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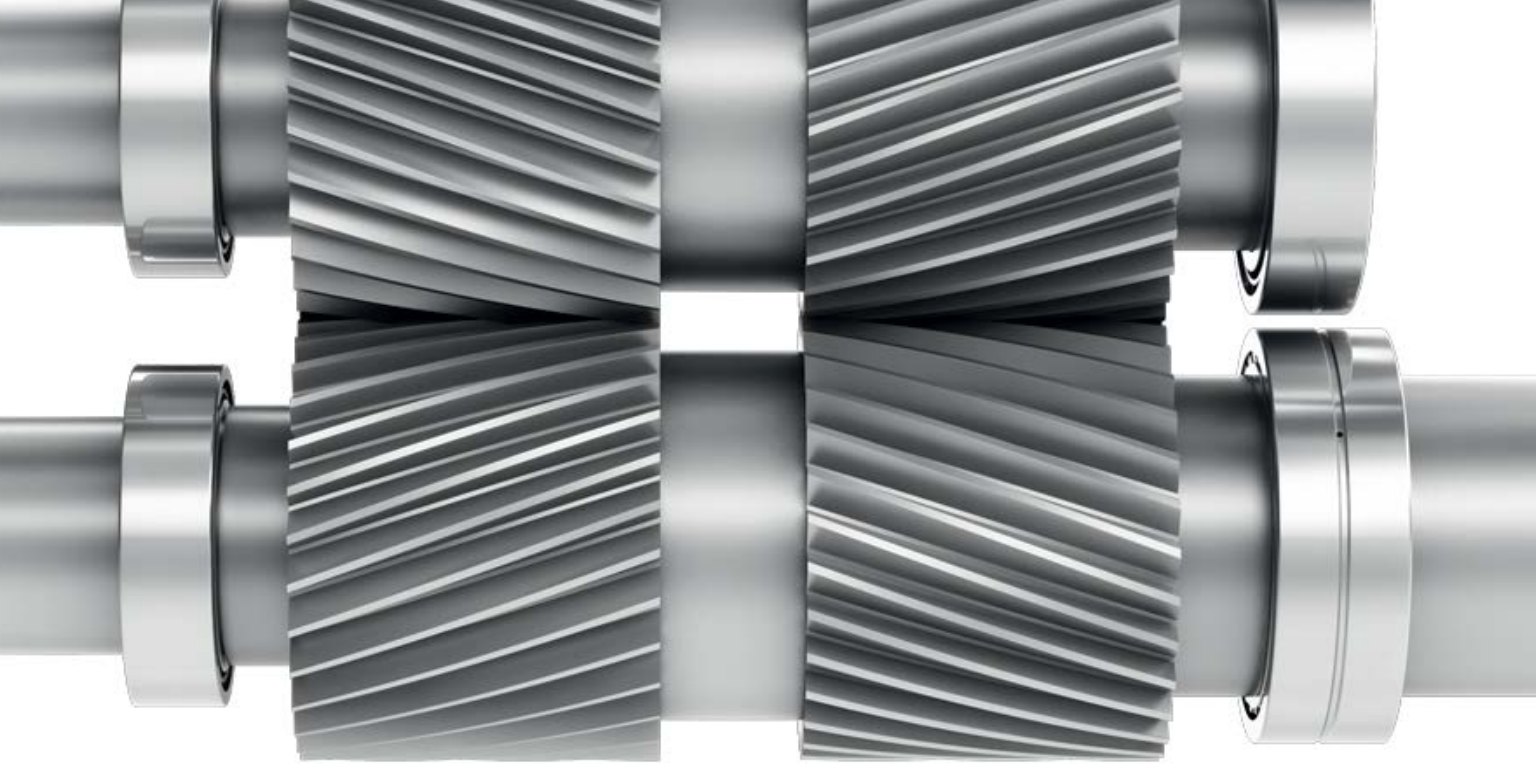
FEATURE ARTICLES

TECHNICAL ARTICLES

Power Transmission Engineering

VOL. 7, NO. 3

Photos by David Ropinski



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Mobility: Check out the PTE Facebook page for the latest information on mobile apps in manufacturing. Companies like SKF, Bosch Rexroth and Baldor are letting iPhone and Android users access a comprehensive range of products and services. *www.facebook.com/pages/Power-Transmission-Engineering/109042075794176.*

PTE Videos: Baldor's motor range addresses key products engineered to perform for demanding applications in poultry processing. Visit *www.powertransmission.com* to see these products featured in a recent Baldor video.

PTE Newsletter: Managing Editor Randy Stott reports on the recent opening of a Siemens geared motor assembly plant in Mauldin, South Carolina. "This factory puts us closer to our machine builder and manufacturing customers," said Doug Keith, president of Siemens Drive Technologies Division North America. Check out this story and more in the May E-newsletter at *www.powertransmission.com/newsletter/pt0513.htm*.

PTE Calendar: Our comprehensive online calendar/event section offers a place to let *PTE* readers know about your upcoming trade show, seminar, gear school or other calendar item. Send your press releases to Matthew Jaster at *mjaster@powertransmission.com*.

Ask the Expert

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

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Randy Stott, Managing Editor

Chasing Ubiquity

Power Transmission Engineering is the magazine of mechanical components. When you think of gear drives, bearings, motors, couplings, clutches, brakes and similar products, we want you to think of us.

But achieving such front-of-mind presence is one of the most difficult goals in publishing, so we have to work hard to achieve it. We have to earn your trust by providing information you can't get anywhere else. You're too busy to chase after every bit of information you need. So we act as your filter, your gatherer and your guide.

And the information doesn't just find us. We have to find it. And that means digging. And traveling. And getting involved in the industries that are important to you. Lately we've been working harder than ever to put ourselves where the most important information is — whether that's at a trade show overseas, a conference across the country or a supplier factory in another state. We talk to the people who make mechanical power transmission components, gathering the insight you need to make smart decisions about the components you use in your machinery.

Here are some of the highlights of where we've been over the past few months.

- **Hannover Messe** — Associate Publisher Dave Friedman and Senior Editor Matt Jaster traveled to Hannover and met with key executives of power transmission component suppliers from around the world. Matt's interview with SKF President & CEO Tom Johnstone appears on page 29. Additional coverage of the show appeared in our April newsletter (*www.powertransmission.com/newsletter*).
- **Gear Forum (Parma, Italy)** — Publisher Michael Goldstein was invited as a guest speaker at this prestigious event featuring leaders of gear and power transmission related organizations around the world.
- **AGMA/ABMA annual convention** — Publisher Michael Goldstein and Associate Publisher Dave Friedman visited with leaders of the gear and bearing industries in La Jolla, California at the associations' annual events.
- **PTDA annual meeting** — Associate Publisher Dave Friedman met with executives from leading manufacturers and distributors of power transmission components.

In the past couple of months, I've traveled to Brevini Wind USA to see a world-class large gear manufacturing facility, as well as Siemens' new Simogear assembly plant in Mauldin, SC to learn how a purpose-built lean assembly facility improves the geared motor supply chain and gets products more quickly to those of you who need them. Senior Editor Jack McGuinn just returned from visiting the new SKF Solution Factory in Cleveland, where he learned about SKF's regional services including bearing application support, spindle and ball screw repair, remote diagnostics and monitoring and other services.

In addition, we've either visited or exhibited at a number of trade shows important to the industries you're involved with, including Automate 2013, ProMat 2013, Windpower 2013 and Sensors Expo.

This month we'll be exhibiting at PowderMet 2013, and in the future, we'll be exhibiting at Gear Expo in Indianapolis (Sept. 17–19), PTC Asia in Shanghai (Oct. 28–31), IPTEX 2014 in Mumbai (Feb. 27–March 1, 2014) and IFPE in Las Vegas (March 4–8, 2014). We hope you'll stop by one of these shows to visit with our staff and learn more about how our products can help you stay on top of the latest technology in mechanical power transmission.

In addition to being in as many places as possible where there is news and information about the latest technology, we have also stepped up our efforts to expand our circulation to reach as many individuals as possible who are interested in mechanical power transmission products. We appreciate those of you who have answered our e-mails or phone calls and subscribed. But if you received this issue of the magazine with a subscription card attached to the cover, that means your subscription isn't current. Please fill it out and send it in. Of if you know someone else who could benefit from the information we provide, please direct them to *www.powertransmission.com*, where they can subscribe online for free.

As long as you keep reading—and subscribing—we'll continue to do the best we can at being where the news is and covering the world of mechanical power transmission components.

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Every day, thousands of power transmission manufacturers around the world rely on precision stock gears produced by Arrow Gear Company.

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With over 65 years experience, Arrow's stock gears are manufactured with the same processes used for our custom aerospace products. With a state-of-the-art production facility and dedicated personnel who are among the best in the business, Arrow Gear offers the expertise and precision for the most demanding quality requirements.

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Predictive Maintenance: There's an App for That

Thomas Hoenig, President of GTI Spindle Technology Inc.

Thomas Hoenig

Implementing a predictive maintenance (PM) program can be tough. Despite its proven success, many companies have been operating the same way for over 50 years and don't know where to start. Understanding where to start and where to focus is critical. The intention of this article is to give insight to start and sustain an effective program using today's technology and devices.

It seems only yesterday that we had to pull over to payphones, stop by the fax machines, or even mail a letter to get things done. In the past 10 to 15 years, technology has drastically changed the way business is done.

All of us are now equipped with devices that can receive emails, texts, video calls and run powerful applications. This technology has brought us much closer with each other and allows us to share data far more quickly than ever before.

We are now entering another level of data sharing using the Internet. Unlike the past, we are now able to send data off to a cloud storage environment. Once sent, authorized personnel can view the data in real time. This fundamental change provides many advantages, especially when we apply it to predictive maintenance.

For example, a very normal but hypothetical situation occurs. A maintenance professional is collecting data from assets and finds something drastically wrong that needs attention immediately. With today's technology he has more options at his fingertips than before. If he is collecting data from an Internet-connected device he can send the information to the cloud with an alert attached so that people monitoring will get the alarm. He may also be able to email or text this data to a decision-maker for immediate action.

In the past, no matter how the professional was collecting the data, he would have to wait until he was done with his route and come back to a computer and upload the data or do further analysis. With this scenario, many times an emergency is forgotten or takes precedence over other urgencies. Unless the professional actually leaves his post and stops what he's doing to alert a subordinate or decision maker, this rarely ever gets action.

This example is just a drop in the bucket of what we all are experiencing in our digital lives. Fifteen years ago, if you wanted to send a picture of your kids to your mother out-of-state, you would have had to lick a stamp and send it. Now we take the picture, type a few of the first few letters of an email or text address and hit send. Wow, what a world we live in!

This technology is catching up with industry and predictive maintenance.

