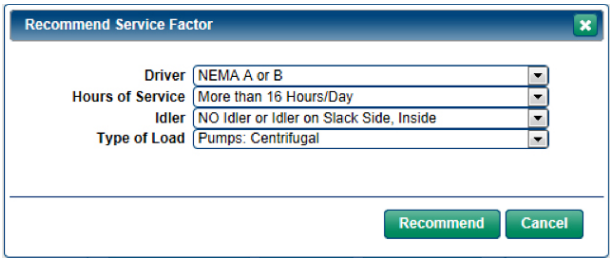
For example, a worm gearbox selected for 1 hp 20:1 ratio for single-shift operation may be a 1.8 in. center distance, but to provide proper life for a two-shift operation, that same 1 hp application would require a 2.1 in. center distance gearbox. The height to the output shaft would change from 2.06 in. to 2.28 in. with the requirement that bearings, shaft alignment and other drivetrain components change as well. The difference between the cost of the initial smaller gearbox and the cost of the larger unit may be approximately $150, but selecting the properly sized gearbox for how the system is going to be used in the future can avoid very significant machine redesign later.

So far we have discussed how service factors can result in upsizing products. When we consider linear products, such as ball screws or linear actuators, load factoring can decrease the impact of the load. Vertical load is always comprised of the weight of the load plus any force applied by the process. But when linear movement is horizontal, the load is likely supported by rails or by linear bearings of some type. Depending upon the coefficient of friction of the support, the load being moved can decrease by a very sizable amount, as shown in Table 3.

Table 3: Coefficient of Sliding Friction for Non-Vertical Loading Applications (Source: Rockford Ball Screw)

Steel on Steel	~.58
Steel on Steel (greased)	~.15
Aluminum on Steel	~.45
Gibb Ways	~.50
Dove Tail Slides	~.20
Linear Bearing (Ball Bushings)	<.001

Industrial component manufacturers have become more sophisticated in providing downloadable or online selection tool software. These include an automatic calculator that will incorporate appropriate service factors for your application parameters, as shown in the online belt drive selection tool screen. Whether they are called service factors, safety factors or some other term, it is important to follow manufacturers' guidance when selecting a power transmission product. Use of proper service factors will ensure selection of correctly-sized product that will provide optimal unit life and performance. Consideration of the entire application for both today's need and next year's can ensure performance now and then. Lastly, manufacturers' tools can help simplify the selection process. Nearly all manufacturers gladly provide application assistance resources to help you make smart, cost-effective choices. **PTE**



Online Belt Drive Selection Tool Screen (Source: *TBWoods.com*)

Choosing the Right Grade: Specifying Stainless Bearing Steel

THE QUESTION

I've determined that a stainless steel bearing is the best option for my application. I'm being asked to specify the grade of stainless steel in my product design. I'm not sure which grade to select and specify. Can you help?

Expert Response Provided by Mark Bos, Director of Business Development, National Bearings Company

Custom bearings are often made from stainless steel, especially in applications where corrosion-resistance, non-magnetic properties or frequent sterilization are needed. Many grades of stainless steel are available, and it is important to select the grade that best meets the requirements of the application.

Most standard bearings are made from 52100 alloy bearing steel. This is a chromium steel that can be heat-treated and ground to achieve high load capacity and durability in bearings. 440C stainless steel is the most suitable grade when an application must meet the full load capacity of a standard bearing. It has higher levels of carbon than other grades of stainless steel, in order to achieve the hardness and strength of 52100. The higher level of carbon also means that this steel, while corrosion-resistant, can rust. Passivation can help eliminate this rusting.

300 series stainless steels cannot be heat-treated but have very high corrosion-resistance properties. These stainless steels are also non-magnetic and non-hardenable. Bearings that have lighter load requirements, such as thrust retainers or window roller bearings, are commonly made from this type of stainless. Typically, a bearing made from 300 series stainless steel has about half the capacity of a standard bearing.

For applications that require moderate load carrying capability and high corrosion-resistance, precipitation hardenable stainless steels are an option. Grades such as 17-4 or 17-7 are specialty grades that can achieve strength greater than 300 series stainless, without the carbon content of the 400 series grades.

Many more grades of stainless can be used in bearing manufacturing in order to customize a bearing to precisely meet the requirements of an application. When designing a custom bearing made from stainless, it is not uncommon to use more than one type of stainless steel. The bearing races and balls may be made from 440C, while the ball cages and bearing shields may be made from 302 grade stainless steel.

In conclusion, while designing for the environmental conditions that the bearing may encounter in application, it is important to consider the loads that the bearings will need to carry. The heavier the load is, the more likely that a hardenable stainless steel will need to be selected.

One note of caution: it is very important to match the material and hardness of both the bearing races and balls or needles. The harder component will wear into the other, causing premature failure. **PTE**

Stainless Steel Bearings - What Grade Works Best?

52100	400 Series	300 Series	17-4 | 17-7
Chromium Steel. Can be heat-treated, ground to achieve high load capacity, and highly durable.	Most suitable grade to meet full load capacity of a standard bearing. Higher levels of carbon and corrosion-resistant but can rust. Passivation can help eliminate rust.	Can not be heat-treated but has a very high corrosion resistance. Non-magnetic and non-hardenable. For lighter loads - about half the capacity of a standard bearing.	Precipitation hardenable stainless steels. Moderate load carrying capabilities and highly corrosion-resistant. Strengths greater than 300 series without the carbon of 400 series.

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Mark Bos is a manufacturing professional with extensive experience in custom bearing and assembly design and manufacturing. In his current position with National Bearings, Bos serves as VP of Business Development, and is actively involved in product development, engineering, marketing and sales management. Bos has specialized in bearings and bearing component design and manufacturing for the past 17 years.

Net-Forged Bevel and Transmission Gears: Applications For Both

THE QUESTION

I am researching gear applications. Examples:
•Net-forged bevel gears: Where are they used outside of differentials?
•Transmission gears: What applications would use a similar gear?
Any help on this would be appreciated.

Reader question answered by Chuck Schultz, *Gear Technology* Blogger (geartechnology.com) and Technical Editor:

Net-forged bevel gears have been around for over 100 years, but have enjoyed renewed interest in the last 20 years as tooling methods have improved for both quality level and tool life.

The advent of front-wheel drive cars has greatly reduced the volume of bevel gears needed. Powder metal technology has improved to take over many smaller bevels that were previously cut. Overall bevel gear use is down; the only "new" application in recent years has been the adoption of the "snuggler-type" gear motor for conveyor and packaging applications. Bevel gear designs do not have the power density available with ground helical gears and require more complex mountings to perform properly.

Auto and truck production volumes dwarf all other industrial activities. The annual need for over 20 million transmissions and axle assemblies around the world has resulted in wonderfully efficient equipment and processes. These methods don't transfer well to lower-volume applications, however. As a result, OEM transmission gears tend to be produced on dedicated, continuous process lines, while similar-sized, but lower-volume, parts get a less-capital-intensive batch processing. **PTE**

Charles D. Schultz is chief engineer and operator of Beyta Gear Service in Winfield, Illinois (*www.beytagear.com*.)

DUDE! — WHERE'S MY PRELOAD?

Norm Parker

Introduction

Many of us have been there; the bearings *had* the correct preload. You know it, you were there, and you personally saw the measurements. Now, the testing is done and the preload is gone. Not a little gone, not sort of gone — *gone*, gone. Finger pointing ensues. Suppliers are dragged in by their wrinkly Polo collars. You know the drill. Losing preload in a tapered roller bearing (TRB) system over the life of your application can be a troublesome problem, particularly for gear sets that are prone to noise or severe applications that rely on a very rigid and stable system.

Two items that are often confused is the drop-in initial running torque vs. true loss of preload. Both will occur in your application, but it is important to understand the differences. Before we get too far into the details, we will review exactly where the drop-in torque and loss of preload originate.

Unlike ball bearings, there is a true sliding surface in a TRB between the bottom of the roller and the large rib. This interface (Photo 1) is also responsible for maintaining preload by physically supporting the roller position. We will learn exactly how to analyze and quantify this in a later section.

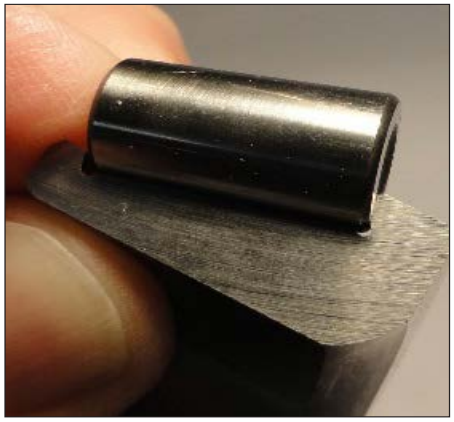

Photo 1 TRB cross-section highlighting rib/roller interface.

Loss of Rolling Torque

First, let's discuss the loss of rolling torque. It is very typical to lose, perhaps, half of the bearing rolling torque in a very short period of time after startup. When the bearings are new, the rib and roller surfaces are as rough as they are ever going to be. As soon as the bearing starts rolling, these surfaces immediately begin to polish each other. This period, often thought of as the "break-in" period, is nothing more than the surfaces of the roller ends and large rib wearing in together. This process produces almost no measurable wear, 1-2 µm at most. The bearings run hotter during this period due to the higher friction between the surfaces, which is why there is usually a 500 mile break-in recommendation for new vehicles and rebuilt axles prior to towing or heavy usage. A break-in period allows for the bearings to wear in without getting too hot (Fig. 1). A hot running bearing can damage the oil, which produces loss in viscosity and additives, which is even harder on the bearing. This is a downward cycle you want to avoid. If you feel like you may have abused a new axle, the bearings were *probably* not damaged (yet); a quick axle lube change can usually get you back on track.

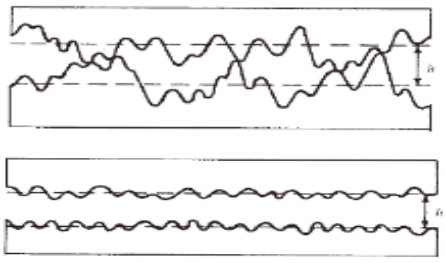

Figure 1 New bearing vs. broken-in bearing.

Of course there are numerous housing deflection issues that can be a source of losing preload. Before you begin to dig into your bearing system, make sure the housing is not playing a role. We are dealing with microns of deflection, so this is not something you are going to visually see happening.

Loss of Preload

Every single tapered roller bearing that is not made from a frictionless, massless material will wear between the roller ends and large rib beyond the initial break-in period. This is unavoidable because there is a true sliding surface between the rollers and large rib, and this wear is responsible for preload

Photo 2 TRB run with no lubrication.

loss. Photo 2 shows a TRB that was intentionally run at a low speed with no lubrication that really captures the major source of friction. The area outside of the rib interface remained undamaged while the rib and roller began to friction-weld together.

Our goal is to try and understand, mitigate and compensate for the anticipated wear. There does appear to be a point at which the system stabilizes and wear slows down considerably. It is thought that this is a combination of components fully wearing in together plus some potential work hardening occurring at the surfaces. While this effect is not yet completely understood, it has been observed that most of the wear occurs within the first 5,000 miles — or roughly 100 hours of usage (Fig. 2).

You can bury yourself trying to understand and predict lubrication flow, EHL and thermal equations — which are an integral part of the bearing function — but aren't incredibly useful in talking about wear. If we are just trying to understand the mechanics of bearing wear, the starting torque equations are a great place to begin. Where there is torque, there is sliding friction, and where there is sliding friction, there is wear.

$$M = \frac{e\mu_e l \sin(2\beta)}{D_{wl}\sin(\alpha)} F_a \quad (1)$$

$$\text{Since } D_{wl} = 2\overline{OB}\sin\beta \text{ and } l = \overline{OB}\sin\alpha$$

$$M = e\mu_e \cos\beta F_a \quad (2)$$

Let's walk through this fairly intuitive formula; as the contact point *e* between the roller and rib increases along with the outer diameter of the roller *l*, torque increases. The larger diameters increase sliding velocity, thus increasing torque/wear. As the roller taper angle β increases, torque also increases. One way to think of this is that there is a wedge created between the cup and cone with the roller in the middle; the steeper the wedge, the more force the roller wants to push out and into the rib. On the other side, as roller diameter D_{wl} increases, torque decreases. The larger the roller creates a smoother transition in and out of the rib contact area, reducing sliding velocity. Finally, as the bearing contact angle α increases, torque decreases. This is just a function of a force acting upon an inclined plane. As the net axial force on the bearing increases, the roller presses harder against the rib, increasing torque. If the raceway is steeper, proportionately more load will be pushed directly on the rolling part of the raceway rather than the rib.

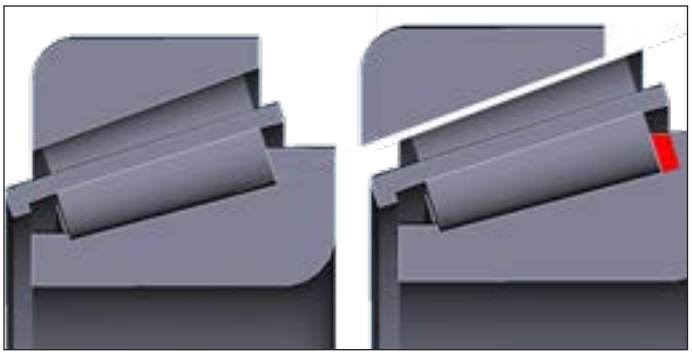

Figure 2 Schematic showing the physical effect of rib wear.