Modern-day tablets, including Apple's iPad, are very powerful computers. We all understand the fascination of absorbing content on these wonderful devices, but it gets forgotten that they are also used for collecting data and getting work done. They are very portable and virtually always connected to the Internet. Thousands of companies have adopted these tablets for use in filling out purchase orders, forms and many other daily tasks by workers collecting data.

One of the most insightful things that leading companies have realized is that most people already understand how to use the operating system and do not require a learning curve to work with today's tablets and smart phones.

Infrared thermography data can be quickly and easily captured and put to use by modern tablet or smartphone devices (image courtesy of Flir).

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Taking all of this information to the next level, imagine the ability to add sensors and tools to these tablet devices; many companies are realizing the advantage of these tools.

Vibration analysis. Vibration analysis is one of the leading measurements taken in the predictive maintenance community of professionals. It has proven itself over and over again to be a method to detect imbalance, misalignment, bent shafts, eccentric rotors sheaves, resonance, mechanical looseness, oil whirl, bearing failures, gear mesh problems, motor problems and more. Most modern analyzers also have balancing capability to correct vibration issues on the floor related to imbalance.

More importantly, data collectors are designed to trend data over time to know exactly when failures will occur.

Infrared thermography. Infrared thermography is used to measure temperature to determine a machine's operating condition and detect thermal anomalies and areas that are hotter or colder than they should be. Infrared practices can be used to detect problems in electrical switch gear, gearboxes, electrical substations, transmissions, circuit breaker panels, motors, bearings, steam lines, and other important industrial components. This technology also aids in letting us know when important assets are going to fail.

Motor condition analysis. Circuit analysis and power readings of the motor windings and motor rotor can also tell us important information about the running condition and general health of the motor.

As mobile devices gain popularity, companies are adopting ways to use their simplicity, portability and connectability to everyday business tasks. We have seen them collect credit card information, bar code scans, photos, custom reports for field engineers, and even navigation data for aircraft pilots.

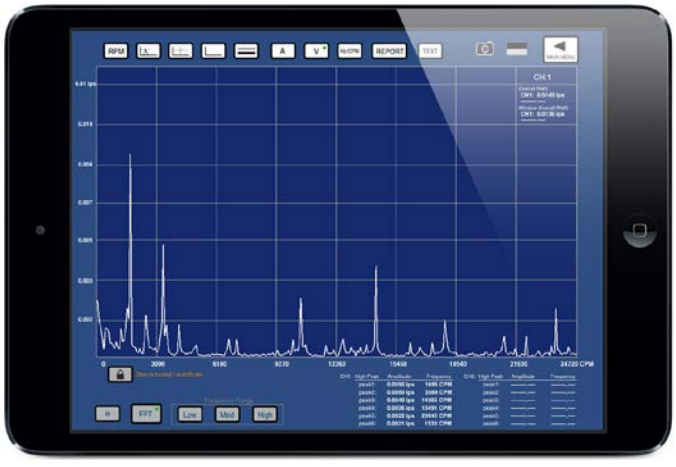
Now imagine the ability to attach complex, precision sensors to the fray. This opens many more possibilities than ever before. Why, you may ask? What is the difference between using a dedicated electronic measuring device vs. using a tablet computer or smartphone for analysis?

1. All of the features for the user that cannot be found on a dedicated measuring device (i.e., e-mails, photos, notes, phone calls, texts, video conferencing, Internet searches for information, storage and viewing of important asset manuals and blueprints, maps and much more).
2. Ease of use and a common operating system.
3. Multiple sensors and applications on one platform/device.
4. Portability and durability with the available cases.
5. Wireless connection to servers, cloud, and Internet with the ability to send out data wirelessly.
6. Continually updated software.
7. Security options, never available on other devices, to remotely wipe data or recover the device.
8. Ability to destroy the device and still recover data from a secure cloud or server.

This list of advantages clearly marks these devices to be the platform of the future; not only for the sound reasons mentioned but also due to the fact all of our youth are using and learning on them in our educational systems.

There are only a few companies breaking into the ability to add external tools and sensors to these devices. With the obvious advantages there will be many to follow. Currently Flir has added the ability to remote to their inferred cameras; GTI Spindle Technology has added vibration analysis, temperature, precision balancing and alignment; Red Fish has added multiple sensors to the multimeter; and Osmium has a full oscilloscope device. There are several others on the web as well.

In closing, I would like to state that the introduction of these new devices into the predictive maintenance and other data collection fields will be welcomed. Many of the devices of yesterday can discourage companies from investing in the technology due to the expense and complexity of the devices. These new tablet devices carry a much lower price point and are learning tools as well as data collectors. Not to mention, they are accepted with open arms by the masses. **PTE**



Vibration analysis and other predictive maintenance data can now be sent quickly and easily to the decision-makers who can act on the data (image courtesy of GTI Spindle Technology Inc.).

Tablet- and smartphone-based vibration analysis tools are speeding up response time to problems with rotating machinery (image courtesy of GTI Spindle Technology Inc.).

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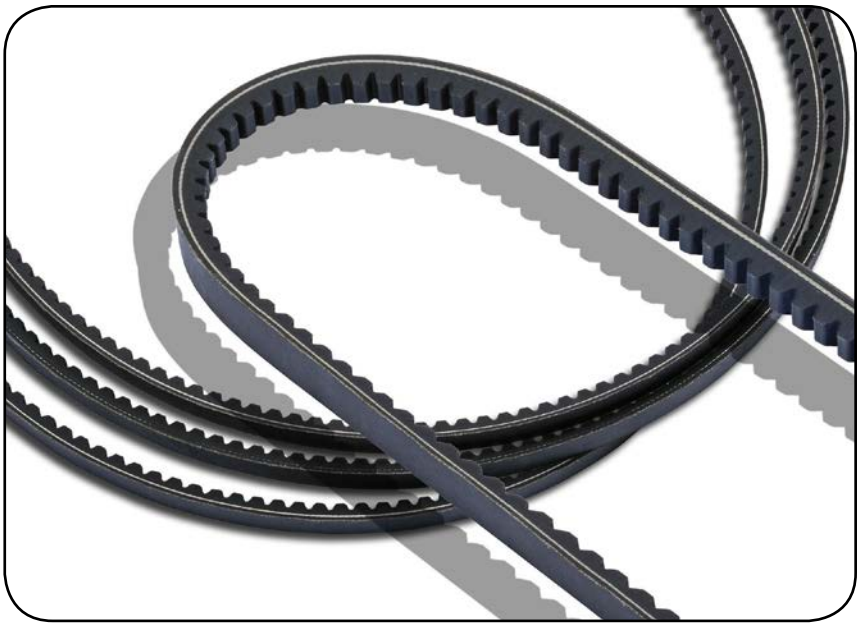

Drive belts from the ContiTech Power Transmission Group are used all around the world in all kinds of applications relating to movement. Whether in small handheld mixers, in large-scale machinery in the textile industry, in agricultural machinery, elevators, or vehicles — the specialist for drive belts and complete drive belt systems ensures that things keep moving. "We have set the benchmark for the industry by introducing the highest quality standards for this technology," said Konrad Müller, business unit manager.

In the process, the company constantly drives new technological developments and pursues new growth markets. The field of electrically powered two-wheeled vehicles provides a good example. Two-wheelers already play a central role in the world of private transport and are set to become even more important. Responding to this trend, the business unit has entered into a cooperative partnership with e-bike drive manufacturer Benchmark Drives in Hofheim, Germany. "Here we envision interesting potential for high-quality products in a very interesting consumer segment," said Müller.

BlueConcept: Added Environmental Value without Additional Costs

The ContiTech Power Transmission Group is continuously expanding its range of BlueConcept-label products, with the aim of making eco-friendly drives available for all industrial applications. A key advantage of eco-belts is that they can replace conventional belts without major additional investment — and also without compromising performance in terms of strength, power transmission and service life.

High-Tech Belts for Special Demands

Special jobs call for ultra-heavy-duty belts. This is where the ContiTech Power Transmission Group is setting new technological standards. A case in point here is the Conti Polyflat PU belt. With lengths of up to 150 m, it keeps elevators moving in the world's tallest building, the Burj Khalifa in Dubai, and elsewhere. In Singapore, drive belts from ContiTech ensure that the glass lifts can even transport cars to the lofts in the 30-story Hamilton Scotts building. "What might seem like a luxury project today, could reap major benefits for disabled people in the near future. They will be able to ride up to their high-rise apartments in their vehicles and wheelchairs without having to deal with any barriers," explains Müller, drawing a link between high-tech solutions and social benefits.

Extreme loads are something that agricultural machines also have to cope with. A suitable alternative to chain drive systems, ContiTech has developed a heavy-duty polyurethane drive belt with carbon tensile members. It is marketed under the brand name Conti Synchrochain Carbon. The belts can transmit maximum forces with a high level of reliability. Even under immense strain, they display barely any stretching. Made of rubber, this heavy-duty timing belt complements applications involving high temperatures.

Performance can be improved — and operations thus rendered more cost-effective — thanks to a new manufacturing technique for the Conti-V Fo-Advance heavy-duty V-belt. It delivers a performance improvement of up to 15 percent. The belt is suitable for many industrial applications in machine and plant engineering, but also in ventilation technology, as well as in pumps and compressors.

Focusing on the Growing Market for Bikes, Pedelecs, and E-Bikes

ContiTech is paying special attention to the two-wheeler market — including, in particular, bikes with electric motors. There is great potential for growth here. Particularly in those regions of the world with highest population density, consumers and companies are starting to recognize the advantages of e-bikes as an alternative mode of transport for short routes. Here they get one around faster than cars, do not cause parking problems, and are cheaper to run. The market for e-bikes and pedelecs is experiencing enormous growth. The worldwide demand is currently around 30 million units a year — and the trend is picking up steam. In China alone, there are more than 120 million electric bicycles on the road. And the German market is also booming: In 2012, Germans purchased around 400,000 pedelecs.

Since February 2013, the company has been working together with e-bike drive manufacturer Benchmark Drives. Müller emphasizes the importance of the cooperation with Benchmark Drives: "We want to work together to set new standards for modern drive technology."