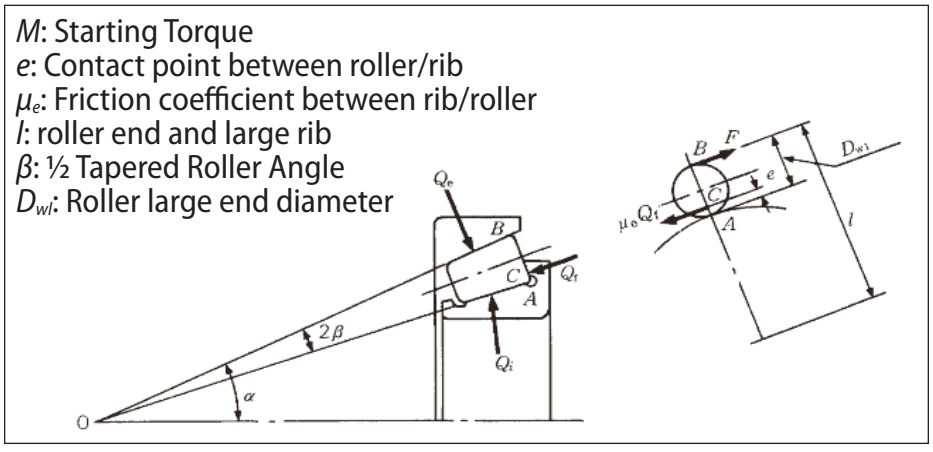

Figure 3 Starting torque equations.

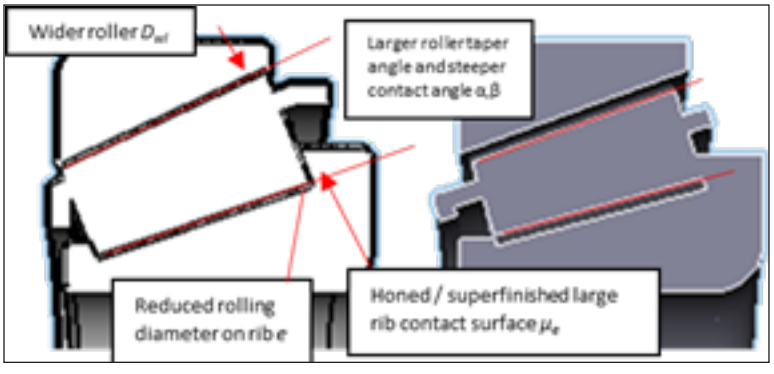

Figure 4 Modern high-efficiency bearing (L) vs. standard bearing (R).

Taking away notes from this formula, if we were to design a more efficient / low-wear bearing, we would:

- Make the contact point *e* of the roller as close to the inner diameter as possible
- Increase the roller diameter D_{wl}
- Increase the taper angle of the roller β
- Increase the contact angle of the bearing α
- Improve surface finish and/or hardness at the rib/roller interface to reduce μ_e

If you made these guesses based on the formula, you just designed a modern, high-efficiency bearing that is currently in tens of millions of vehicles.

For various reasons, we may not want all of these features in the bearing. A simple, effective improvement for TRB efficiency is just super-finishing or honing the large rib. Rib honing was quite difficult a decade ago, but improvements in manufacturing technology along with increased popularity of honing have made this modification accessible to most bearing manufacturers. Many companies now provide this

as a standard feature. Of course this only provides us with the main driving mechanisms for wear at the bearing geometry level. Other significant factors are surface hardness, lubrication type, temperature, contamination, misalignment, etc. We can consider most of those noise factors that can be controlled to some extent.

Measuring and Quantifying

Now that we have established a basic understanding of the mechanics of losing preload, we will move on to measuring and quantifying. Being able to measure the rib directly is a great end-of-test feature to record, but we don't have an A/B to compare with because measuring the rib directly on a new part is not possible for an assembled bearing. A very simple method of directly measuring bearing wear is to measure the stand height as new and then again post-test (Fig. 5). The bearing companies will sometimes do this for you, and there are some inspection houses that will take these measurements if you don't have in-house capability. In a primary drive axle, you can expect head bearing losses in the 10-20 µm range (heavy loads), tail bearings around 5-10 µm (moderate loads), and differential bearings generally 5 µm or less (light/moderate loads). These are very general guides, but if you are seeing double or triple these values, you should have your lubrication analyzed to see if you are generating heavy wear particles from the gearset, or if your oil is breaking down for some other reason.

If you realize you have a preload loss

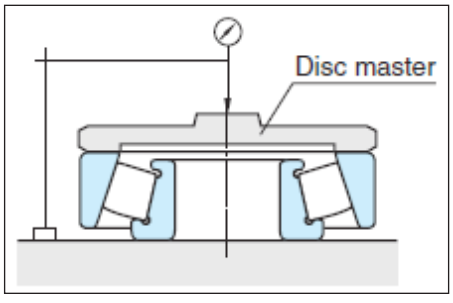

Figure 5 Measuring stand height.

issue after the fact and do not have the initial height measurements, simply measuring the bearing after test will serve little benefit. The stand height tolerance can be up to 200 µm for small TRB's, and we will only be looking for

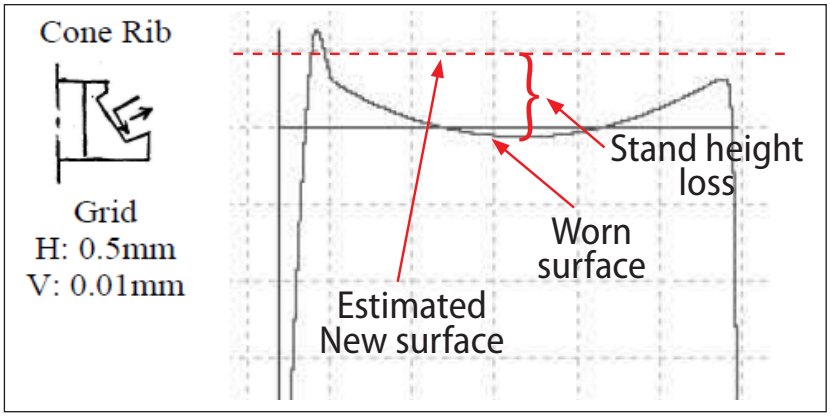

Figure 6 Rib height wear profile.

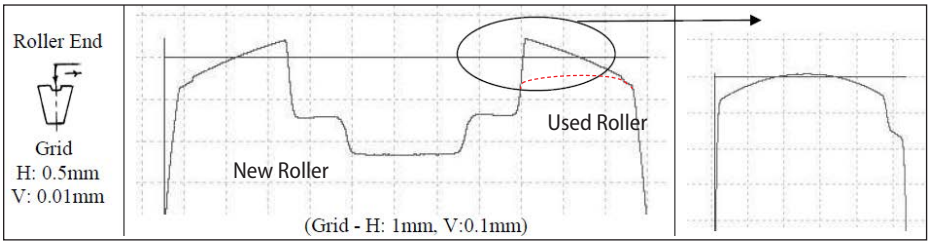

Figure 7 Roller end wear.

a loss of ~15 µm. All is not lost, though. We can still do a little forensic work with which to back up an educated guess. Due to the chamfers on the roller ends and the undercut of the cone where the large rib meets the raceway, there is a small area of the rib that doesn't wear very much. Using this area to project an estimated initial surface can be a decent estimate of the rib wear. In Figure 6 we see that comparing the inner area of the rib (the part that does not wear much) to the center of the rib, where the roller will settle, we see about a 13 µm drop. This is right on target for the values that had been seen for this particular application. For not knowing the initial stand height, this is a good estimate.

Similar measurements can be taken at the roller ends (Fig. 7), though these will usually only have 1-2 µm of wear at most, so invest your time and resources accordingly.

Now you have the pre- and post-test stand height measurements, or you had run traces for your tested bearings and you feel like you have some reasonable stand height loss numbers. Now what? Now we have to find the correlation between stand height loss and preload loss. The change in stand height will be our axial displacement and the loss in preload will be our axial load, . Now we find the fairly manageable relationship by:

$$\delta_a = K_a F_a^{0.9} \quad (3)$$

$$\text{Where } K_a = \frac{0.000077}{\sin\alpha^{1.9} z^{0.9} L_{we}^{0.8}} \quad (4)$$

And, α: Contact angle (½ cup angle) (deg)
L_{we} Effective contact roller length (mm)
F_a Axial Load (N)
Z Number of rollers

Most of these values can be found in catalogs or scaled from the models that are available on most bearing manufacturers' websites.

Let's try this calculation on a real application. A popular pinion bearing arrangement for light utility application is head bearing M802048/11 and tail bearing M88048/10. Let's look at a 5kN axial preload M802048/11 head bearing:

Plugging in values:

A	20°
Z	18
L_{we}	15.5 (mm)
F_a	5,000 (N)

$$\text{Where } K_a = \frac{0.000077}{\sin\alpha^{1.9} z^{0.9} L_{we}^{0.8}} = 4\times10^{-6}$$

Now calculating *Equation 3*,

$$\delta_a = 4\times10^{-6}\times5000^{0.9} = 0.0091 \text{ mm}$$

The calculated deflection for M802048/11 with 5kN preload is 9.1 µm

To compare this result with a table calculated by a bearing manufacturer, see Table 1:

Table 1 Axial load vs. deflection	
M802048/11	
Axial Load (kN)	Axial Deflection (µm)
1	2.24
2	4.19
3	6.03
4	7.81
5	9.55
6	11.3
7	12.9
8	14.6
9	16.2
10	17.8

Not bad at all; our calculated value was within 5% of the manufacturer's calculated value. Also using manufacturer's data for the M88048/10, a 5kN preload will produce 10.6 µm of axial deflection for a total system deflection of ~ 20 µm.

Housing Elasticity

If we review our wear estimates of 10-20 µm for the head, and 5-10 µm for the tail, the situation begins to look grim; we could easily lose all of our 5kN preload just through expected wear. Fortunately, we have one other factor benefiting our system — the elasticity of the housing. If your company designs housings internally, very likely you can obtain an FEA analysis of the housing at the bearing journals to help you estimate the housing deflection in the preloaded state. If that is not available, a reasonable estimate can be had by assuming the bearings are roughly twice as stiff as the housing (true for most thin-wall housing applications). This means if you are axially displacing the bearings by 20 µm, you have to displace the housing by 40 µm in the process. After the preload is set, the total system deflection is a 60 µm.

With this added feature, we now see as we lose preload, the housing continues to spring back, helping to maintain preload. If we lose a total of 30 µm bearing height, using the housing / bearing ratio, we proportionately lose 10 µm of bearing load and make up the remainder with the housing springing back by 20 µm.

Photo 3 Housing spreader tool to aid in installing differential bearings in a rear axle. When the housing is released, the bearings will be preloaded and the remaining housing tension will aid in maintaining preload as the bearings wear.

Just for simplicity: if we split the 10 µm between the 2 bearings, we have only *effectively* lost 5 µm worth of preload per bearing. If we review Table 1, we see that 5 µm of loss is roughly equal to 2.5 kN of preload, which is encouraging.

Even though we lost 30 µm of bearing stand height, we only lost approximately one-half of our preload with the aid of the housing providing some spring-back. After the system is dialed in through testing to see how much preload we expect to lose, it is a simple task to add 2 kN of preload in the initial setup to compensate for the expected wear. Testing has shown that marginally increasing the preload does not increase wear, so this is usually an effective compensation technique for battling preload loss.

Conclusion

All TRBs will have a break-in period, followed by a wear period.

Wear can be quantified by measuring new and tested/used bearings and increasing the initial preload to compensate for some or all of the anticipated wear.

Housing elasticity can play a role in maintaining preload over the life of the application, and should be understood through physical or analytical measurements.

Purchasing bearings with honed ribs along with good, clean lubrication and good shaft alignment will assist with the break-in period and reduce overall loss of preload. **PTE**

Norm Parker is the bearing technical specialist for the driveline division at General Motors LLC, and thus a certified PTE "Expert."

Testing of Alternative Spiral Bevel and Hypoid Gear Theory

W. R. Winfough and D. B. Dooner

Following is a presentation of a gear design based upon a theoretically perfect gear technology, for which an overview is offered for consideration. What follows is a report on the design's testing and subsequent manufacture of a hypoid gear pair for a 1999 Ford Mustang.

Background

A system of curvilinear coordinates is presented to describe general bevel and hypoid gear elements. Subsequently this system of coordinates is used for the mathematical development of fundamental relations describing general gear pairs. One set of relations is defined as the *Three Laws of Gearing*. An overview of these three laws is presented to help demonstrate the capabilities of this theoretically perfect theory for spiral bevel and hypoid gear design vs. existing practice for the design and manufacture of spiral bevel and hypoid gear elements. This gear theory can be used to produce any gear form shape.

Cylindroidal Coordinates

A system of curvilinear coordinates (*u, v, w*) is introduced to describe spiral bevel and hypoid gears. The coordinates (*u, v, w*) used to parameterize these families of pitch, transverse, and axial surfaces are formulated using the cylindroid defined by the input and output axes of rotation. A design methodology for spatial gearing analogous to cylindrical gearing begins with the equivalence of friction cylinders (Fig. 1). These generalized friction surfaces are two ruled surfaces determined by the instantaneous generator. The transmission of motion between the two generally disposed axes, $\$_i$ and $\$_o$, via two friction surfaces requires knowledge of the instantaneous generator. The location of the instantaneous generator relative to the two axes $\$_i$ and $\$_o$ depends upon the distance E along the common perpendicular to rotation axes $\$_i$ and $\$_o$, the angle D between axes of rotation $\$_i$ and $\$_o$, and the magnitude of the gear ratio g.

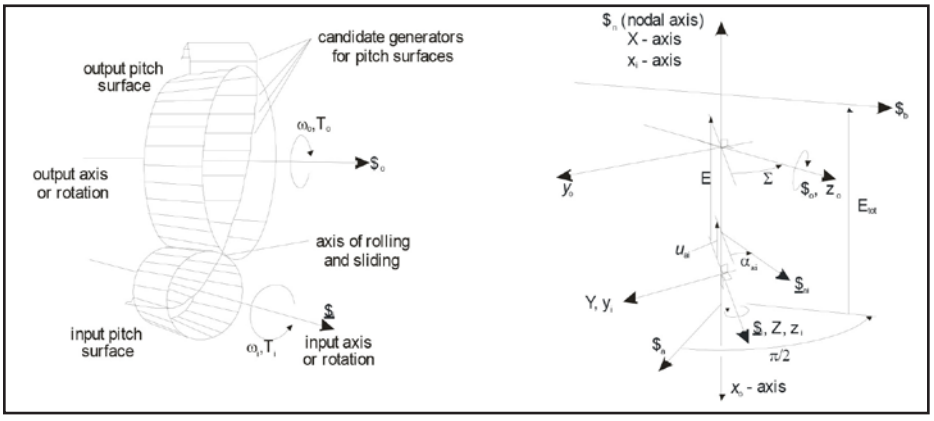

Figure 1 Two hyperboloidal friction wheels for motion transmission between skew axes.

The synthesis of a spatial three-link gear mechanism is similar to the synthesis of the planar three-link geared mechanism. The twist displacement of one Body relative to another Body is denoted by $dv\$$, where dv is the magnitude of the twist $\$$. The relationship for the twist displacements of three bodies is:

$$dv_{12}\$_{12} + dv_{23}\$_{23} + dv_{31}\$_{31} = 0 \quad (1)$$

where:

$dv_{12}\$_{12}$ is the relative displacement of Body 2 with respect to Body 1

$dv_{23}\$_{23}$ is the relative displacement of Body 3 with respect to Body 2

$dv_{31}\$_{31}$ is the relative displacement of Body 1 with respect to Body 3

Body 1 represents ground; Body 2 is the input Body; and Body 3 is the output Body. If $dv_i\$_i$ is the twist displacement (pure rotation) of the input with respect to ground, $dv_{is}\$_{is}$ is the twist displacement of the output Body relative to the input Body, and $dv_o\$_o$ is the twist displacement of the output Body relative to ground, then the vector loop (Eq. 1) for the spatial three-link mechanism becomes:

$$dv_i\$_i + dv_{is}\$_{is} - dv_o\$_o = 0 \quad (2.a)$$

Dividing by dt, its significance to gearing is:

$$\omega_i\$_i + \omega_{is}\$_{is} - \omega_o\$_o = 0 \quad (2.b)$$

where:

ω_i angular speed of input gear

ω_{is} angular speed of output gear relative to input gear

ω_o angular speed of output gear

$\$_i$ zero-pitch twist coordinates of input axis of rotation

$\$_{is}$ homogeneous twist coordinates of IS (instantaneous screw)

$\$_o$ zero-pitch twist coordinates of output axis of rotation

This paper was first presented at the 2013 VDI International Conference on Gears, Technical University of Munich, Garching, Germany, and is reprinted here with VDI permission.

The *transmission function* is the functional relationship between the angular position v_i of an input element and the corresponding angular position v_o of a mating output gear element. The instantaneous gear ratio g is the ratio between the instantaneous, angular displacement dv_o of the output and the corresponding, instantaneous angular displacement dv_i of the input, thus:

$$g \equiv \frac{dv_0}{dv_1} = \frac{\text{infinitesimal angular displacement of the output body}}{\text{infinitesimal angular displacement of the input body}} \quad (3)$$

The displacements dv_i and dv_o are about the input and output axes $\$_i$ and $\$_o$, respectively. The angular speeds ω_i and ω_o are, respectively, the angular displacements dv_i and dv_o per-unit time d_t. The kinematic geometry of toothed bodies is independent of time t and, hence, speed ω_i of the input. Rearranging Equation 2b, $dv_{is}\$_{is}$ becomes:

$$dv_{is}\$_{is} = -dv_i(\$_i - g\$_o) \quad (4)$$

Axodes are ruled surfaces that roll and slide upon one another in a special way. In order to distinguish which pitch surface is the axode, the "theorem of three axes" will be applied to the two special twists $\$_i$ and $\$_o$. A fixed reference frame (X, Y, Z), an input reference frame (x_i, i_y, z_i), and an output reference frame (x_o, y_o, z_o) are used to parameterize these pitch surfaces. The screw axis $\$_i$ of the input reference frame coincides with the Z axis of the fixed reference frame. The distance E — along the common perpendicular between the input and output axes $\$_i$ and $\$_o$ — is along the positive X axis of the fixed reference frame. The z_o axis of the output reference frame is perpendicular to the X axis of the fixed reference frame.

Two systems of curvilinear coordinates based on the cylindroid are used to parameterize toothed bodies in mesh. An input Cartesian coordinate system (x_i, y_i, z_i) is introduced where the z_i axis is aligned with the input's axis of rotation and the x_i axis is along the common perpendicular. An output Cartesian coordinate system (x_o, y_o, z_o) is introduced where the z_o axis is aligned with the output's axis of rotation, and the x_o axis is along the common perpendicular. Twist coordinates $\$_i$ used to parameterize the displacement of the input body are shown in Figure 1 where:

$$\$_i = (0, 0, 1; 0, 0, 0),$$

and the twist coordinates $\$_o$ used to define the displacement of the output body are:

$$\$_o = (0, -\sin\Sigma, \cos\Sigma; 0, -E\cos\Sigma, -E\sin\Sigma).$$

Applying the theorem of three axes given by Equation 4, the twist coordinates $dv_{is}\$_{is}$ are used to determine the relative displacement between the input body; the output body then become $dv_{is}\$_{is} = dv_i(0, -g\sin\Sigma, g\cos\Sigma - 1; 0, -gE\cos\Sigma, -gE\sin\Sigma)$.

The intersection between the ISA and the fixed X axis can be expressed as:

$$r \times C_{is} = \zeta_{is} - h_{is}C_{is} \quad (5)$$

where:

r is the point of intersection between the fixed X axis and the twist $dv_{is}\$_{is}$

h_{is} is the pitch of the twist $dv_{is}\$_{is}$

and:

(C_{is}, ζ_{is}) are the twist coordinates of $dv_{is}\$_{is}$

Crossing C_{is} into the above relation and expanding

$$r = \frac{C_{is} \times \zeta_{is}}{C_{is} \cdot C_{is}} \quad (6)$$

since $r \perp C_{is}$.

Substituting values for C_{is} and ζ_{is} into Equation 6, $r = u_{ai}i_i$, where the radius u_{ai} of the input axode is:

$$u_{ai} = E_g \frac{g - \cos\Sigma}{1 + g^2 - 2g\cos\Sigma} \quad (7)$$

The Plücker coordinates of the generators for the input axode are specified in terms of the direction cosines C_{ai} for an arbitrary angular position v_i of the input. The included angle α_{ai} between the instantaneous screw axis and the input axis $\$_i$ is defined as the cone angle. Projecting the free vector C_{is} onto the input axis $\$_i$, the cone angle α_{ai} becomes:

$$\alpha_{ai} = \tan^{-1}\frac{-g\cos\Sigma}{1 - g\cos\Sigma} \quad (8)$$

The axode is *left-handed* when the cone angle α_{ai} is positive about the x_i axis. A positive displacement dv_i of the input gear must be accompanied with a negative parameterization of the axode. Thus the free vector part C_{ai} for the generators of the input axode becomes:

$$C_{ai} = (-\sin\alpha_{ai}\sin v_i)i_i + (-\sin\alpha_{ai}\cos v_i)j_i + (\cos\alpha_{ai})k_i \quad (9a)$$

If r_{ni} denotes the coordinates of the neck, then the moment part ζ_{ai} is expressed as:

$$\zeta_{ai} = r_{ni} \times C_{ai} \quad (9b)$$

where $r_{ni} = u_{ai}(\cos v_i i_i - \sin v_i j_i)$.

The Plücker coordinates for the generators of the output axode are similar to those of the input axode.

A *transverse surface* is an infinitesimally thin surface used to parameterize conjugate surfaces for direct contact between two axes. Each angular position v_i and axial position w_i define a unique point p in space for a given g. The point p traces a curve in space as g varies from $-\infty$ to ∞. Another value of the input position v_i defines the same cylindroid. It is this two-parameter loci of points p that compose the transverse surface. The Cartesian coordinates r for the single point p on the generator $\$_{ai}$ are:

$$r = u_i i_i - w_i \sin\alpha_i j_i + w_i \cos\alpha_i k_i \quad (13)$$

Rotating the above curve r about the z_i axis, an amount v_i leads to:

$$r = \begin{bmatrix} \cos v_i & \sin v_i & 0 \\ -\sin v_i & \cos v_i & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_i \\ -w_i \sin\alpha_i \\ w_i \cos\alpha_i \end{bmatrix} \quad (14)$$

The *axial surface* provides the relationship between successive transverse surfaces. For each value of v_i, the axial surface is the locus of generators determined by g, where $-\infty < g < \infty$. The

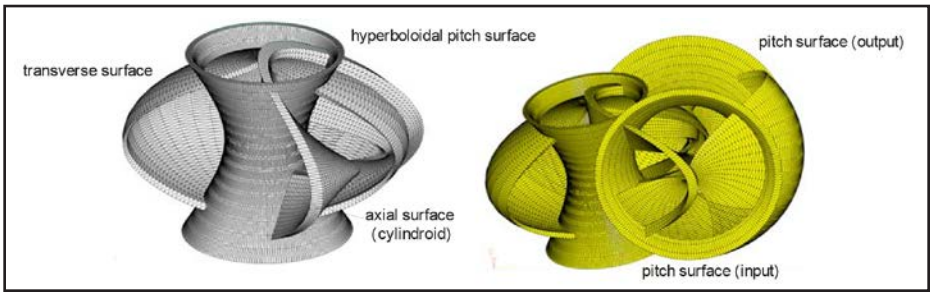

Figure 2 Pitch, transverse, and axial surface for uniform motion transmission.

curves defined by holding two of the three parameters — u, v, and w constant — are coordinate curves. Two parameters used to define a surface are the curvilinear coordinates of that surface; i.e. — the pitch surface by v_i and w_i (u_i = constant); the transverse surface by u_i and v_i (w_i = constant); and the axial surface by ui and wi (v_i = constant). Shown in Figure 2 are a set of pitch, transverse, and axial surfaces using cylindroidal coordinates (u_i, v_i, w_i).

The Three Laws of Gearing

Three laws of gearing are presented in terms of toothed bodies in mesh or gear pairs. Present day design and manufacturing techniques make approximations to the ideal conditions necessary for motion transmission — resulting in limitations in face width, number of teeth in mesh, spiral angle, and pressure angle. The three laws of gearing are established in terms of a three-link, 1-dof mechanism.

***Three laws of gearing*:**

1. Defines the relation between the tooth surface normal and the desired gear ratio
2. Establishes the relation between pitch surfaces, spiral angle, and desired gear ratio for any tooth profile
3. Establishes the relative curvature between tooth surfaces in direct contact.

Gear pairs are special, direct-contact mechanisms where motion is achieved by surfaces in direct contact. Depicted in Figure 3 are the input axis of rotation $\$_i$, the output axis of rotation $\$_o$, and the instantaneous screw axis $\$_{isa}$ along with the tooth contact normal $\$_l$. Shown is the shaft center distance E between the two axes of rotation $\$_i$ and $\$_o$, along with the included angle Σ between these two axes. Invoking Ball's reciprocity condition between the line of action $\$_l$ and the vector loop Equation 2a yields:

$$\$_l \bullet (dv_i \$_i + dv_{is} \$_{is} - dv_o \$_o) = 0 \quad (15)$$

Specifying that the reciprocal product between the line of action $\$_l$ and the instantaneous twist $\$_{is}$ is zero (i.e., $dv_{is} \$_{is} \circ \$_l$), the above relationship is rearranged to:

$$g = \frac{\$_l \circ \$_i}{\$_l \circ \$_o} \quad (16)$$

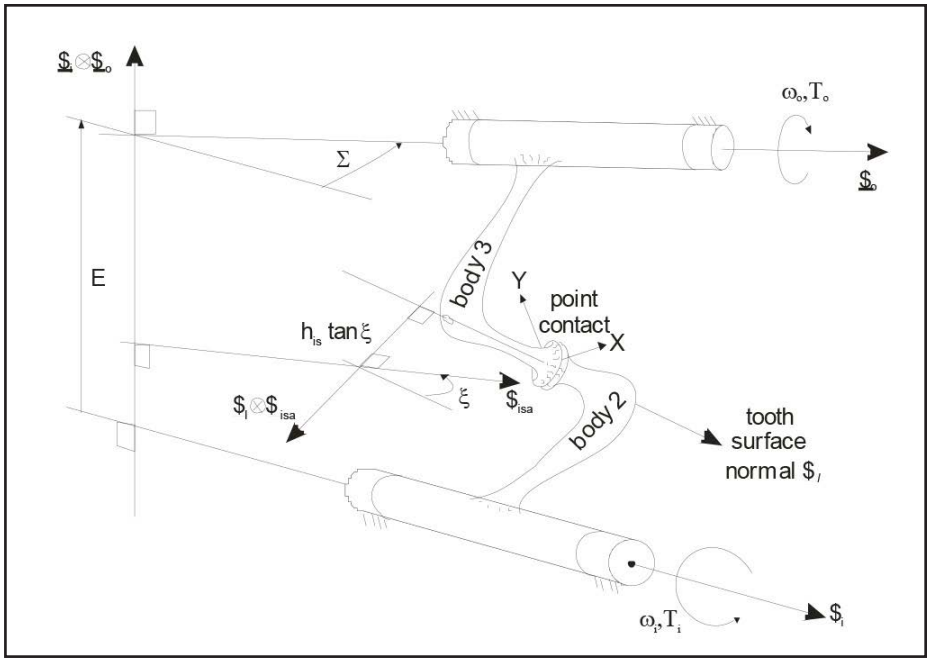

Figure 3 Relation between input axis $\$_i$, output axis $\$_o$, ISA $\$_{isa}$, and contact normal $\$_l$.

where:

g instantaneous gear ratio
$\$_l$ homogeneous screw coordinates of tooth contact normal
$\$_i$ homogeneous twist coordinates of input axis of rotation
$\$_o$ homogeneous twist coordinates of output axis of rotation

Gear tooth mesh — where the tooth surface normal $\$_l$ is reciprocal to the desired twist $\$_{is}$ — is defined as conjugate action. The above relation is independent of the contact position between the two gear elements and depends only on the line of action $\$_l$ and axes $\$i$ and $\$_o$. The first law of gearing can be stated as:

For motion transmission between two axes via two gear teeth in direct contact, the contact normal to the two gear teeth in direct contact must be reciprocal to the instantaneous twist defined by the two axes of rotation, and the gear ratio in order to achieve the desired instantaneous gear ratio.