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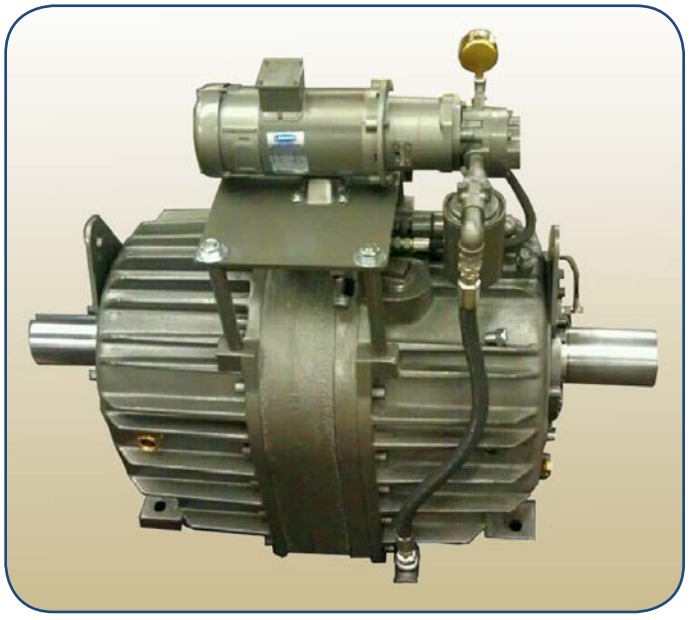
CLUTCH BRAKE OFFERS OIL SHEAR TECHNOLOGY

Force Control Industries introduces the new Size 30 Posidyne Clutch Brake with "Oil Shear Technology" that can be operated as a clutch only for applications such as pumps or fans, or as a clutch brake for cycling or indexing applications. This Posidyne clutch brake dynamically accelerates or decelerates high-inertia loads without wear on friction discs, providing years of maintenance-free, no-downtime operation. That is in contrast to dry friction clutches or brakes which are designed to lock up, and tend to have significant wear if used dynamically. The Size 30 features smooth and quiet acceleration or deceleration due to the Oil Shear Technology. It is ideal for bulk materials-handling applications such as conveyors, load-out conveyors, as well as bulk loading applications like rail car dumpers, portside conveyors, and other critical "no downtime" applications.



Simple Design Yields Big Benefits

The Posidyne Size 30 consists of 7 basic components: (1) the input shaft which is connected to the motor or engine; (2) the output shaft which is connected to the load; (3) a clutch and brake stack consisting of multiple alternating friction discs and drive plates; and (4) a centrally located piston between the brake and clutch that will engage either the clutch or brake, but never overlap to engage both at the same time. Two other important components are (5) the piston seals (o-rings with Teflon liners with each o-ring) and (6) springs tending to push the piston to the brake side (there are many combinations of springs and pressure called "logic types"). The final component is (7) the transmission fluid that makes the whole unit possible.

Actuation media to move the piston creating pressure on the clutch or brake can be air (maximum 80 psi, only 97 in^3 per engagement) or hydraulic pressure for applications outside or away from a compressed air supply.

Unique Features and Benefits

The Posidyne Size 30 provides quiet, smooth, maintenance-free operation with no adjustment or regular downtime required. It features a totally enclosed, heavy duty, foot mounted, cast–iron-sealed housing operation in dirty, dusty, wet environments. In the mine or outside, at loading facilities, or on barges or boats, the Size 30 functions with no regular maintenance intervention during its 40,000,00-cycle design life (annual fluid changes are suggested for maximum service life).

The multiple disc friction stacks provide high torque and thermal capacity in a low inertia (only 61 lb-ft^2) compact package. Highly developed friction materials function optimally with the transmission fluid and resist wear. Teflon liners protecting every piston o-ring seal eliminate cracking and leaking of the o-ring seal, and provide smoother, quicker engagement. Because there is virtually no wear of the friction material, piston travel is reduced, utilizing less actuation air or hydraulic fluid, and providing a quicker response.

Oil Shear Technology

Oil Shear Technology is the heart of all Force Control clutches and brakes. Transmission fluid flowing through the friction stack is put in a shear condition during dynamic engagement. It transmits torque between the friction discs and drive plates, protecting the parts from mechanical contact, and absorbing the heat of engagement as it flows through the stack. Upon exiting the stack it flows down the housing walls, where it is cooled, and back into the bottom of the unit to recirculate back into the friction area. As the pressure continues to clamp the friction stack together, it reaches a point of static lock-up, unless continuous slip is a desired condition. The transmission fluid also serves to lubricate the bearings and splines for greatly improved operating life. Depending on the thermal loads, the additional cooling of the transmission fluid can be done with fan cooling, water cooling, external oil-to-air cooling, or oil-to-water cooling; and for continuous slip applications, forced lube units are available. This highly reliable clutch brake operates nearly maintenance free for the duration of its design cycle life of approximately 40,000,000 cycles. Repair kits are available, as is rebuild service by Force Control Industries, which is recommended.

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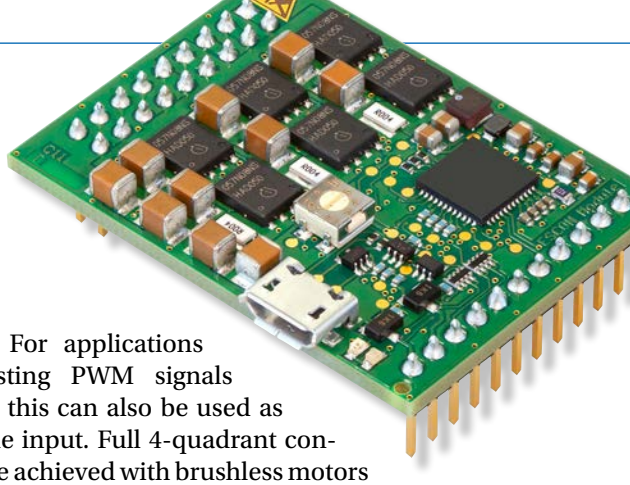
Maxon Motors

OFFERS PWM SERVOMOTOR CONTROLLER



Maxon precision motor's newly released DC servomotor controller, the ESCON 50/5 OEM module, is a 4-quadrant Pulse Width Modulated (PWM) servomotor controller that can efficiently control permanent magnet brushed DC motors (PMDC motors) and brushless DC servo motors (BLDC motors) containing Hall effect sensors, with power levels up to 250 watts.

The OEM module features exceptional motor control properties and contains very fast digital current control bandwidth capabilities, enabling peak DC motor current (and therefore torque) control. Speed control of DC motors is devoid of drift while remaining dynamic. The DC motor speed can be controlled from 0 rpm up to 150,000 rpm. A completely configurable, broad range of functions can be set to operate from the onboard analogue and digital inputs. The DC motor speed can be set for open or closed loop with preset current/torque levels, or the motor torque and direction can be set with analogue inputs. The inputs can be scaled and midpoints independently set with the "easy-to-use servo controllers" *PC graphical user interface (GUI),* allowing fast integration into difficult motor control applications. Detailed design guides are supplied, allowing easy integration onto the main equipment PCB. There is also an evaluation board for easy initial test and measurement.

This DC servomotor controller can also be used with an external potentiometer or the integrated on-board potentiometer. For applications with existing PWM signals available, this can also be used as a set value input. Full 4-quadrant control can be achieved with brushless motors using only Hall sensors. A DC tacho or encoder can be optionally used with the DC motor for tighter feedback loops, and digital inputs can be switched for activation in a particular motor direction of rotation.

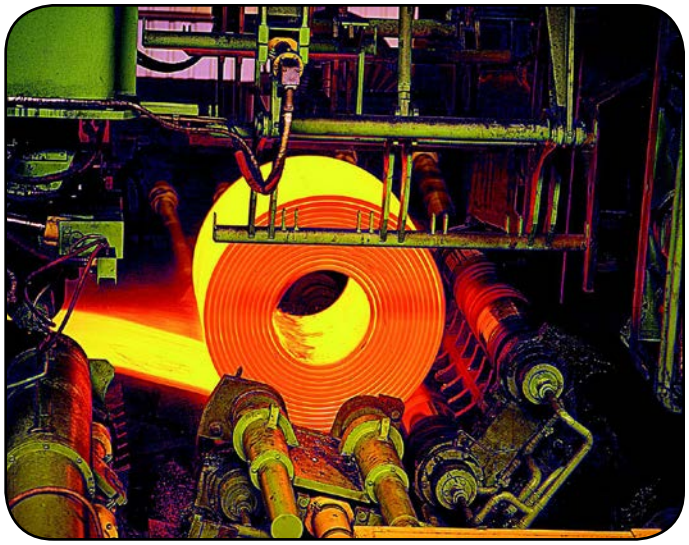
Protection features are inbuilt on the motor controller against overcurrent, over-temp, under-voltage and overvoltage. Transients and short-circuits on the motor are also covered. The maximum allowable motor currents can be configured easily on the USB connection with the PC GUI. The small-sized electronic motor controller has a 98 percent efficiency and can be used on common 12V, 24V and 48V DC systems, making it suitable for process control, robotic and manufacturing equipment applications.

For more information:
Maxon Motors
Phone: (508) 677-0520
www.maxonmotorusa.com

WEG

EXTENDS MOTOR RANGE FOR STEEL INDUSTRY

WEG has extended its range of reliable and robust motors for the steel industry. The company now offers a complete roller table motor line, ranging from 132 to 400 IEC frame sizes, which was previously limited to IEC 200. The high-quality motors, with a torque of up to 2,972 N-m and four to twelve poles, have low maintenance requirements and costs, thus enabling steel plants to increase productivity and operating efficiencies.



Motors driving rollers are subjected to sudden torque variations, sometimes from zero to overload, immense acceleration requirements and frequent rotation reversals. WEG has designed its motors with high starting and breakdown torques so that they operate exceptionally in these conditions. Depending on the application, WEG can also customize the right solution to fit the individual need.

The roller table motors function with complete reliability in the harsh steel rolling environment where there is contact with corrosive agents, water, steam, dust and high temperatures. They include features such as WEG's innovative W3seal sealing system for added protection against water ingress (IP66), and WEG's WISE insulation system, which ensure a longer lifespan. Thanks to the special design of the fins, an accumulation of solid and liquid agents is avoided, thus providing balanced heat dissipation and easy cleaning procedures. The non-ventilated construction results in reduced maintenance efforts and a smaller size.

The motors offer complete design flexibility, being available in several different configurations. They can be coupled directly to the rollers or through gearboxes with dedicated flange and shaft end dimensions. They can also be controlled with variable speed drives. WEG's motors are available in a top or lateral terminal box mount, or with the terminal box attached to the non-drive and end-shield.

"Steel industries are known as one of the most aggressive industrial environments for electric motor operation, with extremely demanding applications requirements such as high torque and heavy-duty cycles," says Marek Lukaszczyk, European marketing manager at WEG. "WEG roller table motors are designed especially to work reliably in these conditions. Our smaller size motors are already proven in the steel industry and now customers will be able to benefit from the high-quality larger sizes, which have a low cost of ownership.

For more information:
WEG
Phone: (687) 2459-2000
www.weg.net

Zero-Max

INTRODUCES ETP HYDROPRESS

ETP Hydropress from Zero-Max provides quick and precise fastening of components in tight spaces on large shafts from 80 to 200 mm diameter. Hydropress shaft bushings are suitable for locking into position gears, sprockets, pulleys and similar components in a machine's power transmission system. Handling torque ranges from 21,000 to 200,000 ft.-lbs., ETP Hydropress bushings utilize hydraulic pressure contained in a double-walled sleeve to lock components into position on a shaft. Utilizing a grease pump for mounting, both radial and axial connection to the shaft is easily made. Once mounted and pressurized, the conical angle of the outer sleeve locks the device into position forming a very tight, continuous connection between the shaft and mounted component. The bushing aligns precisely without axial movement as it is pressurized. The Hydropress can be reset at different positions on the shaft without losing concentricity. Transmittable torque can be varied by altering the mounting pressure. A flange on the Hydropress has two valves – one for the pump connection and a pressure release valve for dismantling. Available in custom sizes and stainless steel, these ETP Hydropress bushings are a cost-effective choice for new and retrofit applications including food processing and packaging applications.

For more information:
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www.zero-max.com

Boston Gear

EXPANDS 700 SERIES SPEED REDUCERS

New 80:1 and 100:1 ratios are now available in single-reduction 700series worm gear speed reducers. The new models provide the compact size of a single-reduction reducer with a lower purchase price than traditional double-reduction units. Units are backwards-compatible with all 700 series industry-standard mounting dimensions. These economical reducers are ideal for low-torque, light-duty material handling, food processing, and packaging applications. The new ratio reducers are available with projecting, quill or coupling input options. Hollow and solid (projecting) output options are also offered. Models are available with standard paint, BK/SBK coatings or stainless steel housings. Boston Gear's 700 series, the standard for modular worm gear construction, is known throughout the industry for its durable, efficient, and trouble-free performance. The internal worm is specially-ground for enhanced efficiency and lower heat generation leading to prolonged product life. 700 series reducers feature rugged cast iron or stainless steel housings with high-strength bronze worm gears mounted between heavy-duty tapered roller bearings. Quality materials and proper heat treating of the 700 series components provide strength and durability. Large oil reservoirs also provide efficient heat dissipation and lubrication for longer operating life.

For more information:
Boston Gear
Phone: (800) 825-6544
www.bostongear.com

Voith

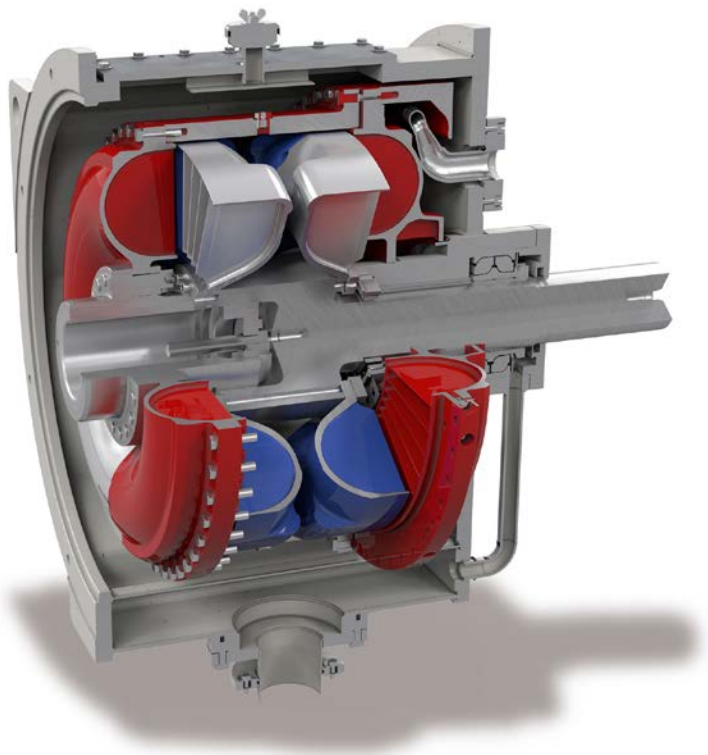
FLUID COUPLINGS ASSIST BELT CONVEYORS

New fluid coupling TurboBelt 780 TPXL from Voith raises the productivity of high-powered belt conveyors. Developed especially for the drives on open-pit mining belt conveyors, the latest fluid coupling technology from Voith provides a lot of benefits. Thanks to the innovative XL blade wheel profile, the TurboBelt 780 TPXL coupling transmits power upgrades. It is designed for 6- and 8-pole induction motors operating at speeds of 900 to 1,200 rpm. The start-up with precisely-controlled introduction of torque not only protects the belt, but also the entire driveline. Even overloaded belt conveyors are started reliably. Start-up times of up to several minutes can be individually set in the control system.

In May 2012, the initial start-up of this new fluid coupling was in one of the biggest sea terminals in northern Brazil, where iron ore is shipped worldwide. In order to handle the increasing amount of iron ore, the operating mining company decided to install three TurboBelt 780 TPXL couplings in the drives of a 1,451-m (4,760 feet)-long conveyor. The couplings assure smooth operation and avoid unscheduled downtimes of the belt conveyor. As the conveyor transports around 10,000 tons of iron ore every hour, its reliability has high priority for the mining company.

The maintenance efforts can be reduced to a minimum as the hydrodynamic power transmission is completely wear-free. Compared with traditional couplings, the TurboBelt 780 TPXL requires only half as much installation space and is also significantly lighter. This has enabled a simple and quick installation and alignment in the Brazilian sea terminal in May 2012.

Altogether, the new TurboBelt 780 TPXL couplings raise the productivity and profitability of the belt conveyor. Be-



sides the couplings, the mining company benefits from a customized package also delivered by Voith.

Solutions for drive units

In order to operate the conveyors in the most efficient way, Voith offers not only couplings but also optimal drive solutions based on the customer's needs. The drive package solutions include the drive hardware, PLC controller and supervision of installation as well as commissioning.

For more information:
Voith Turbo GmbH
Phone: (717) 767-3200
www.usa.voithturbo.com

Pepperl+Fuchs

OFFERS R2 SERIES SENSORS

Pepperl+Fuchs introduces the R2 Series Ultra-Small Sensors - a complete family of ultra-miniature photoelectric sensors available in four sensing modes to suit varied application needs. These sensors feature a 24 mm × 7.5 mm × 11.2 mm housing, industry-standard mounting footprint, a flush- and wear-resistant antistatic glass lens and a 45 degree cable outlet to maximize mounting flexibility. Consequently, the R2 series can be mounted where other photoelectric sensors cannot – in extremely tight spaces and close to moving objects — to deliver high performance and reliable operation in a wide range of applications, regardless of the color, texture or shape of the object(s) being sensed.

"The R2 series is the only nano-sized photoelectric sensor available today with background evaluation (BGE) mode. Utilizing a fixed background such as a conveyor or machine part as a reference, R2 series BGE sensors are a unique alternative to retro-reflective sensors, reliably detecting objects without the need for a reflector," says Pepperl+Fuchs product manager, Michael Turner. "Advanced thru-beam mode R2 sensors are equipped with a secondary emitter LED that provides a laser-like spot size for high-precision applications and eliminates the hassle of applying external apertures. The R2 series is also available in polarized retro-reflective and background suppression modes."

Industry standard 15 mm mounting hole separation enables R2 series sensors to easily retrofit into existing applications. Threaded sensor mounting holes enable installation without mounting nuts to simplify installation and save time. This also negates the potential to lose or drop mounting nuts while installing a sensor in very small, tight spaces.

R2 series sensors feature a glass optical surface which is more resistant to environmental contaminants, chemicals and abrasion than is the fragile plastic optical surface of many conventional photoelectric sensors. Additionally, the tamper-proof housing of each R2 series sensor ensures that unauthorized personnel cannot make modifications or alterations after the sensor is set up. Enhanced and strategically placed LEDs clearly indicate the sensor's operating state. "The R2 series' powerful emitter LED literally outshines the competition, offering the brightest, most powerful, easiest to

align and most uniform light spot. The result is greater signal strength to optically 'burn through' environmental contaminants, more consistent detection and better visibility on dark materials," explains Turner. "These extra-bright LEDs ensure that everyone, especially maintenance personnel, can easily see them at a distance and at various angles."

Their ultra-compact size, robust design and range of operating modes make the R2 series a suitable photoelectric sensing option in any number of material handling, print-and-paper, packaging and general purpose applications that have very tight mounting space. The high optical burn-through power and rugged housing are well suited for automotive applications, and semiconductor applications could benefit from R2's ultra-low-profile housing and high-precision through-beam sensors. Its size and features also make the R2 series a good solution in certain biomedical and pharmaceutical applications.

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Lenze Americas

UPDATES DSD TOOL

Lenze Americas has launched an updated version of its *Drive Solution Designer (DSD)* drive dimensioning tool. *Version 4.0* brings *DSD* users expanded application functionality and enhanced drive dimensioning for winding-unwinding motion control applications. "*DSD 4.0* makes drive dimensioning simpler and even more convenient," states Craig Dahlquist, Lenze automation product leader. "In addition to numerous user enhancements, the precision drive dimensioning designer for winders offers our customers a powerful new engineering tool."

Lenze *DSD 4.0* now comes standard with dimensioning tools for optimizing drives in typical center winding and unwinding machines. The winding-specific motion designer takes into account special features unique to the motion control of winders, with expert support in selecting winding technologies, a diameter-based representation of the load variables, and examination of the winding process in the torque-speed diagram of the motor-inverter combination. The field-tested energy performance certificate, available on earlier *DSD* versions, completes the winder solution for both single- and multi-axis systems.

Other new features of the *Windows-8*-compatible *DSD 4.0* release include a series of solutions designed for mains voltages in U.S. markets. A new application tuner provides *DSD 4.0* users greater detail in precision drive dimensioning and enables varying types of process data to be leveraged in drive optimization. This extended functionality makes it possible to integrate more potential operating states and material recipes into the dimensioning process. Additionally, *Version 4.0* includes enhancements to usability and improved support for generating CAD data.

"*DSD 4.0* incorporates a wealth of process data, motion and speed profiles, and in-depth knowledge about drive physics, variants and energy efficiency applications—automatically calculated and readily available at the user's fingertips—to create a complete, optimized drive structure for all of a machine's motion control requirements," adds Dahlquist.