The cited first law of gearing is a generalization of Euler's original "Laws of Gearing." It encompasses noncircular gears where the position of the pitch point varies in addition to spatial gearing, where the common tooth normal does not intersect the generator of the axodes or the instantaneous screw axis.

The orientation of the gear tooth on the pitch surface must ensure that the desired gear ratio is maintained. The orientation is based on two angles — a pressure and spiral angle. The independence of pressure angle from spiral angle is explained in terms of the linear line complex defined by the twist $\$_{is}$ (Ref. 1). Such specification of spiral angles de-couples the spiral angle from the pressure angle, and the second law of gearing can be stated as:

For motion transmission between two axes via two gear teeth in direct contact: in order to achieve the desired instantaneous gear ratio for any pressure angle, the spiral angle on the reference pitch surface must be determined by the planar pencil of contact normals reciprocal to the instantaneous twist defined by the two axes of rotation and the gear ratio.

Gear tooth geometry at a point on the pitch surface can be specified in terms of the normal curvature and geodesic torsion of two separate curves on the tooth surface. These separate curves are the line of contact and the intersection between the gear tooth and the reference pitch surface (the tooth spiral). Knowledge of the curvature and torsion between these two curves embedded in the gear tooth surface uniquely define the gear tooth curvature; this relation is independent of the tooth type. Together these expressions are used to establish a fundamental relation for the relative curvature of two conjugate surfaces in direct contact; thus the third law of gearing can be stated accordingly:

For uniform motion transmission between two axes via two teeth in direct contact, relative curvature between the two teeth in direct contact depends on the gear ratio, the spiral angle and pressure angle, and is independent of the gear tooth geometry.

Comparison to Old Technology

An overview of face cutting methods for spatial gear design and manufacture is provided by Shtipelman (Ref. 1), Stadtfeld (Refs. 2-3) and Litvin-Fuentes (Ref. 4). Below are three companies providing machines and machine tools used to produce crossed-axes gear pairs:

- The Gleason Works (*www.gleason.com*)
- Klingelnberg-Oerlikon (*www.klingelnberg.com*)
- Yutaka Seimitsu Kogyo, Ltd.*(www.yutaka.co.jp)*.

Figure 4 displays circular face cutters used today for fabricating spiral bevel and hypoid gear elements. The ideal shape of hyperboloidal gears cannot be produced using circular face cutters, resulting in restrictions on candidate gear designs. One goal of the presented approach is to establish a new method for the fabrication of hyperboloidal gears that overcomes certain limitations of existing face cutting technology.

Design, Manufacture, Testing

Over 75% of manufactured spiral bevel and hypoid gears are utilized in automotive and locomotion activities. This test showcases the benefits of the perfect transmission computational method. The intent is to demonstrate that *theoretically* perfect gears, which, ultimately, will be manufactured using a hob for hypoid, spiral bevel and skew axis gearing, is in fact robust and as functional as the current face hobbing process for spiral bevel and hypoid gears. A 1999 Ford Mustang coupe was chosen as the test vehicle. The Ford Mustang came with a Ford 7.5-inch, 2.93 ratio hypoid rear end, and a V6 small block.

The availability of the details associated with all engineered products, like automobiles, is typically considered proprietary to the OEM. Since the OEM specifications for the hypoid gearset were not available, measurements were taken of existing components to complete the design. A replacement rear axle assembly was purchased from a local repair company. The differential case was disassembled and the mounting features were measured and toleranced. Figure 5 shows both the rear axle and the gear pair removed from the assembly.

After extraction of the ring and pinion, a drop-in replacement was designed specific to the application. (The intent of the drop-in replacement was to match the transmission ratio and footprint, given the manufacturing

Figure 4 Circular face cutting.

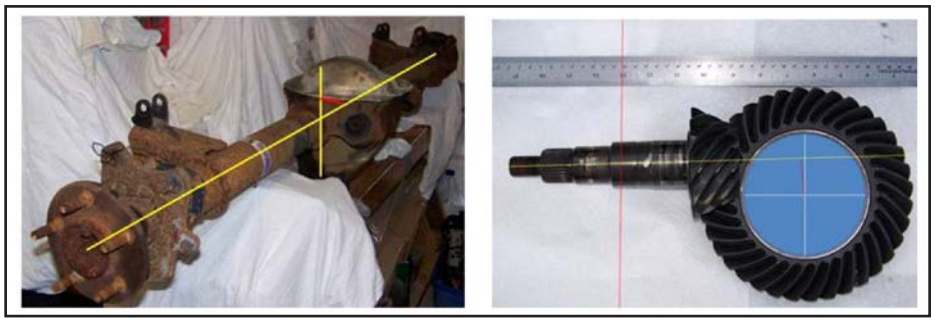

Figure 5 Differential assembly and removed ring and pinion.

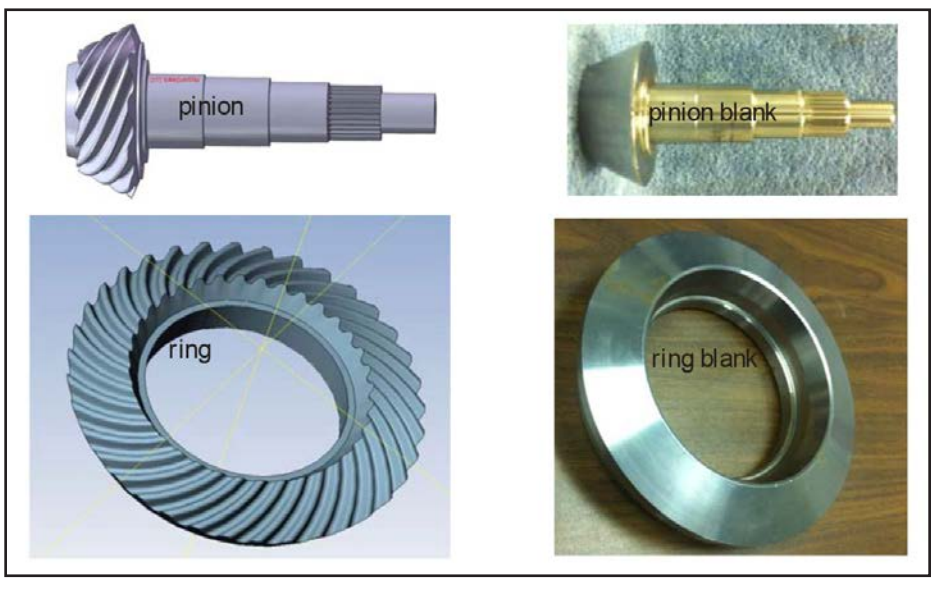

Figure 6 CAD models of pinion and ring gear, along with blanks prior to gear teeth addition.

flaws and inability of the original design relative to our theoretically perfect design — essentially creating a direct comparison between the OEM gear pair and the theoretically perfect gear pair.)

Utilizing the mounting features from the OEM parts for mounting dimensions for both the gearbox (differential case) and the gears (ring and pinion), a 3-D model for each of the components was created for proper assembly. Figure 6 shows the 3-D solid model for each of the components.

After completion of the solid model, manufacturing blueprints were created, including standard gearing nomenclature for the precision of each feature. Three sets of gear blanks were started, assuming that we may make a manufacturing or design error (Fig. 6).

The next step in the manufacturing process was to add the teeth. This was done using standard contour milling available with any 5-axis milling machine. Photos of the components prior to heat treatment can be seen in Figure 7.

The next steps in the manufacturing process were to heat treat the components, finish grind the seating features and chase the threads. Final quality control included inspection and pattern check prior to assembly in the test bed. Figure 8 shows the gears set mounted in a gear alignment machine to check the contact pattern. As can be seen, with known perpendicular axes with the proper pinion offset, the pattern runs along the tooth. This is due to the theoretically optimized torque transmission around both axes. The current industry standard cannot achieve this contact pattern using circular face cutters (i.e., both the heel and toe cannot be engaged simultaneously without loading). These methods of manufacturing and computation are patented (Ref.6).

Figure 7 Ring and pinion prior to heat treatment, along with gears prior to installation.

As the pattern was nearly perfect, no lapping was required and the first gearset was sent to shop for installation in our 1999 Ford Mustang. Prior to final assembly a black oxide coating was added to the gears to highlight wear on the tooth flanks during the testing stages (Fig. 7). As these were standard components, a certified Ford mechanic installed the gears.

Figure 9 shows the differential case just before closing after the gear pair had been set up during pattern checking. Both pinion and ring carrier assemblies were adjusted using standard spacers. As can be seen after assembly, the pattern continues to run exactly parallel to the spiral. The pattern is slightly short of the toe as we missed the location of the pinion by about 0.05 mm. But not bad at all for the first one — made and installed for the first time. At this point, the assembly was complete and ready for testing.

Testing for this assembly was conducted prior to disassembly and after replacement for general comparison. Four phases of testing were conducted. The test bed has been driven for over 7,000 miles/11,250 km, while maintaining an overall tested fuel efficiency of over 30 miles-per-gallon (mpg). The EPA rating for this vehicle was 27 mpg. Figure 10 shows the results of one set of testing. Four sets of testing that each lasted 18 days and about 1,330 miles each. The test route was elevation-neutral and the same fueling location was used at the beginning and end of the route. The route was selected to allow for normal "highway" driving for 74 miles per day. On open stretches, the cruise control speed was recorded and the average speed was calculated by taking the distance recorded on the odometer and dividing by the time collected on a stop watch. The average daily fuel efficiency is also plotted. All four phases averaged over 30 mpg. This is a fuel efficiency of more than 10% better than the "highway mileage" published at *epa.gov* for this vehicle.

The four lines shown in Figure 10 are the distance traveled each day — nearly a flat line at 74 miles. The blue line shows the "cruise control" speed used on the open stretches — about 80% of the trip. The red line is the average speed calculated using the odometer reading and a stopwatch. Lastly, the fuel economy was recorded daily. This was done using the same gas pump at the same gas station and recording the daily fuel added to the tank divided into

Figure 8 Pattern check after heat treatment and grinding to test seating features.

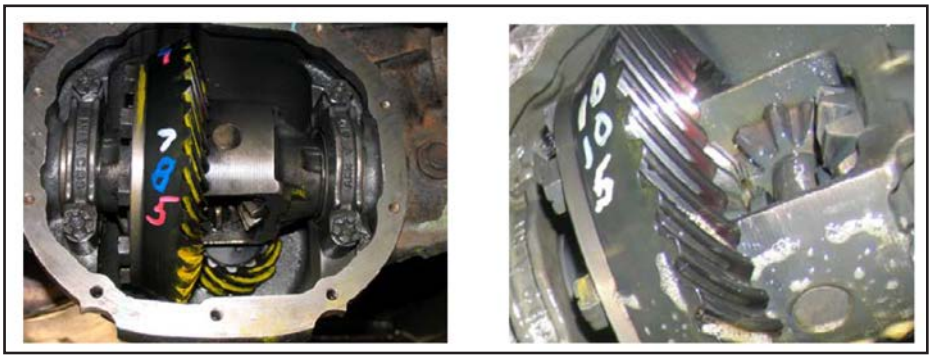

Figure 9 Ring and pinion installed with shim settings marked; wear check 8,200 km.

the distance traveled. Some fluctuation is expected for fuel economy and average speed, as this was a road course with the normal, other influences including rain, traffic, wind and other variations in driving conditions.

The last telling point was to look at the wear of the ring and pinion in application. Figure 9 shows the freshly washed gears after Phase 3 of the testing and 5,100 miles of use. As seen in the gear pair, the wear pattern is easily observed due to the special coating applied. It is clear the wear is absolutely parallel to the tooth. Of note is the extra use of the face width towards the heel of the gear. This implies that with access to the exact design details of the gear box, the same power gears with this design will be able to fully utilize the entire face width. As is commonly known, face width is proportional to power density.