For more information:
Lenze Americas
Phone: (800) 217-9100\
www.lenzeamericas.com

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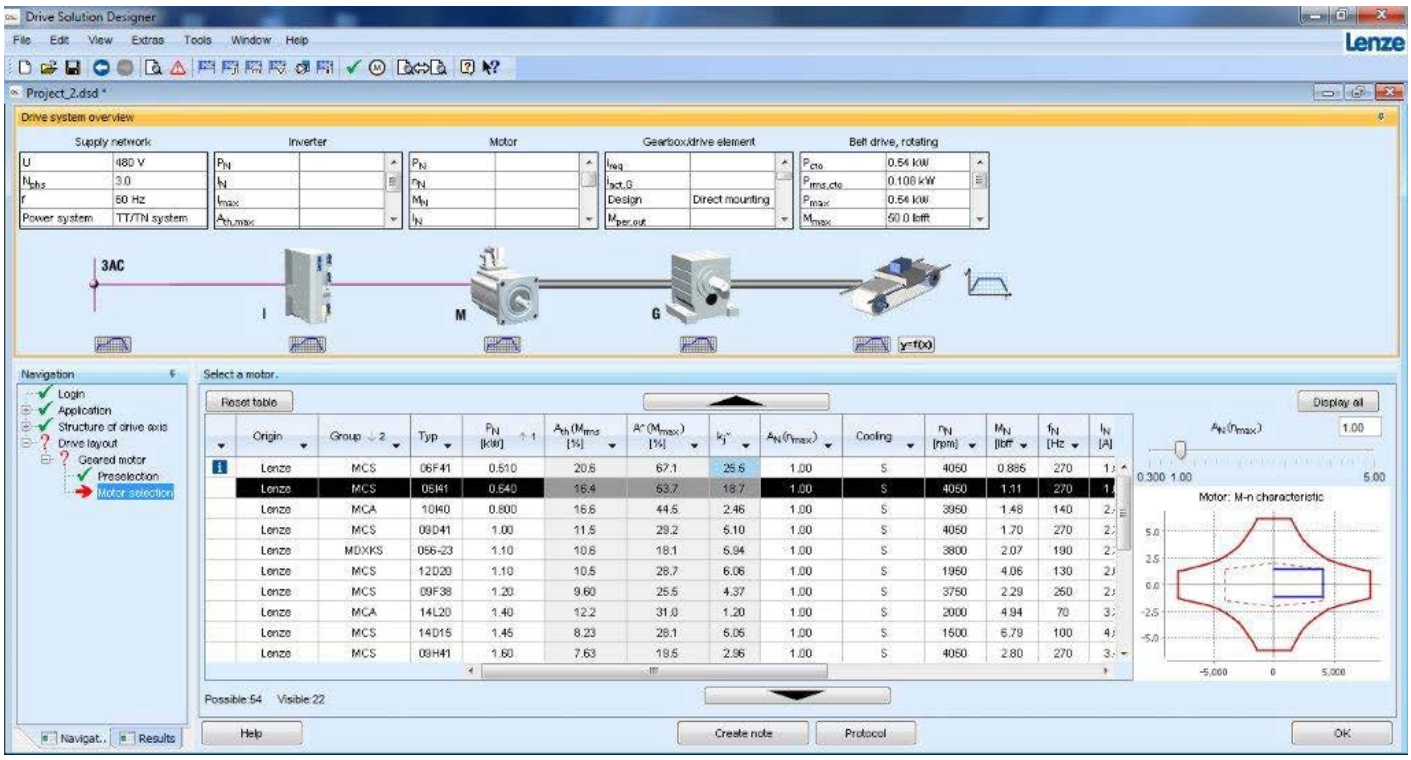
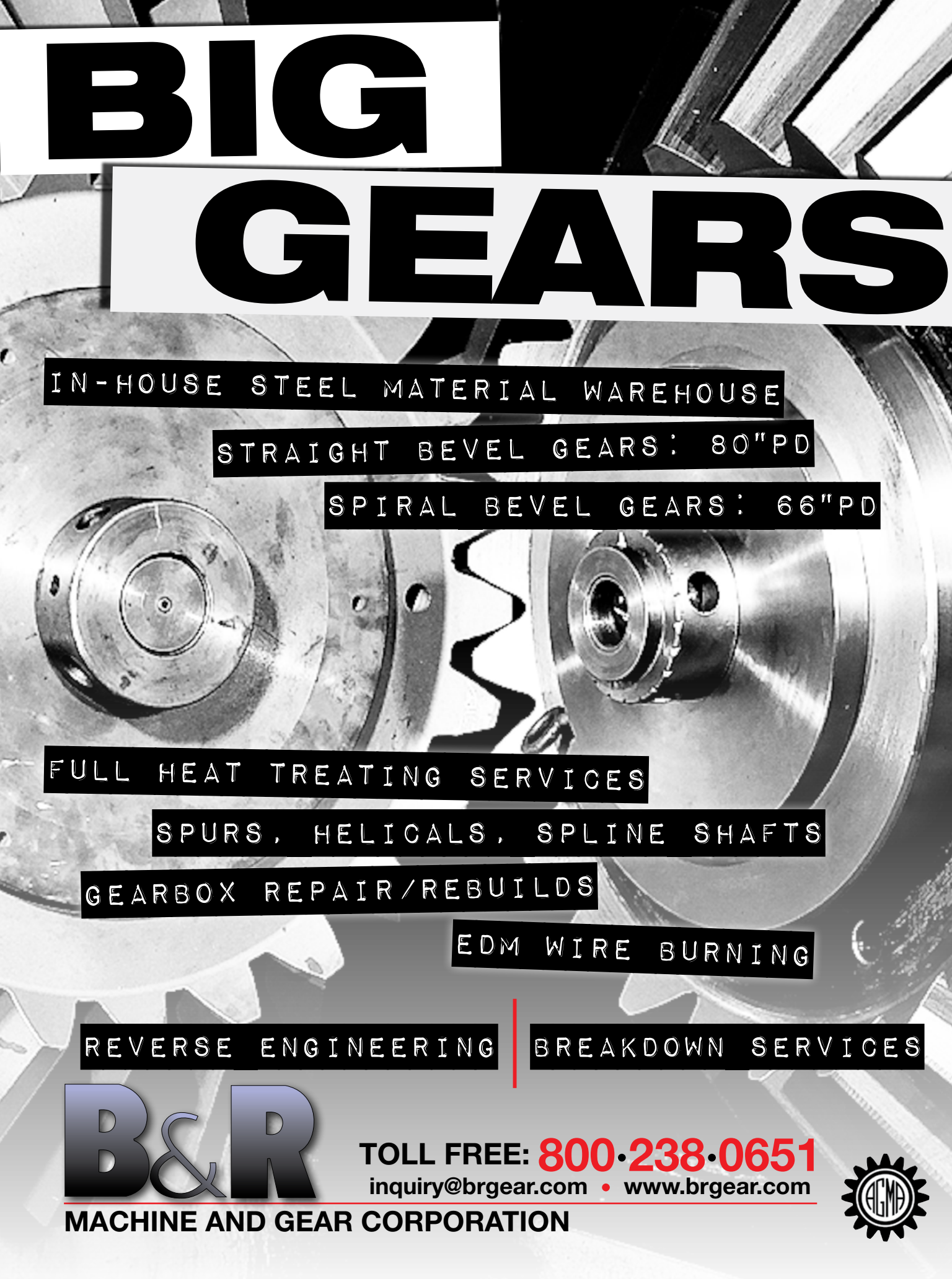
Your news items may be featured in print, online, or in our e-mail newsletters



BIG GEARS



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AGMA

Boilermakers Announce Bearing Technology Breakthrough

Student research project at Purdue could revolutionize predictive bearing failure

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Jack McGuinn, Senior Editor

Bob Griese. Len Dawson. Drew Brees. Anurag Garg. Anurag Garg?

No doubt about it—a mention of Purdue University typically elicits thoughts of All-American college quarterbacks going on to become NFL gunslingers of renown. *Anurag Garg*?

No, you won't be seeing him on your friendly flat screen on fall Saturdays pitching the pigskin around. But remember that name — as well as the names of fellow student colleagues and co-inventors Lokesh Gupta, Andrew Kovacs and Christopher Ochynski — for they, along with Garg, are the Bearing Analytics team — a Purdue Boilermakers juggernaut of a different brew entirely. (Garg, Kovaks and Gupta are doctoral candidates in the school of electrical and computer engineering's adaptive radio electronics and sensors group; Ochynski is a senior in the school of electrical and computer engineering and a first-year student in the MBA program at the Krannert school of management.)

And no, they haven't helped the storied university in West Lafayette, Indiana win any Rose Bowls. But they did, for example, take the student Grand Prize at the prestigious Midwest Clean Energy Challenge in Chicago this past February ($100,000 and $10,000 worth of legal services); finished in the money ($1,250) in the April Rice Business Plan Competition in Houston; and also took the Best Written Business Plan Award ($3,000). The Rice success qualifies the team to compete in the national competition this month in Washington, D.C. But this should come as no surprise as, leaving college football aside, Purdue has long nurtured its well-deserved reputation as a top-flight engineering school.

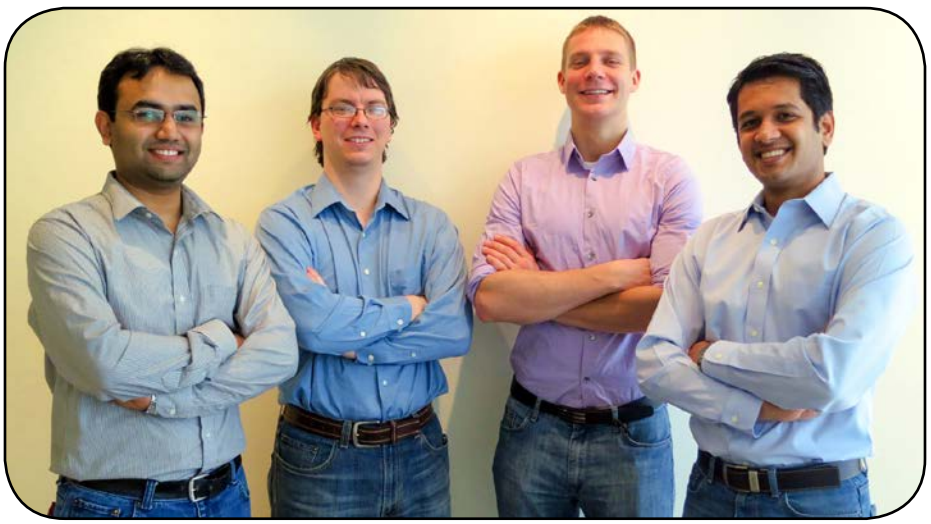
The hard work that has gotten the Bearing Analytics team this far was in their developing a patent-pending sensor —*fixed directly onto the bearing cage* — that monitors bearing performance with a predictive accuracy that, until now, was virtually impossible. While conventional bearing sensors that monitor real-time bearing performance are mounted outside the bearing, which limits the ability to determine internal conditions, "The Purdue-developed technology allows a sensor to be placed directly on the bearing cage, which is the source of temperature and vibration fluctuations," explains Anurag Garg, a doctoral candidate in Purdue's School of Electrical and Computer Engineering. "As a result, (the sensor's positioning) provides a more reliable indicator of impending bearing failure and has a better response time than any commercial sensor available on the market."

Like most things worth having, the new sensor technology took time to develop; no eureka moments here. Garg relates that "The technology was developed over numerous iterations and incremental developments (at Purdue) over seven years of research.

Also deserving recognition for their roles in the project are the team's "mentors," who the team credits with "guiding the development of the technology": Professor Dimitrios Peroulis, School of Electrical and Computer Engineering and School of Mechanical Engineering; and Professors Farshid Sadeghi and Douglas Adams of the School of Mechanical Engineering.

During that timeframe, Garg states that "The sensor has been reliably tested in high temperatures — up to 800°F — and in turbochargers with speeds up to 100 rpm. (These conditions) cover nearly all applications, at least as far as industrial machinery is concerned. Of course there are some applications (Dept. of Defense, etc.) where additional research and testing may be required."

The sensor would appear to be a major breakthrough in the technical art of predicting bearing failure and a legitimate leap beyond existing manu-



The Purdue University Bearing Analytics Team (left to right): Lakesh Gupta, Andrew Kovacs, Chris Ochynski and Anurag Garg. The team's business plan is in support of a patent-pending, predictive bearing maintenance technology for a sensor that mounts—in unique fashion—directly onto the bearing cage, thus providing the ability to predict impending bearing failure sooner and more accurately than commercial sensors currently on the market (courtesy Bearing Analytics).

facturing technology. If it works as advertised, it will have a far-reaching impact on any number of industries and manufacturing processes, and for both OEM and downstream users. Right now, however, the Bearing Analytics team is focused on wind turbine gearboxes— already a singularly significant slice of the predictive maintenance market.

"Wind turbine gearboxes are our primary target market for (roll-out)," Garg says. "However, the applications for this technology permeate nearly every industrial segment (owing to the fact that bearings are a fundamental component to nearly all mechanical systems). Some of our potentially most profitable markets include bearings used in the manufacturing industry, and rotary systems (e.g., pumps and motors used in the oil and gas industry)."

And in case you were wondering, federal agencies have some skin in the game as well. Indeed, while the sensor has drawn the expected, considerable interest from (un-named for now) numerous companies across various industrial segments, Garg reveals that "The research was completed through grant funding (from) USAFR (U.S. Air Force Research Lab) and NAVAIR (U.S. Naval Air Systems Command)."

Garg also points out that an enhanced capability to forestall and/or prevent bearing breakdowns will alert workers to "take early corrective action (that) could improve safety conditions for (personnel) while "(reducing) operational downtime and increase bearing life." (One can almost see the smiles on the faces of plant superintendents and QA managers, for example, once this new technology is in place. And the potential

And as every successful Broadway play has a deep-pocketed "angel" in the wings, the Bearing Analytics Team has the Purdue Office of Technology Commercialization. The office oversees one of the most extensive technology transfer programs of any premier research universities in the country. The services provided by this office support the economic development initiatives of Purdue University and benefit the university's academic activities.

One last detail; mention counterfeit bearings to anyone in the industry and you will reap a wide range of — given their vehemence — not-for-publication responses. But keep hope alive—counterfeiters' comeuppance might possibly be at hand. Garg makes no promises on whether the new sensor is up to the job of ferreting out illegal knock-offs, but allows that, "In theory, yes, this might be possible. However no tests have been conducted to validate that hypothesis. It is something that can be explored in the future to create additional value." **PTE**

For more information:

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1281 Win Hentschel Blvd.
West Lafayette, IN 47906
Phone: (765) 588-3342
sgmartin@prf.org

Healthcare at Hannover

SKF Insight Ups the Ante on Condition Monitoring Technology

Matthew Jaster, Senior Editor

Donald Howieson demonstrates SKF Insight during Hannover Messe in Germany (all photos courtesy of SKF).

The reliability of components can make or break a manufacturing operation. It's not just dollars and cents (though that plays a significant role); it's also an issue of time management, worker safety and productivity improvement. It's no wonder that condition monitoring is so popular today. Reducing repair time and maintenance costs and optimizing machine performance makes executives and their accountants very happy. And the technology is making it easier for maintenance, repair and upgrade professionals to integrate it all under a single, cohesive platform.

At the SKF booth during Hannover Messe, the SKF Knowledge Engineering team had attendees covered whether they were looking for bearings, seals, mechatronics, services or lubrication systems. Everything was in its place, from energy management to tribology to condition monitoring techniques. It was like walking into an Apple store that decided to highlight bearings over iPhones and iPads. The floor space SKF utilized could have been a shop floor, a laboratory or even a well-maintained emergency room. The medical motif actually made some sense when the discussion turned to SKF's latest condition monitoring technology, SKF Insight. This technology was, in a practical sense, healthcare for bearings.

"Traditional condition monitoring uses vibration or temperature to monitor damage in the bearing after it has occurred," said Donald Howieson, business manager, service platform at SKF. "This is similar to someone who has become seriously ill and is perhaps being cared for in a nursing home where doctors and nurses are ensuring the best quality of life can be achieved. Alternatively, consider someone who monitors their heart whilst jogging, monitors their weight and if required modifies their diet — they can perhaps avoid many health problems before they occur. In a similar way, SKF Insight enables you to monitor the bearings' operating conditions, understand the complex history of load in service and quality of lubrication throughout life. It can also identify overloads, duty excursions, lubricant contamination and lubrication problems so that modifications can be made to the operating conditions to avoid damage before it occurs."

A New Condition Monitoring Concept

By selecting the appropriate sensors for the application, using appropriate electronic processing technology to capture the data required and with the application knowledge of where and how the bearing is being utilized, SKF can implement the specific tools to the application. SKF Insight was conceived in 2009 when SKF had a vision to create an integrated, self-powered sensor package that could communicate the condition of a bearing at any time. Following extensive R&D work, including miniaturization, solving power generation challenges and developing unique packaging of sensors and electronics, SKF Insight made its official debut during Hannover Messe 2013 in April. Alan Begg, senior vice president of group technology development at SKF, spoke fondly of the concept behind SKF's latest condition monitoring technology. "This technology makes condition monitoring autonomous. It powers itself and it talks to the Internet. That allows it to be in places that were never possible before," Begg said. "In the planetary bearings in a gearbox, for example, where wires would quickly get wrapped around the moving parts; or in a steel mill, where hot metal and water sprays make it a very aggressive environment for condition monitoring."

Begg remarked that traditional condition monitoring looks for early signs of failure by measuring vibration. "A bearing starts to have vibration signals when the first small fragments of steel spall off the surface of the rings or the rolling elements (balls or rollers). By the time these fragments have come off, you are getting close to the end of life of the bearing—it is already damaged. SKF Insight can detect early changes in the microstructure of the steel, before macroscopic damage has

occurred, so giving earlier warnings of problems, and in some cases, allowing preventive action."

According to Begg and Howieson, SKF Insight will benefit applications involved in complex rotating systems, aggressive environments, remote and inaccessible places and high measurement points (large areas). An investment in SKF Insight offers a lower cost of ownership, greater reliability, optimized maintenance and the ability to safely push a plant closer to its operating limits. It also enables OEMs to reduce size and weight of their products through an improved understanding of the operating environment.

How SKF Insight Works

Howieson explained that bearings with SKF Insight create a mesh network, communicating through each other and with a gateway. "The gateway can be local to the machine, or local to the plant. System information is either made available to the customer for analysis using SKF @ptitude, or sent via the SKF cloud to our SKF Remote Diagnostic Centers. From here, dashboards and reports can be made available to the plant operator, the machine manufacturer, to SKF, or any other authorized person with Internet access."

Real-time condition monitoring data are accessible to everyone involved. Machine failure can in many instances not only pull the plug on a production run, but also cause huge financial burdens to a manufacturing outfit. Bearing failure can be more easily addressed with a system like this.

SKF is able to monitor the conditions that can cause damage, from the first microscopic effect as it is happening, and with this information, customers can take remedial action to reduce the reason for damage in the bearing — adding lubricant, mitigating transient overloads, etc. In addition, by monitoring the load directly on the bearing, SKF Insight makes it possible to measure the load the bearing actually experiences rather than what is was designed for. This valuable information can be routed back into the design phase to improve both the system and bearing design. "It is essential when designing any engineering application to have accurate knowledge of the structural loads," Begg said. "These are well understood in mature systems with simple loading. For newer systems, especially when there is little control over the applied loads, SKF Insight will give big benefits. For example, wind turbines are getting larger all the time, as larger turbines reduce the

average cost per kilowatt for the power generated. These are new systems, and the since loads come principally from the wind loading on the blades, they are by nature random and unpredictable."

The Future of Condition Monitoring

At Hannover Messe, SKF demonstrated the potential of SKF Insight with many comparisons to healthcare for humans. It's the first step in a condition monitoring system that will continue to evolve. "Today SKF Insight is our ability to power and package the appropriate sensors and electronics, to wirelessly communicate data, the algorithms and interpretation of the data into information for specific applications, and combine that with related diagnostic software and services from SKF," Howieson said. "We demonstrated that with a demo rig at Hannover Fair on small/medium-sized bearings. Today we have to start with a customer's general arrangement drawing of their application. Tomorrow — whether it is 5 or 10 years — who knows? — SKF Insight could be standard in specific bearing sizes or types."

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Brake and Accelerate

SKF President/CEO Discusses Global PT Market at Hannover

All the talk of the next industrial revolution is very true, according to Tom Johnstone, president and CEO of SKF. "It's really a question of what area of the world you're talking about," he recently said during an interview with *Power Transmission Engineering* at Hannover Messe. "We're facing different speeds in different parts of the world. Some market segments are more challenging than others. You have to put on the brakes in some areas and accelerate in others."

Whether it's North America, Asia or Europe, Johnstone said that SKF (headquartered in Sweden), has made a push recently toward expanding its global reach by moving closer to its customers. "How do you make your products not just a passive part of the equipment but an active part? This is a question we ask regularly and it's SKF's goal to bring our knowledge, our technologies and our products to our customers so they can improve productivity and reduce costs."

SKF currently has 21 Solution Factories across the globe. According to Johnstone, these facilities offer knowledge and resources that cover the various technology platforms at SKF. "We're hoping to have 50 total Solution Factories in the next three to four years. These factories bring us closer to our customers and let us become a more integrated part

Tom Johnstone, SKF president and CEO

of their business. And each one is unique depending on the area. It's like a buffet table of the many different services that we provide."

"The Perth (Australia) Factory, for example, is focused on mining and rail applications. The Houston (Texas) facility is centered on the oil/gas industry. Cleveland (Ohio) is focused on heavy industry and machine tools. Additionally, we have mobile factories that we can take out to a specific industrial segment. Mobile mining factories, for example, allow us to refurbish and recondition large bearings directly at the mining site," Johnstone said.