The design, manufacture and testing of these theoretically perfect gears show that this is a viable competitor to other current, empirical solutions available on the market. The gear design cycle for drop-in replacement is two hours; the solid model preparation is 8 hours; and programming the CNC machine is about 40 hours. Effectively — with proper machine availability — from prototype sequence to the beginning of cutting metal can be completed in one work week.

The assembly here was the first set of parts produced for this application and has clearly demonstrated strong performance. The totals for testing to date are over 7,000 miles, with an average fuel economy of 32.0 mpg, 72 days of tests, running 74 miles-per-day. Additional miles occurred as the car was driven without the mileage checks. This is not intended to imply that better than average fuel economy is always possible, but looking at these results, i.e. — no reduction in fuel economy, extremely quiet, no change in wear, extremely fast design cycle — and the fact that these gears are ready for manufacturing in a few days vs. (the current standard) months — this is a viable competitor to the current market offerings. Additionally, it seems logical that optimization of fuel economy from theoretical first principles is likely to come in the future from this design methodology.

In Summary

Demonstrated here is the absolute first gear pair constructed with new technology and methodology, in direct "competition" to currently available market solutions. In aerospace jargon, this new gear pair would be considered the same as "flying the first article." The perfect design methods and reverse engineering resulted pragmatically — fully validating the use of the presented gear technology as a future, preferred gear design methodology. **PTE**

Acknowledgment. *D.P. Technologies for the* Esprit *license.*

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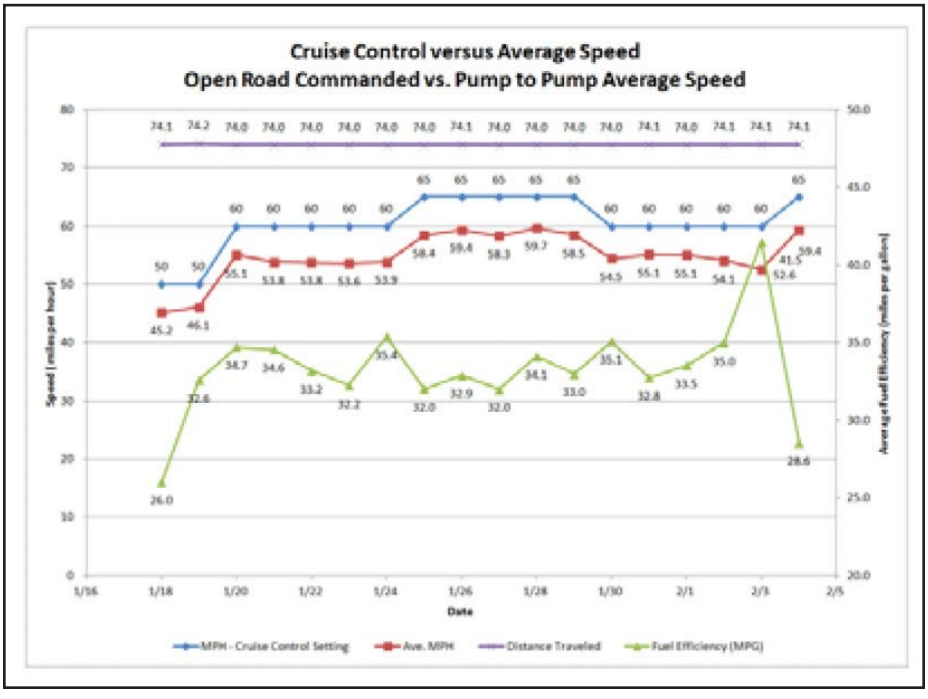

Figure 10 **Phase I at 18 days, 1,330 miles.**

David Dooner graduated from the University of Florida in 1991. Afterwards, he was a visiting scientist with the Russian Academy of Sciences in Moscow and joined the University of Puerto Rico-Mayaguez (UPRM) in 1994. Since joining UPRM, he has been involved with teaching, services, and research. His research focus involves a mathematical approach for the design and manufacture of general hypoid gear pairs. He currently teaches mechanism design, machine design, and senior capstone design. He is currently a member of ASME, ASEE, and AGMA.

Bob Winfough has spent his 20 year career working in various engineering, manufacturing and management roles. He has devoted half of that time to designing and building machining systems, including gear hobbers, shapers and inspection machines. In addition, Winfough spent five years as machining system end user. Over half of his career was on the equity ownership side of the companies for which he worked. Winfough is a member of SME, ASME, Pi Tau Sigma and Tau Beta Pi. He has three earned engineering degrees.

The Reluctance Motor Springs Forth

Dan Jones

There are three major types of reluctance motors: all three reluctance motors are non-permanent magnet, brushless motors. They are synchronous motors with a non-linear relationship between torque and current. The variable-reluctance step and switched-reluctance motors utilize the principle of magnetic attraction by inducing magnet poles within the soft-iron rotor, and by energizing a set of coils wound around stator teeth resident in the laminated stator. These two reluctance motors must be sequentially excited to achieve continuous, steady-state rotation. The design of all reluctance motors requires finite element analysis (FEA) software.

History

The first reluctance motor was invented in 1838 to propel a locomotive. The mechanical switches used for sequentially energizing the windings available at that time could only energize the motor at very slow speeds. This switched-reluctance motor would have to await fast-switching electronic devices (e.g., transistors, FETs, IGBTs) that would become available in the 1970s to drive these motors.

The 1920s saw the development of variable-reluctance step motors in the U.K. for use in naval gun and navigation indicators. The emergence of the computer peripherals (printers, cash registers, and electronic typewriters) provided the application families for the thousands of variable-reluctance step motors in the 1970s and into the 1980s.

The emergence of the solid state devices at that time provided for the creation and control of the switched reluctance (SR) motor. It possesses the same motor configuration as the variable reluctance step motor, but with a completely different drive and control electronics strategy. Hewlett-Packard's draft master plotter was one of the early successes of SR motors in the U.S. Switched Reluctance Drives Ltd (SRDL) — now part of Nidec-Emerson — played a key role in generating interest in Europe at that time.

The synchronous reluctance (SynRM) was initially developed in the 1920s by J.K. Kosko. It too was unable to achieve its performance potential until the advent of high-performance power-and-control electronics used in variable speed drives (VSDs). A number of SynRM, axially laminated rotor designs executed in the 1970s coincided with the emergence of these electronic drives.

The Switched-Reluctance (SR) Motor

The SR motor employs the simplest structure of any electric machine. It is a doubly salient motor with independent phase windings on the stator that are made of magnetic steel laminations — usually for both rotor and stator (Fig. 1). There are a number of unequal rotor and stator teeth — with four rotor and six stator teeth a very typical combination for 3-phase operation; a 6-rotor and 8-stator SR motor would use a 2- or 4-phase drive combination.

The SR drive electronics is unique in that the drive current energizes each set of stator windings with a unipolar (one-direction) current. A traditional inverter cannot be used to drive an SR motor. The motor inductance varies significantly from one rotor-stator tooth alignment to the next alignment position during motion. In SR drives and controls, two power

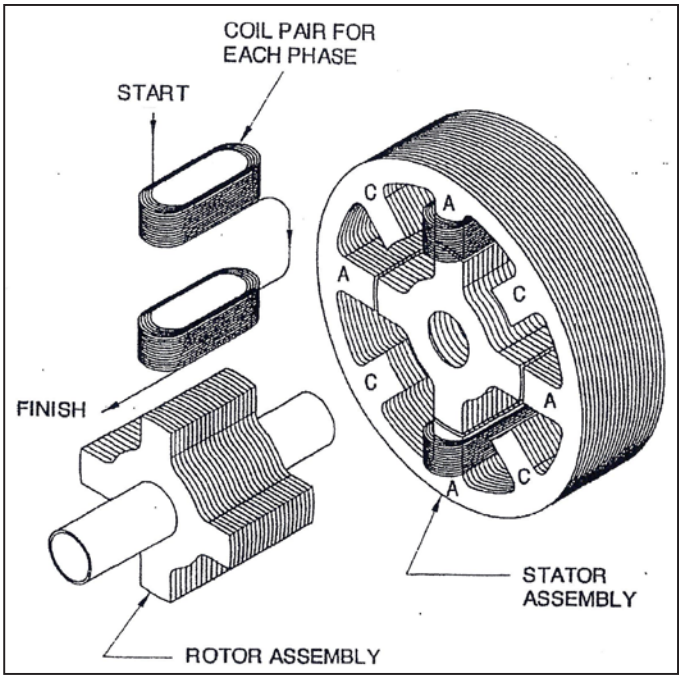

Figure 1 The SR motor employs the simplest structure of any electric machine.

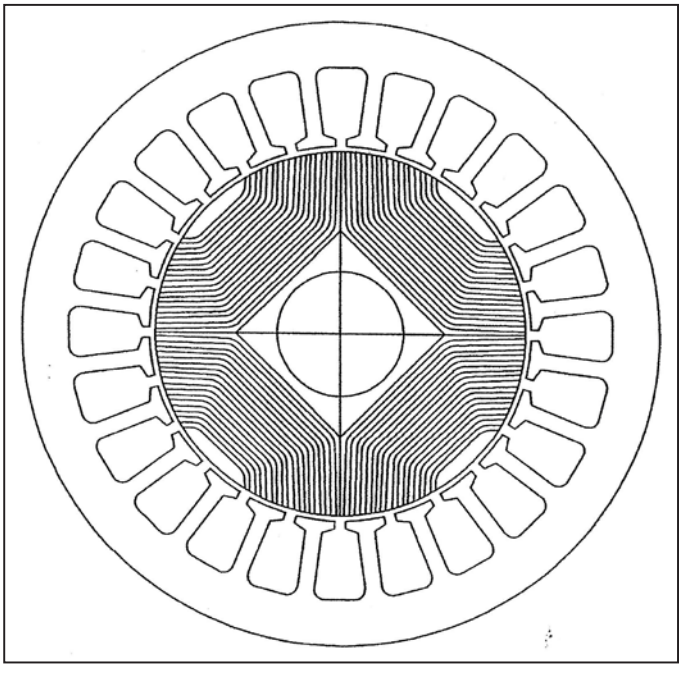

Figure 2 The SynRM motor has a stator construction very similar to 3-phase induction and PM brushless motors. The rotor is quite different than any other motor type. The rotor is composed of various flux tubes alternating with flux barriers; the magnetic flux is directed along these flux tubes.

devices per phase must be used to regulate the current magnitude and the waveform shape to achieve controlled operation of the SR motor.

The Synchronous Reluctance Motor (SynRM)

The emergence of the variable speed drive (VSD) brought the SynRM motor back into the limelight. It has the potential to exhibit a power efficiency higher than equivalent-sized AC induction motors. The various world governments' emphasis on higher power efficiency provided motor manufacturers with a strong stimulus to evaluate this motor type.

The SynRM motor has a stator construction very similar to 3-phase induction and PM brushless motors. The rotor is quite different than any other motor type. The rotor is composed of various flux tubes alternating with flux barriers; the magnetic flux is directed along these flux tubes (Fig. 2). A typical number of poles is four or six. There are few rotor losses when the synchronous reluctance motor achieves synchronous speed. It operates on 3-phase sinusoidal voltage similar to an induction motor.

Today's Application Successes

The ever increasing cost of rare earth magnets through the first decade of this century resulted in many motor manufacturers looking toward investigating both reluctance motor types for many cost-sensitive applications.

Switched-reluctance motor applications are found in appliances and automobiles. They are designed along with the electronic drive primarily for high-volume applications. One SR motor application is the Dyson cyclone upright vacuum cleaner that operates at a speed just above 100,000 rpm. The other application describes an electric bus in Belgium that uses a 130 Kw SR motor in combination with a 55 Kw SR motor-generator (Fig. 3). These two applications illustrate the range of SR motor and drive applications today.

The synchronous reluctance motor was developed into a full product line by ABB and announced at a German motion control show in November 2012. Their new high-efficiency product line ranges from 11 Kw to 200 Kw. Figure 4 shows the various losses and motor efficiency of the ABB 50 hp (37 Kw) induction motor in black, and the equivalent SynRM motor in blue. The power savings over one year is in excess of $1,250 (£964). The overall SynRM efficiency reaches 95.3% against the current 50 hp induction motor at 92.7%. The SynRM motor can utilize a conventional inverter for variable speed used in indus-

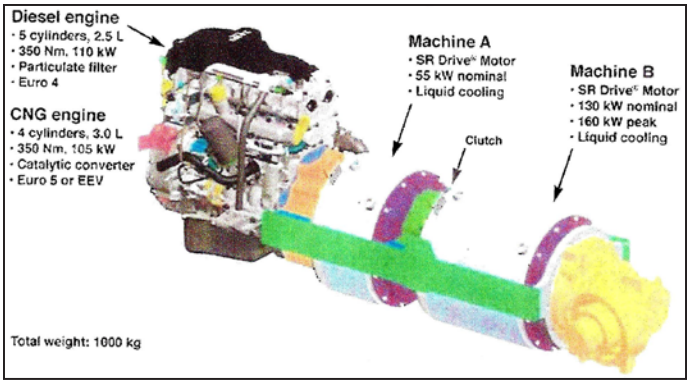

Figure 3 One SR motor application is the Dyson cyclone upright vacuum cleaner that operates at a speed just above 100,000 rpm. The other application describes an electric bus in Belgium that uses a 130 Kw SR motor in combination with a 55 Kw SR motor-generator.