Digital/Mobile Solutions

SKF continues to offer the latest technology solutions to best communicate with both its employees and customers. Since launching the SKF cloud in November 2012, the global network of SKF Remote Diagnostic Centers have been connected, bringing together global IT solutions and making all application data accessible in a single cloud-based system. This collective data reflects the company's desire to assist in diagnosing and solving customer machinery maintenance issues in applications across all major industries worldwide. SKF Asset Diagnostic Services can now leverage and share this knowledge, and at any time of day, SKF service engineers — located in time zones around the world — can be available to provide support in response to any problems that their remote diagnostics systems have identified.

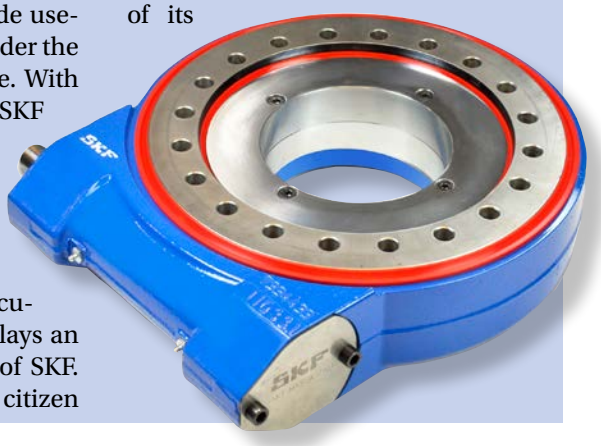
SKF mobile apps (available to employees, customers and students) are another set of tools that provide useful and current information under the Knowledge Engineering theme. With apps like Bearing Calculation, SKF Care, Distributor News and a Web Customer Link, SKF is staying ahead of the game in mobile technology.

"Our continued development in global mobility, particularly with the SKF Care app, plays an important role in the history of SKF. Being a responsible corporate citizen in the communities where we live and work has been a part of our daily operations since SKF started over 100 years ago," Johnstone said.

SKF Care is separated into four distinct areas including Business Care, Employee Care, Environmental Care and Community Care. This and other mobile applications allow smart phone users to access a content-heavy database of engineering solutions, case studies and other resources for both internal and external use. SKF's mobile network was proudly displayed during Hannover Messe and attendee questions were answered by Robin Ottenfelt, global mobility development at SKF.

SKF's Role at Hannover

Johnstone took time during the show to discuss SKF's massive booth in Hall 22. "We have a great deal of new products and technologies here at Hannover," Johnstone said. "SKF is launching its extended life spherical plain bearings and rod ends. These are aimed primarily at applications in the farm, forestry and construction sectors. We have new systems for solar applications including the SKF Solar Linear Actuator and Solar Hub that will contribute to the reduction of CO_2 emissions by increasing energy production. There's also a new motor solution for aeration blowers in wastewater facilities, which can reduce energy consumption by up to 40 percent. A standard wastewater plant roughly uses 80 percent of the energy on the blower."In addition to these products, Johnstone also commented on new global additions to SKF's Solution Factories, the continued success of its



network of Remote Diagnostic Centers and its new condition monitoring system known as SKF Insight.

At the front of these various new developments is SKF's condition monitoring platform, SKF Insight. "It's certainly a new development in the way we monitor bearings in challenging applications," Johnstone said. "This condition monitoring technology will allow our customers to have more control of their machinery and equipment, which will lead to a decrease in costs as well as an increase in reliability."

The U.S. Market

SKF's history in the United States dates back to 1909 when the SKF Ball Bearing Company was founded in New York. Today, the company is based in Pennsylvania and provides products and solutions through a network of more than 4,000 U.S.-based authorized distributors. Johnstone is excited about the opportunities for SKF in North America. "Ten years ago, labor costs were a real problem and it took six to eight weeks to get something from Asia to the United States. We see a huge opportunity for reindustrializationin the U.S. market today."

Although the wind market has been rather stagnant in North America, Johnstone believes it will probably reach the peaks it did five years ago and start developing more positively. He's also excited about solar power potential even though renewables account for only six percent of

SKF's business. "There's still opportunities in oil and gas in North America and we seem to be a bit enamored with shale gas at the moment. These are interesting developments if the opportunities in shale can lower energy costs and create energy independence."

Johnstone is excited about SKF USA and its goals moving forward, "We have made a lot of big investments in the United States and I expect SKF to continue to grow significantly in this market in the future."

The Future of SKF

Johnstone reflects on the future of the entire organization with equal enthusiasm. "I've been with the company for 36 years and the evolution is astounding. We've managed to get closer to our customers through our Solution Factories and our mobile technologies. It makes it that much easier for us to be a better partner to our customers. It's our commitment to them that brings the most value back to our organization." **PTE**

Tom Johnstone has been with SKF for 36 years. He has held several management positions within the SKF Group until becoming president and CEO in April 2003. He served as an executive vice president at AB SKF from 1999 to 2003 and president at the SKF Automotive Division from 1996 to 2003. Holding an Honorary Doctorate in Business Administration from the University of South Carolina, USA, and an Honorary Doctorate in Science from Cranfield University, UK, Johnstone has held senior management positions within SKF since 1987.

Bearing Associations Help Demystify Bearings Buys

The ABMA, BSA and PTDA help keep things rolling

By Jack McGuinn, Senior Editor

Bearings are everywhere—from toy dolls to barstools to robots performing brain surgery. You name it, and somewhere upstream or downstream bearings will be in play. But much like their gear counterparts, bearings usually go unnoticed in everyday life—until they fail. Or until, perhaps, you are the person charged with specifying and/or purchasing them for your company. And, there are bearings—and then there are *bearings*. The distinction being that while commodity-type bearings are prevalent in the marketplace, that's not much help to you if you are looking for, say, special dimension or custom bearings.

Indeed, commodity-application bearings are a big portion of what in the U.S. alone is approximately an $11 billion industry, which includes ball, roller and plain bearings (*Source: Freedonia Group report*). That's a lot of bearings to keep track of. So it is little wonder that U.S. bearing associations have formed and evolved over the years to become major players in the industry for their selling and buying members—whether they are sellers *or* buyers.

That said, the breadth of knowledge of today's bearing groups goes way beyond commodity bearings. They are fully capable of working with their members to identify the most complex bearings used in the most complex applications. Indeed, working in tandem, the associations do just about everything for their members—from publishing industry statistics to providing invaluable training in the often very complex world of bearings. In the United States the bearings associations work with members to provide training and education opportunities, standards updates (where they exist), lobbying and public policy initiatives, as well as regularly held business forecast functions and seminars, trade shows, and other networking opportunities.

Aside from the above activities, however, bearings associations are, in essence, accomplished matchmakers; they exist to facilitate hooking up bearings buyers with bearings sellers, and to everyone's mutual satisfaction and benefit. There are three such bearings organizations in the U.S.—the American Bearing Manufacturers Association (ABMA), the Bearing Specialists Association (BSA) and the Power Transmission Distribution Association (PTDA), with the latter involved in not only bearings but other power transmission components as well.

Add to that mix the commercial bearing distributorships, both here and around the world, and you have a robust mix of bearing-specific effort and expertise. Is there a distinction between associations and distributorships? You bet.

"When your company belongs to a trade association, you're amongst those who not only understand your business but can help you resolve some of your toughest challenges—because they've been there too."

ANN ARNOTT, PTDA

"A not-for-profit trade association is not a distributorship," says Jeri Church, executive secretary of the Glen Ellyn, Illinois-based BSA. "It is totally different; BSA does not sell bearings or related products as do our distributor members."

Or, as Ann Arnott, PTDA executive vice president/CEO explains, "While PTDA *is* a distributor organization, manufacturers have been members of the association since its inception," explains Ann Arnott, PTDA executive vice president/CEO. "Our founders believed bringing together distributors and their supplier partners was essential in helping distributors do a better job of serving *their* customers. PTDA covers more than 15 product categories—from bearings to belt and chain drives" to motors to motion control. What we've found is that many of our distributor members are selling products from across most of those categories, so they value the involvement of manufacturers from all of those categories."

But although distributorships, like associations, indeed offer some value-

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added icing on the cake in the form of education, inventory and supply chain management, for example, their primary reason for being is to make money. In fact, every major bearing manufacturer in the world—the Timkens, SKFs, Schaeffler Groups, etc.—has direct ties with distributor sales entities.

So think of the ABS and PTDA as resources for the information needed in order to find and obtain exactly the type of bearings you need.

We called on representatives from the three groups mentioned here with the goal of determining what's new with them and their industry, as well as to gain a complete understanding of how they can help end-users and buyers, as well as their members.

The PTDA's Arnott paints a mental picture for us.

"Imagine a community where you don't have to pause (and sigh) before you answer the question, 'So what do you do?' When your company belongs to a trade association, you're amongst those who not only understand your business but can help you resolve some of your toughest challenges—because they've been there too. For PTDA, we focus on creating opportunities for industry executives to discuss business issues and to network. (We offer) market and industry information to make better decisions for your company and resources to build the skills of your employees—all within the umbrella of the power transmission/motion control distribution industry."

"The more we look for, the more (counterfeits) we find. This continues to be the single-most important issue facing the global bearing industry."

SCOTT LYNCH, ABMA

Adding to that list is Scott Lynch, president of the D.C.-based ABMA.

"ABMA serves its members in a variety of ways. First and foremost, we are the voice for the U.S. bearing industry, which includes our engagement with the bearing supply chain, U.S. Federal Agencies, as well as our global activ-

ity with the World Bearing Association. We also offer various benefits to members, including industry statistics, influence over industry standards, and education curriculum focused on educating engineers that work with bearings. Finally, our efforts to fight counterfeit bearings domestically and abroad have had positive impacts throughout the supply chain."

Knowledge is power, and, to a great extent, bearing associations are in the knowledge business. As Church explains, "BSA members are all authorized distributors of bearings and bearing-related products from various manufacturers. These companies provide the technical expertise needed to purchase bearings. BSA has published 27 *Bearing Briefs*, single-topic installation and/or maintenance technical resources for the distributor and end-user, as well as five *Industry Briefs*, which discuss bearing usage for various industries. Both *Bearing Briefs* and *Industry Briefs* are developed by industry experts and are available as free, downloadable PDF documents from the BSA website. BSA has also launched an online knowledge center featuring how-to videos on bearing installation and maintenance, bearing service and care, and bearing characteristics, all produced by a number of participating BSA manufacturers on the association website."

And the ABMA has bearing manufacturers and material suppliers. While they do not have a distributorship dynamic—the association works with the BSA and PTDA in support of its mission.