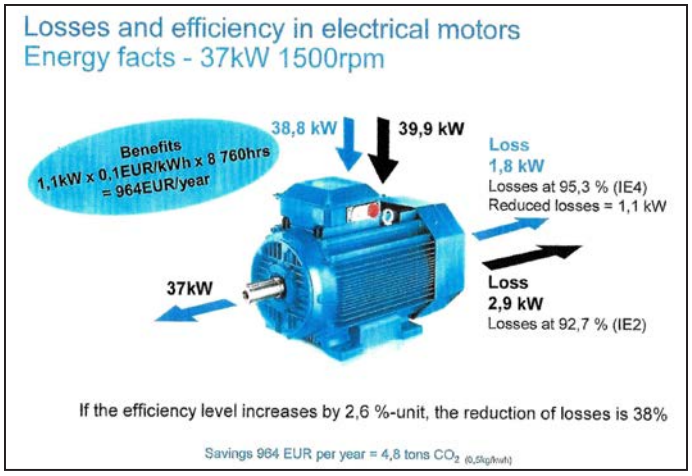

Figure 4 The various losses and motor efficiency of the ABB 50 hp (37 Kw) induction motor in black; and the equivalent SynRM motor in blue.

trial fan and lower applications. Their IE4 efficiency level is one higher than the U.S. Premium Efficiency level.

What Will the Future Bring?

The SR motor and its associated drive will continue to be utilized for higher-volume solutions in the cost-conscious automotive and appliance markets. The SynRM motor will compete directly with the induction motor in the many larger pump and fan applications within the HVAC and other industrial markets. Can the induction motor continue to hold its current primary position?

Only time will tell. **PTE**

Dan Jones received his B.S. degree in electrical engineering from Hofstra University and a M.S. degree in mathematics from Adelphi University. He has since 1962 been a chief engineer and staff engineer with numerous companies. Either as a direct employee or consultant, he has applied his technical skills and experience working on DC motors, step motors, AC motors, brush and brushless motors, electronic drives, and on control systems in applications for the military, industrial, and commercial markets. Jones is a former president of the Association of International Motion Engineers (AIME) and has served on the Board of Directors of the Small Motor Manufacturers Association (SMMA). Jones is now president of Incremotion Associates, a firm combining the capabilities of engineers and marketing focusing on the motion control and power conversion industries.

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Global Industrial Outlook: Das (Human) Kapital

By Brian Langenberg, CFA

SUBJECT	WHAT WE SAID	WHAT HAPPENED	WHAT NOW
Current Outlook	Solid, 2Q bounce-back	Solid, 2Q bounce-back	Continued recovery; soft employment
Big Deal – Alstom	GE, Siemens — GE better buyer, one would get	GE wins with modified agreement w/French Govt.	GE — strengthened position in steam turbines, European service.
Geopolitics	Russia, Ukraine; China = Defense spending will rise globally over time.	Additions to the list:Israel vs. Hamas;Ukraine escalation	Europe will take its defense needs seriously; Poland, Scandinavia will move first.

Second quarter financial results are yielding few surprises and confirming our views. Economically we felt the U.S. would bounce back from an artificially depressed first quarter (weather) which has proven to be the case. Our prior installment "Frogs' Legs, Bratwurst and the Bear" addressed three areas (see chart, above, right).

This month I will provide a current outlook update; provide key findings from a recent energy sector conference where I met with 16 management teams (within Oil & Gas); and go back to the "E" from our C.H.I.E.F. issues commentary back in February — i.e., Education and Employment.

Oil & Gas: We were fortunate to meet with the management teams of 16 major companies from offshore drillers like Transocean, to oilfield services provider Dresser-Rand. We also spoke directly to Exploration & Production companies. In a nutshell this is what we are communicating to our institutional investors and corporate relationships:

1. ***Offshore is poised to accelerate in 2015.***
2. ***Midstream (pipelines).*** Strong expansion continues to get upstream energy supplies to market, supported by capital availability and approval of condensate shipments (recent approval to start exporting energy).
3. ***Refineries.*** Because of condensate export approvals (meaning lightly refined product) expect rising demand for new, modern LNG/LPG tankers and infrastructure.

Energy export is becoming a major opportunity for you. Get out in front of it. And we include the marine transport sector.

Mining. *Still* wretched. But the worst is over. Caterpillar mining revenue fell (37%) in 2Q with aftermarket almost flat. The U.S. market alone was down (28%). Dealer inventory declines are moderating and sales were up 6% vs. 1Q — but don't expect a rapid upturn, given awful coal market conditions exacerbated by weak China demand for iron ore, coal and capital.

Power generation. More of same, near-term. Band-Aid sales (wind turbines) are strong, gas is advantaged in U.S. vs. coal and trending upward.

Transportation infrastructure. Nothing major, pre-election. Highway "Trust Fund" about as well-funded as a college student. No solution before '16 elections and no political will to fund through higher gas taxes or other revenue. This is problematic from the standpoint of U.S. competitiveness.

Water & environmental. Municipal budgets and tax receipts are modestly improving. Recent concern about slower U.S. housing starts will prove overblown; prices are up, supply has declined. Municipals are already increasing purchases of things like garbage trucks.

Machinery. *North American truck demand continues to accelerate* — with Cummins raising its full-year heavy duty truck revenue guidance to +14% — from +11% (2Q was +10%). *Construction equipment demand will grow* despite a couple headwinds — namely China and lack of U.S. highway funding — owing to easy comparisons and improving, non-residential construction activity. *Agriculture will remain soft against comparisons* on lower farm cash receipts, but still at a healthy level.

Consumer (auto, appliances). Global auto demand remains secularly positive, and U.S. sales will continue to benefit from a growing economy and aging fleet. Housing start sluggishness has raised concern, but we note that home *prices* are improving as inventory declines. Every reason to think conditions will continue to support sales of construction equipment.

Aerospace/Defense. Commercial air transport remains strong and the recent Farnborough air show yielded strong orders for Boeing, General Electric and United Technologies. Aftermarket activity remains robust. Defense-related declines have moderated and our secular view (more defense spend) has been fleshed out.

C.H.I.E.F. Issues Update

Back in February we spent time discussing the "C.H.I.E.F" issues impacting the current economic recovery and the long-term health of the U.S. economy.

Corporate tax reform
Housing
Immigration
Education and Employers
Finance

Corporate tax reform. I actually think this gets done in 2015. There is bipartisan agreement and support. Scenarios against this would be Democrats retain majority and Harry Reid stonewalls. A Republican-led House and Senate could deliver a bill and probably get pragmatic Democrats to go along (they do exist).

Housing. The economy has strengthened enough to pull back on "quantita-

tive easing," but employment concerns will keep Federal Reserve Chairman Janet Yellen from hiking interest rates that could derail a housing recovery and employment growth. While inflation is a concern, we see real unemployment as being too high to drive broad wage hikes.

Immigration. Given the orchestrated border issue / political stunt, with its human toll, nothing happens in '14. Long-term, the 11 million people living here *are not leaving* and another 100,000 people are a rounding error. But this could now take a while. Democrats want additions to their voting bloc, corporations want access to "ready labor;" engineers, scientists, unskilled, and much of the U.S. population is saying, "Oh, and what about us?" Stay tuned. This is messy.

Education & Employment. Health care, education, and training; we address some moving parts shortly.

Finance. While the drag of increased regulation and compliance from Dodd-Frank continues to impact major banks, the availability of credit for large companies and large deals remains high. We've also seen improved access to capital for smaller companies.

Das (Human) Kapital

Just in case you missed it — which you did not — the economic statistics show continued growth, rising corporate profits and improving consumer confidence. After the near-depression experience of 2008–2009, this is to be expected. But it is not good enough. In addition to weak employment growth, health care costs continue to rise, labor policies create obstacles, and the middle class is struggling to maintain their "margin" between income and expenses.

Unfortunately, it affects your revenue, your profits, and your ability to find, train, and retain good people. But, being the great businessperson you are, there is always another way to skin a cat. Sometimes you get price — great! Oftentimes, you must find a way to do more with less or *get more for less*.

First, let's show how government does not help:

Health Care. I have a high-deductible family health insurance policy through Aetna. No extras like prescription drug benefits, etc. I have health insurance simply to ensure emergency room access if we ever need it and to get some benefit from Aetna's supposed purchasing power on health care and medicines. In the last four years I have probably paid in about $25,000 in premiums and collected zero in reimbursements. No worries — I would rather be healthy and spend less. What is disconcerting is that somehow, in the past three months, a prescription medicine I take, and which had been steadily priced at $220–$230 per month for about four years, has ballooned to $300 per month since ObamaCare more or less went into effect. I have no reason to believe the raw material costs went up by 20%. I believe I am being forced to subsidize a botched reform and Aetna has done *nothing* to represent my interests as their customer. I have told them as such.

What can you do about it? Near-term, very little. Implementation issues, enrollment shortfalls and litigation of a

range of issues, plus an election year, mean air cover for insurance carriers to raise rates, play with exclusions, etc. I think, over time, that more cost-effective solutions can be devised to include a degree of "self-insurance" at the employer level; but large companies will tackle this first.

Education. A full year at the University of Illinois with tuition, books, room and board, and incidentals is now priced at $30,000 – 35,000 per year for in-state. This happens because price rises to absorb all available government funding and student loans. But change is coming. The University of Indiana, now being led by former governor Mitch Daniels, is working on the theory that there was no need for a 75% increase in administrators, and is designing a 3-year degree based on *knowledge* — not just classroom hours.

Alert, Alert, Alert. Starbucks recently cut a deal with Arizona State University that portends a big opportunity for companies to attract, retain and reward employees — and also help the company. Besides goodwill and a concurrently announced price increase, Starbucks is seeking to improve employee retention. The online degree program at ASU is $3,000 – 10,000 per year for an individual. Compare that to U of I on campus. Starbucks intends to deliver 15,000 – 21,000 students to ASU and pay for all or part of their school. Let's assume they negotiated a ⅓ discount to $2,000 – 7,000 per year. If Starbucks pays even half, it would cost them no more than $3,500-per-head (<$2/hour) and their employee/student can pay out of pocket and graduate with work experience and no debt. Everybody wins!

Can your 40-person shop get that same deal? Probably not. But why not have the AGMA negotiate a discount with a few "brand name" schools and technical colleges for all AGMA members, their employees *and the families of their employees?* Could this be a way to provide a valuable benefit without breaking the bank, and helping to offset health care cost pressures? Hmmm.

My point is there are innovative paths to leverage purchasing power and negotiating capabilities that come with hard-earned experience to benefit your organization *and* your employees!

Langenberg & Company	PERCENT TOT.		CHANGE		REVENUE		
	COMPANY	REGION	Y/Y	Q/Q	Act.	Prior Qtr	Prior Yr
CATERPILLAR							
Energy & Transportation	16%	38%	2%	9%	2,259	2,082	2,215
Construction Industries	17%	41%	21%	15%	2,402	2,092	1,989
Resource Industries	6%	15%	(28%)	19%	866	725	1,198
NORTH AMERICA	**42%**		**6%**	**13%**	**5,881**	**5,219**	**5,526**
Resource Industries	4%	19%	(41%)	5%	510	484	864
Energy & Transportation	7%	38%	(8%)	16%	1,040	894	1,128
Construction Industries	8%	41%	(1%)	(11%)	1,102	1,242	1,116
ASIA PACIFIC	**19%**		**(14%)**	**1%**	**2,713**	**2,677**	**3,142**
Energy & Transportation	10%	44%	4%	6%	1,406	1,329	1,352
Resource Industries	4%	16%	(41%)	(2%)	523	532	879
Construction Industries	8%	37%	14%	4%	1,192	1,144	1,044
EAME	**23%**		**(3%)**	**3%**	**3,202**	**3,105**	**3,312**
Resource Industries	2%	21%	(46%)	(15%)	342	402	630
Construction Industries	5%	45%	1%	21%	711	586	701
Energy & Transportation	3%	29%	(17%)	(0%)	470	471	568
LATIN AMERICA	**11%**		**(16%)**	**5%**	**1,595**	**1,512**	**1,906**

FOCUS COMPANY: CATERPILLAR (CAT)

We are revisiting Caterpillar because it is a) large and important; b) you care; and c) changing trends that warrant your attention. CAT generated strong financial results, despite revenue softness. Positives include continued North American demand in construction — which should continue — and signs that the mining debacle has passed its worst.

But we also detect difficulties. First — China is softening. Excavator demand has slowed and Cummins, a major supplier in China and to CAT, is calling for China excavator demand to fall (14%) for all of 2014. Further, China is showing no signs of increased appetite for iron ore and metallurgical coal, which puts a damper on mining and Australia.

Second, locomotive production is running flat out this year in front of higher emissions requirements, and the company is signaling clearly a sharp decline in 2015 – 2016.

Finally — the company is authorizing $2.5 billion in share repurchase, signaling they have plenty of productive capacity.

So while things are not terrible, we sense overall demand upside is limited.

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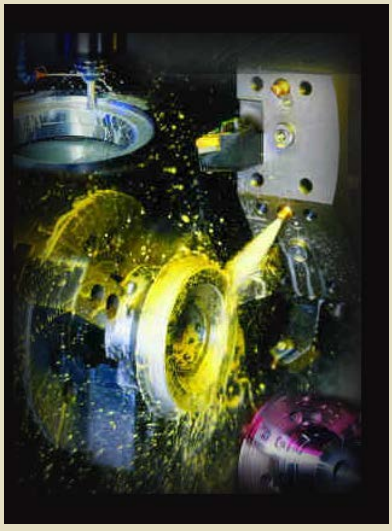
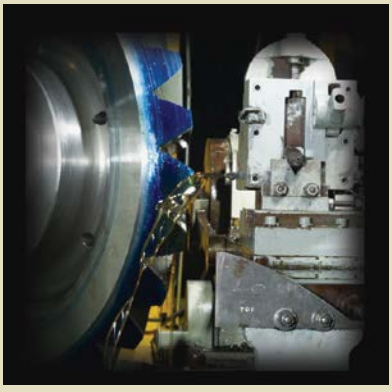
Brian K. Langenberg, CFA, has been recognized as a member of the Institutional Investor All-America Research Team, a *Wall Street Journal* All-Star, and *Forbes/Starmine* (#1 earnings estimator for industrials). Langenberg speaks and meets regularly with CEOs and senior executives of companies with over $1 trillion in global revenue. His team publishes the *Quarterly Earnings Monitor/Survey*—gathering intelligence and global insight to support decision-making. You can reach him at *Brian@Langenberg-llc.com* or his website at *www.Langenberg-LLC.com.*

CUSTOM
BEVEL GEAR MANUFACTURING





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Wittenstein

ANNOUNCES NEW DIRECTOR OF SALES

Wittenstein North America recently announced that Tom Coyle has been promoted to director of sales. Coyle has been a crucial member of the organization for over 14 years holding positions as a service technician, application engineer, regional sales engineer, national sales manager, and now director of sales. This new role will widen his reach on positively impacting the organization to continue providing and improving a customer focused strategy. As director of sales , he will continue to lead the sales organization, and will gain responsibility for inside sales, technical support, and customer service. Coyle will lead, develop, and build the North American sales organization in line with the overall Wittenstein group strategy. He will also be responsible for developing and supporting North American sales channels in conjunction with Wittenstein AG and support necessary processes to grow the North American business. He will continue to be based out of the Wittenstein North American headquarters in Bartlett, Illinois.

Siemens

COLLABORATES WITH STREETSCOOTER ON ELECTRIC CAR

Siemens' central research department and the electric vehicle manufacturer StreetScooter agreed to equip an electric car with an innovative electronic and software architecture. The associated technology was developed during the RACE project. Siemens is the consortium leader of the research project, which receives funding from the German Ministry of Economic Affairs and Energy. For the first time ever, the architecture will make it possible to retrofit functions such as electrical brakes and systems such as lane-keeping assistants using a plug-and-play process like on home PCs. The two companies plan to incorporate the RACE architecture into an electric delivery vehicle by December 2014. The work will be conducted at Siemens' research center in Munich, Germany. The partnership's aim is to test the new technology in practice for the first time. For more information, visit *www.siemens.com*.

According to Prof. Armin Schnettler from the Siemens central research department (right), the technology could revolutionize car design. Achim Kampker, managing director of StreetScooter (left) wants to be able to integrate updates and individualize pioneering developments for his customers.

IDC-USA

PARTNERS WITH BRANCE-KRACHY

Headquartered in Houston, Texas, Brance-Krachy has been providing power transmission and cathodic protection solutions to customers since 1932. They strive to exceed their customers' expectations in service, quality and product selection because they know every order carries their reputation. In addition to these high standards, Brance-Krachy supports its customers through innovative and flexible purchasing and stocking programs. Jim Schulte, president, and Scott Hunt, vice president, of Brance-Krachy were looking to improve purchasing and data management. "We needed a way to streamline our business and the answer was partnering with IDC-USA," stated Hunt. "Now we can combine orders of various product lines from multiple suppliers." Additionally, they now have a tight-knit community of other independent distributors and suppliers from all corners of the industry to share operational and organizational expertise.

Established in 1988, IDC-USA is a distributor-owned purchasing and national marketing cooperative of independent distributors of industrial bearing, power transmission and industry related products. The cooperative currently consists of over 300 independent distributor branches located nationwide. IDC-USA's Distribution Center, IDC University and corporate offices are headquartered in Indianapolis, Indiana. IDC-USA serves the western half of the United States from its Reno, Nevada distribution center.

Comer Industries

JOINS VDMA

Comer Industries has officially become part of the German Engineering Federation VDMA. Representatives of both companies met at Comer Industries' plant in Matera (Italy), where Dirk Decker, deputy managing director of VDMA Power Transmission, personally handed to Comer Industries' Managing Director Matteo Storchi the plate of association. The presentation took place during the visit to Comer Industries› plant in Matera of the delegation of the Eurotrans (European Committee of Associations of Manufacturers of Gears and Transmissions Parts) annual meeting, of which VDMA is a member. Eurotrans' meeting was held in Bari last June 26-27, as an annual gathering of European associations, the American Gear Manufacturers Association (AGMA) and the companies they represent.

The event has been organized by Assiot, the Italian Association of Gears and Transmission Elements Manufacturers. Agenda included visits to associated companies in the industry. "In line with the corporate mission to be preferred

supplier of the leading manufacturers of agricultural machinery, construction equipment, industrial, and renewable energy applications worldwide, we have decided to join VDMA Power Transmission to sustain our company's success. This is a further step to strengthen our position in the growing market of Germany," said Storchi.

Caption: Dirk Decker (right) of the VDMA welcomes Matteo Storchi (left).

The VDMA has key functions for networking in Germany, where companies share experiences, collaborate and develop complex topics for the industry. Within the organization, customers, suppliers and competitors can discuss fundamental issues and develop solutions. "Comer Industries will not be the only one to benefit from the VDMA Association. Also our customers and potential clients can reap the advantages of this membership, as the VDMA will contribute to the ongoing development of Comer Industries' products," continued Storchi.

Ohio Electric Motors

WELCOMES SALES & MARKETING MANAGER

Ohio Electric Motors, Inc. recently announced that Randall R. Snyder will be their new, sales and marketing manager. "I am extremely pleased to announce that Randall Snyder will be our sales and marketing manager," said Ken Cooper, general manager of Ohio Electric Motors, Inc.

Snyder has an exceptional background and work history combining engineering, technical service, manufacturing and managerial experience. His scientific knowledge, manufacturing, client service and sales experience will be of great benefit to our customers in fulfilling their motor product requirements and changing application needs.

Ohio Electric Motors produces a diverse line of standard and custom-designed DC motors, including brushless, wound field, explosion-proof, SCR rated (interchangeable with other brands), permanent magnet, battery powered, hydraulic pump, material handling and other special application types.

Snyder was formerly the corporate director of sales/client services for Southern Petroleum Laboratories, Inc. Prior to that position, Snyder has held engineering, marketing, technical and sales management positions for several industrial manufacturing, engineering and technical service companies, including: Dynamic Flow Computers, Bayer Engineering & Technical Sales, Co., Acran, Inc., AT&T, Daniel Measurement & Control, Breard-Garner, Inc. and Oceaneering International, Inc.

Snyder has studied electrical engineering at Mississippi State University (Starkville, MS). He has also completed a variety of manufacturing technical training courses for Liquid, Gas and Ultrasonic Flow Measurement, Magnetic Flow Metering, ASTM and GPA Methods for Hydrocarbon Analysis, Transient Voltage Surge Suppression, Gas Chromatography and Liquid/Gas Turbine Flow Metering.

VDMA Machine Vision Board

WELCOMES NEW MEMBERS

Donato Montanari, general manager of the Machine Vision Business Unit of Datalogic Automation in Italy, and **Lou Hermans,** COO at CMOSIS in Belgium were recently elected by the VDMA Machine Vision members to strengthen the board of the VDMA Machine Vision unit. The election was conducted as a result of the decision taken at the last Members' Assembly of VDMA Robotics + Automation with regard to the opening of the association to European members. "Becoming a member of VDMA is natural for CMOSIS since we already have a very good working relationship with many members of its Machine Vision Group. There is a big potential for stepping up the technological leadership of our group if we work closely together, and VDMA Machine Vision provides an excellent platform for us to do so," said Hermanns.

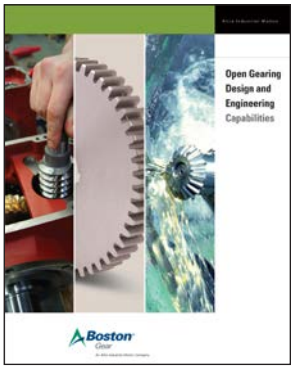
Montanari added: "I would like to thank the VDMA and its members for the opportunity of serving on the board. As a non-German member, I will make it my first goal to increase the number of non-German companies in the association. I am convinced that European companies can bring a different and complementary perspective to the machine vision industry."

According to the results of the recent VDMA Machine Vision Market Survey, the industry turnover of the machine vision industry in Germany increased its turnover by 8% in 2013 reaching the mark of 1.6 billion euro. The growth impetus came mostly from exports: While domestic turnover stagnated, exports from Germany went up by 15% in 2013. The export share rose from 55% to a new all-time high of 58%. Due to a very favorable order intake in the first five months of this year, the German machine vision suppliers are expected to expand their sales volume by 10% in 2014 exceeding a sector turnover of close to 1.8 billion euro. According to the latest VDMA market survey, the sector turnover in Europe grew even by 10%, with a further growth expectation of 12% in 2014.

Boston Gear

HIGHLIGHTS OPEN GEARING CAPABILITIES

A new brochure from Boston Gear provides an overview of the company's open gearing design and engineering capabilities. A wide array of gearing solutions are available including spur gears, worm and worm gears, spiral and straight miter gears, bevel gears, and helical gears. Engineering assistance is provided to help ensure that customers select the optimum gearing solution from over 2,500 in stock gearing products, all with immediate availability. If a stock gear is close to meeting customer requirements, Boston Gear engineers can quickly provide a stock product with various modifications including reduced face width, added keyways, added tapped holes, enlarged bores and reduced hub diameter and projection. Most modified stock gears are shipped within 24 hours. In many cases, a fully customized gear solution is required. Customers can rely on the vast experience and expertise of Boston Gear engineers to design the most economical custom gearing solution without long lead times. Boston's in-house test lab can simulate, evaluate and troubleshoot applications.



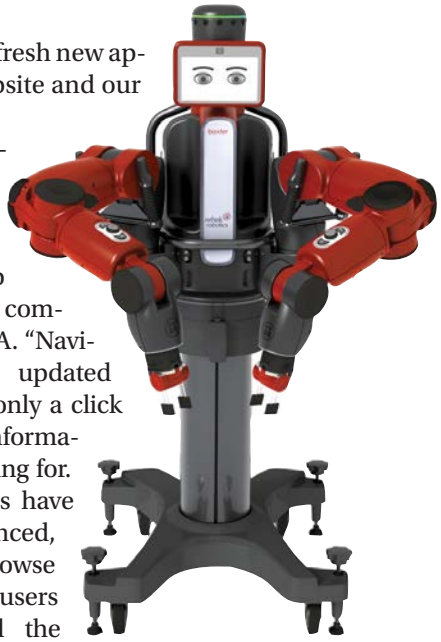
RIA

CELEBRATES 40 YEARS OF ROBOTICS

The Robotic Industries Association (RIA), the trade association for the North American robotics industry, has launched a completely redesigned website. Robotics Online, the online resource for robotics which has more than 330,000 visits each year, has been extensively updated with a new look and navigation capabilities. In conjunction with the updated website and in celebration of the organization's 40th anniversary, RIA has also unveiled a new logo.

"The new RIA logo refreshes our brand while sticking to our roots of being the robotics industry advocate for over 40 years," said Jeff Burnstein, president of RIA. "The design reflects how we strive to connect the robotics and automation community around the world through education, promotion and advancement of robotics, related automation technologies and companies delivering integrated solutions. We're

excited about the fresh new approach to our website and our updated look."



"The new Robotics Online is a much improved experience for visitors," said Bob Doyle, director of communications at RIA. "Navigation has been updated so that users are only a click away from the information they are looking for. Search capabilities have been greatly enhanced, along with a 'Browse By' function, so users can quickly find the products, companies, and services that meet their needs. The rotating home page graphic will highlight the most important upcoming events, educational opportunities and news that the robotics industry needs to know.

"The Industry Insights articles will continue to provide the latest in-depth news on the robotics industry," Doyle added. "Member news will always be prominently displayed on the home page, along with upcoming educational information, webinars and events that will keep you abreast on the latest advances in the industry." For more information, visit *www.robotics.org*.

Adcole Corporation

NAMES REECE PRESIDENT AND CEO

Adcole Corporation, a manufacturer of special purpose machines for measuring engine components such as camshafts, crankshafts, and pistons, as well as sun angle sensors for space satellites has appointed Brook Reece president and CEO. Adcole was founded in 1957 by Addison D. Cole who was president and CEO for 57 years, retired at age 95, and sold the business to Artemis Capital Partners. Terms of the purchase were not disclosed. Reece previously served as vice president sales at Adcole Corporation for 20 years and is uniquely qualified to lead the company. "Our heritage is one of innovation and trusted accuracy and our vision is to be the most trusted and valued name in the space and industrial metrology industries. We are presently on an extremely fast product development track in response to the rapid technological changes in engine development. Innovation is our heritage and central to our future business strategy," he said.

September 8–13—IMTS 2014. The International Manufacturing Technology Show (IMTS) is the largest manufacturing technology show in the Western Hemisphere. IMTS 2012 drew more than 100,000 industry decision-makers in areas like metal cutting, tooling, metal forming, abrasives, controls, CAD-CAM, EDM, gear generation, industrial automation and more. The IMTS conference brings the industry together to discuss new opportunities and network with the manufacturing community. Other highlights include the Smartforce Student Summit, Exhibitor Workshops, the Emerging Technology Center and IMTSTV. IMTS is co-located with Industrial Automation North America and Motion, Drive & Automation North America. For more information, visit *www.imts.com*.

October 7–8—AWEA Offshore Windpower 2014. Sheraton Atlantic City Convention Center, Atlantic City, New Jersey. 2014 has become a turning point for the U.S. offshore wind energy industry. With projects in advanced stages of development, lease auctions in several states, and additional government funding for advanced technology demonstration projects, the U.S. offshore wind energy industry is picking up speed and momentum. The United States has a vast offshore wind energy resource and in early 2011, the U.S. Department of the Interior (DOI) and the U.S. Department of Energy (DOE) unveiled a coordinated strategic plan to achieve the deployment of 10 GW of offshore wind power capacity by 2020 and 54 GW by 2030. State and federal processes for developing offshore wind projects in the U.S. were well underway at the end of 2013, with 12 offshore wind projects in the proposal stage. These projects span 10 states off the east, west, Great Lakes and Texas coasts and represent over 5,000 MW of offshore development with turbine sizes ranging from 3.0 to 6.0 MW, along with a transmission project that could carry up to 7,000 MW. For more information, visit *www.awea.org*.

October 14–16—GFMC 2014. MGM Grand, Detroit, Michigan. The Global Forecasting and Marketing Conference is where industry experts will provide presentations on technology forecasts, end-user forecasts, sales strategies and marketing tips. The gathering of 200-250 leaders in the manufacturing industry provides a forum to network and discuss the future of the industry. The Association of Manufacturing Technology (AMT) promises in-depth conference presentations as well as quarterly updates via webinar and analysis from AMT's Industry Intelligence staff using several forecasting resources for members. For more information, visit *www.amtonline.org*.

October 22–24—ASME DSCC 2014. Marriott Plaza Hotel, San Antonio, Texas. The Dynamic Systems and Control Conference (DSCC) is the showcase technical forum of the Dynamic Systems and Control Division (DSCD). It provides a focused and intimate setting for dissemination and discussion of the state of the art in dynamic systems and control research, with a mechanical engineering flavor. The 2014 DSCC technical program will cover the modeling, simulation, analysis, design, and control of dynamical systems. Topics will include control theory, industrial applications, and innovations in dynamical systems and control education. Technical themes for the conference—including advanced manufacturing, renewable and traditional energy, bioengineering and biomedical engineering, and cybersecurity for critical infrastructure—will be featured in special tracks. The program will include contributed sessions, invited sessions, tutorial sessions, special sessions, workshops, and exhibits. For more information, visit *www.asmeconferences.org*.

October 22–25—PTDA 2014 Industry Summit. Orlando, Florida. Join more than 550 delegates for a networking event from the leading distribution and manufacturing companies involved in the PTDA. The summit includes educational workshops, networking forums, one-one-meetings, social events and an optional golf outing. Mike Ditka will give a keynote presentation on "Attitude, Character and Enthusiasm," on Friday October 24.Alan Beaulieu will give a keynote address called "The Beaulieu Report" that provides an accurate and straightforward forecast of the PT marketplace. For additional information, visit *www.ptda.org*.

November 2–5—Pack Expo International 2014. Chicago, Illinois. Decision makers from a broad range of industries come to Pack Expo International for the opportunity to talk shop with vendors and "think outside the plant." Corporate managers, engineers, sales managers, plant managers, manufacturers and production supervisors, brand and marketing managers, quality controllers, purchasers, research/development and package designers from across the U.S. and around the world find value in learning where their companies stand on the technology curve and how they can provide flexible options for their customers. For more information, visit *www.packexpointernational.com*.

November 14–20—ASME 2014 IMECE. Montreal, Quebec. The annual ASME International Mechanical Engineering Congress and Exposition (IMECE) is the premier global conference that focuses on today's technical challenges, research updates and breakthrough innovations that are shaping the future of engineering. The Congress convenes engineers, academics, scientists and technologists of all disciplines for the purposes of exploring solutions to global challenges and for the advancement of engineering excellence worldwide. Engineers have long contributed to human progress by solving complex challenges on a global scale. Many of these challenges are found in developing and emerging markets, particularly as they relate to critical infrastructures, such as access to energy, clean water, effective sanitation and healthcare. For more information, visit *www.asmeconfernces.org*.

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For publication guidelines and more information, please contact Jack McGuinn at *jmcguinn@powertransmission.com*.

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Solving the Longitude Challenge

300-Year-Old Discovery Remains Vital to Scientific Research Today

Photo courtesy of the National Maritime Museum, London.

Global position is described by two coordinates, latitude and longitude. Lines of latitude measure positions north and south and run parallel to the equator. Lines of longitude run pole to pole and measure positions east and west. Latitude is easy to measure from the sun. Longitude presents a bigger challenge. In the early 1700s, countries including Spain, the Netherlands, and France offered rewards for solving the longitude problem. But it was Britain that the approach paid off as a result of the 1714 Longitude Act.

In 1714, the British Government offered, by Act of Parliament, £20,000 for a solution which could find longitude to within half a degree (equivalent to 2 minutes of time), and a group later known as the Board of Longitude was set up to assess submissions and offer rewards. These experts included the Astronomer Royal at Greenwich and other scientific, maritime and political leaders. It was considered by many one of the greatest scientific challenges of the century.

One of the remarkable things about the longitude story is that two practical solutions were developed at the same time. In the field of mechanical timekeeping, John Harrison, a working-class joiner and clockmaker with little formal education came closest to receiving the reward money through his extraordinary mechanical talent and determination, culminating in his marine timekeeper, H4. This would become the instrument known as the marine chronometer. At the same time, the work of John Hadley, German astronomer Tobias Mayer and others perfected the instruments and astronomical tables necessary for the lunar distance method. Greenwich was central to the story.

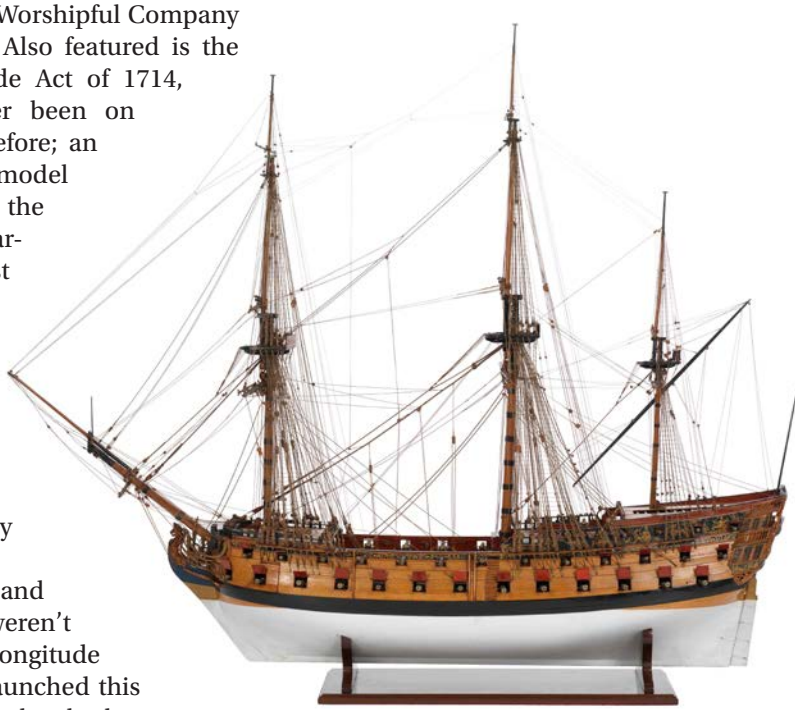
Above all, Astronomer Royal Nevil Maskelyne's observations at the Royal Observatory, his work on the Nautical Almanac and the Board of Longitude demonstrated the complementary nature of astronomical and timekeeper methods, ultimately leading to the successful determination of longitude at sea. As solutions were developed, the Royal Observatory became a testing site for marine timekeepers and the place at which the astronomical observations needed for navigational tables were made. It was this work that would eventually lead to Greenwich becoming the home of the Prime Meridian, zero degrees longitude for the world.

To mark the tercentennial of the Longitude Act of 1714, a new exhibition at the National Maritime Museum (located in Greenwich) runs from July 2014 to January 2015 called, "Ships, Clocks & Stars: The Quest for Longitude." This exhibition draws the latest research to shed new light on the history of longitude and how it changed our understanding of the world.

Highlights from the exhibition include all five of Harrison's famous timekeepers. H1, H2, H3 and H4 will move from the Royal Observatory Greenwich to be displayed in the National Maritime Museum for the first time in nearly 30 years. H5 is being loaned from the Worshipful Company of Clockmakers. Also featured is the original Longitude Act of 1714, which has never been on public display before; an intricate 1747 model of the *Centurion*, the ship which carried out the first proper sea trial of Harrison's H1, and the elegant, padded silk 'observing suit' worn by Nevil Maskelyne at the Royal Observatory during the 1760s.

If exhibitions and celebrations weren't enough, The Longitude Prize 2014 was launched this year to bring together both amateur and professional scientists to help solve some of *today's* greatest global challenges. The Longitude Committee (led by Astronomer Lord Martin Rees) brought together more than 40 scientists, engineers and politicians to discuss global challenges in energy, environment, global development, technology/robotics, communications and health and wellbeing.

After a heated debate, the British general public had the opportunity to vote on the proposed area of concentration for the Longitude Prize 2014 and the public chose antibiotics. The challenge is to create a cost-effective, accurate, rapid and easy-to-use test for bacterial infections that will allow health professionals to administer the right antibiotics at the right time. The Longitude Committee and Nesta are finalizing the criteria for how to win the £10 million prize. Contestants will have five years to solve the challenge. The success of this research will mirror that of the inventors, scientists and curiosity seekers that came together back in 1714. For more information, visit *www.rmg.co.uk* or *www.longitudeprize.org*. **PTE**



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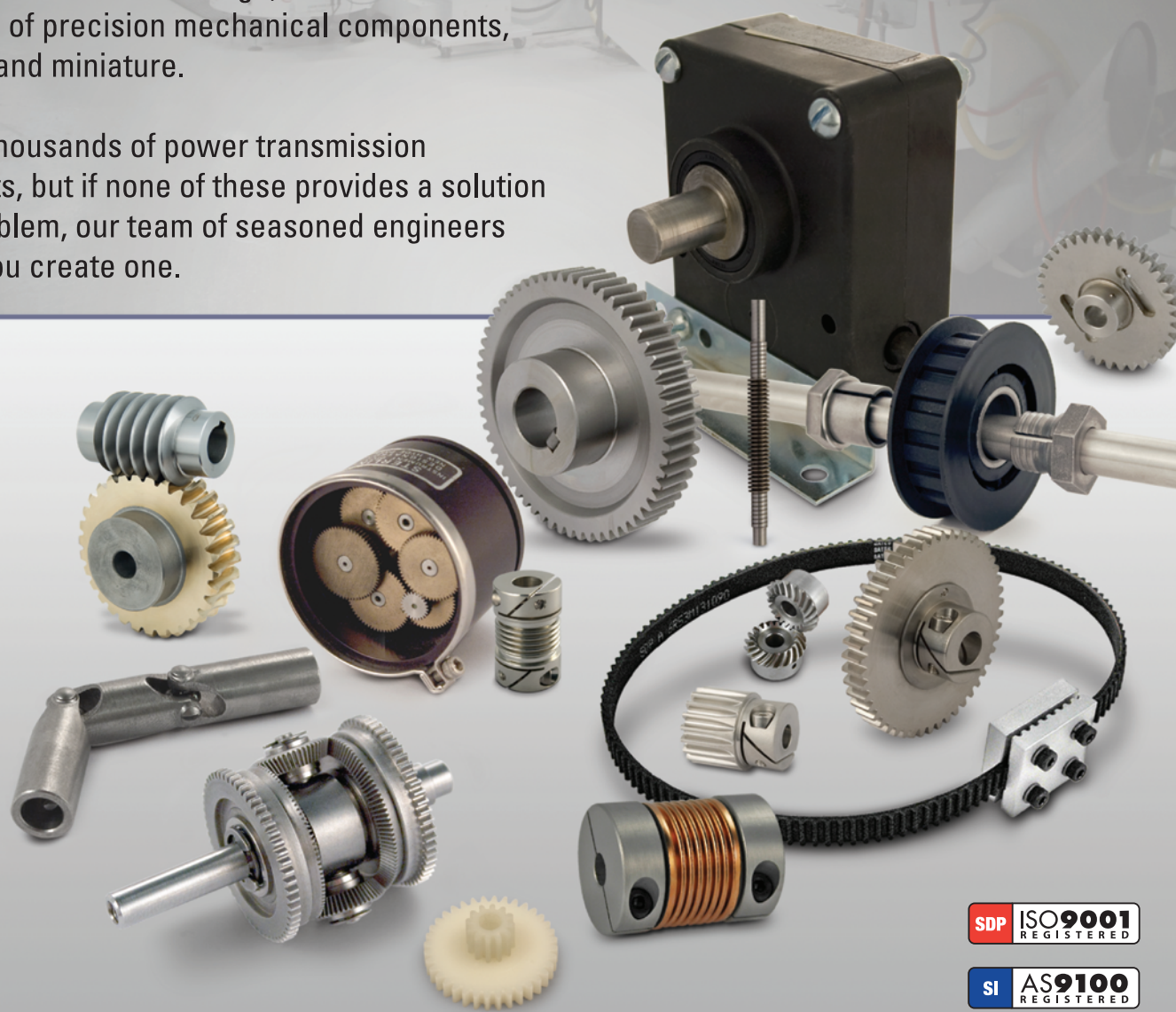

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