"ABMA does not have distributors as members of the association, but we work closely with the BSA and the PTDA. A majority of the bearings are sold through distribution, so they are an important segment in our industry. Authorized distributors know the products they sell and work to ensure that only genuine products are sourced in the supply chain."

Obviously, the buy/sell dynamic is the bottom line for all of these groups. But just to be clear, why *buy* from a distributor?

"The short answer is because your distributor knows what you need *before* you need it, and can get it for you quickly to minimize your downtime and improve your bottom line," says Arnott.

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And then there is the know-what-you're-buying and who-you're-buying-it-from equation to think of. Remember—there is still a lot counterfeiting going on out there.

"Buying bearings from any source other than an authorized distributor is risky," Church cautions. "Distributors can be relied upon to determine that the product has been manufactured, stored, transported and handled properly. Using a bearing from some source other than an authorized distributor could raise questions about its functionality and safety. A Certified Bearing Specialist from an authorized distributor is the best resource for proper bearing selection. *(Ed.'s Note: go to www.bsa.com to read "The Top 10 Reasons to Buy from an Authorized Distributor" and for information regarding the BSA Certified Bearing Specialist program.)*

And why *sell* through distribution?

"Again, the short answer is because distributors can reach customers more effectively and in a more cost-effective manner than many manufacturers," says Arnott. "Distribution focuses on application and support for the customer, allowing manufacturers to concentrate on product innovations and improvements."

And just what is an "authorized" distributor?

"BSA defines an 'authorized distributor' as (one) who has been notified, specifically and demonstrably, by a bearing manufacturer that it may (offer) itself to (potential buyers), and as having the status of an authorized distributor for one or more of such manufacturer's basic (bearing) types and sizes," says Church, adding, "If (the) manufacturer withdraws such authorization, the distributor is no longer considered an authorized distributor for that manufacturer's products."

Revisiting counterfeit bearings, it must be said the problem continues to exist, worldwide. What to do?

"Counterfeit bearings continue to be a serious problem," Church confirms. "However, end users who purchase bearings from an authorized distributor can be confident that they are purchasing materials from the identified manufacturer."

"PTDA has adopted a joint statement with our European affiliate, EPTDA, regarding all counterfeit product," says Arnott. "(The) PTDA and EPTDA jointly support and promote among their members the highest standards of quality, authenticity, legality, safety and ethics in the supply of industrial products and equipment, and do not condone the distribution of illegal counterfeit product."

Nevertheless, the bearing supply chain remains compromised around the globe.

"The more we look for, the more (counterfeits) we find," says Lynch. "This continues to be the single-most important issue facing the global bearing industry. Over the last 15 months, Chinese Customs has seized more than 1 million counterfeit bearing products at their borders, and we have seen a huge up-tick in bearing seizures by U.S. Customs in the first quarter of 2013. This issue is not going away, and all partners in the bearing supply chain must remain vigilant to ensure that only genuine products are sourced."

And what happens—hypothetically—if bearings bought from a distributor should prove to be bogus? It will be expensive, for one thing.

"An example is a December 2012 conviction and tough sentence which sent a strong message to the market in a recent high-profile case," Church says. "And although this is the first time people in Sweden have been identified, charged and found guilty, it once again focused the need for ongoing vigilance in the battle against counterfeiting. The case resulted in a one-year jail sentence for the guilty individual, as well as a five-year ban on trading, and a payment of SEK 600,000 ($91,472 USD) to SKF."

Given all of the above, it is not hard to understand why bearing associations and distributorships—affiliated or otherwise—have a place in the market. On the other hand, the mantra throughout the world of manufacturing today is that reliance upon one-source suppliers is the optimal business model. Where do associations fit in?

"(In fact), our distributors *are* being asked to carry a wider selection of products," Arnott allows. "That means they need relationships with manufacturers from several product categories in order to get their customers what they need. That's where the relationship and networking aspects of PTDA's meetings really become valuable. Our MD-IDEX during the Industry Summit features more than 130 manufacturers, giving our distributor members the opportunity to refine marketing and sales plans with current suppliers and start conversations with potential suppliers."

Lynch adds, "While the distributor/manufacturer relationship is a focus of BSA and PTDA, ABMA has had recent success engaging other partners in the

bearing supply chain with a membership expansion with material suppliers to the bearing manufacturers, and a Webinar series focused on OEM end users."

"A desire for one-source suppliers doesn't alter the importance of relationships," Church explains. "Maintaining and building relationships among buyers and sellers up and down the supply chain has never been more important than it is now. Participation in BSA helps to strengthen those relationships for distributors, manufacturers and the end-use customer."

And then there is the Internet—an international bearings bazaar open to all comers and takers. How are the associations/distributors coping?

The bearings universe is indeed a vast one, and one can't help but wonder what the future holds for such a huge industry.

"Anything that twists, turns or moves probably has a bearing, so we are present in a variety of industries," ABMA's Lynch says. "In addition, with the globalization of all industry sectors, in many cases it is more about the economics of the country/region, than the sector.

"Buying bearings from any source other than an authorized distributor is risky. Only an authorized distributor can be relied upon to determine that the product has been manufactured, stored, transported and handled properly."

JERILYN CHURCH, BSA

"For example, the American automobile sector has been a bright spot, but as you look to Europe that is not the case. Wind energy has picked up since the re-authorization of the tax credit but much of this could be due to a lack of demand in previous quarters due to the uncertainty of the credit."

There you have it, and Lynch makes perfect sense. After all, don't bearings make the world go 'round? **PTE**

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Rolling-Element Bearing Analysis

How Multi-body Dynamic Software can Help Identify Issues with Design

Yijun Fan

This article describes how more sophisticated modeling techniques allow the latest software to identify design issues with bearings, shafts, gears and complicated multi-body systems.

Bearings play an important role in powertrain design. For example, in modern transmission systems, there are three major bearings that support the main shaft from front to back. They include the pilot bearing, the input shaft bearing, and the rear support (angular) bearing. The role of a pilot bearing is to stabilize the nose end of the main shaft and clutch disc with the flywheel. If this bearing fails, this portion of the shaft will be able to vibrate/thrust up and down as the disc rotates. This new clearance will allow the clutch to engage at an axis that is no longer centered along the line of power flow, which can cause catastrophic transmission element failure.

Because of the importance of the bearing, the prediction and control of rolling-element bearings on system performance are becoming some of the major concerns in powertrain design. Important considerations include how bearing clearance could affect the gear mesh, how bearing stiffness could impact the system natural frequency, or how different bearing parameters could change the stress distribution of the rotating main shaft.

Multi-body dynamics software is used to study the dynamics of moving parts and to determine how loads and forces are distributed throughout mechanical systems. Multi-body dynamic software like MSC Software's *Adams* is usually applied to model and analyze the powertrain systems by engineers at major OEMs. However, due to the complication of the bearing model itself, a "bushing element" is usually applied to represent the bearing model. While the bushing element plays a decent role in constraining relative motion between different parts, it lacks the fidelity of incorporating most of the bearing properties and limits engineers' ability to study how different bearings would impact the transmission system performance.

MSC Software has recently released a new member of the *Adams* family, *Adams/Machinery*, which is a set of productivity modules with the capability for wizard-based modeling and adjustable-fidelity simulation of common mechanical subsystems and components, including belts, chains, gears and bearings.

In the *Bearing Module*, there are three modeling methods designed for different levels of fidelity. For example, in the "Detailed" method, a force is used to represent rolling element

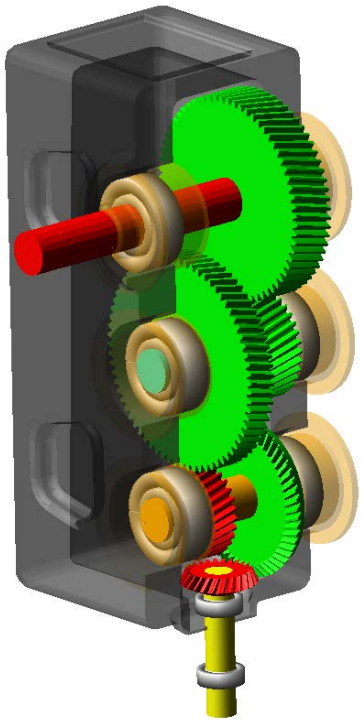

Figure 1 Gear train model.

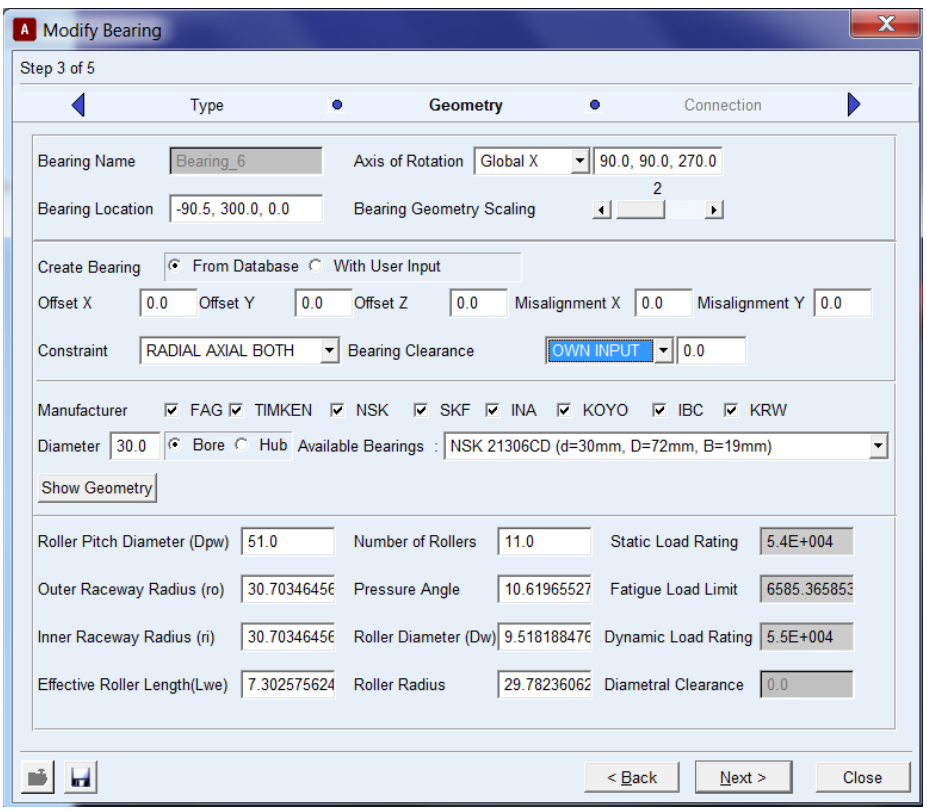

Figure 2 Bearing creation wizard.

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bearings. Using advanced analysis technology from drivetrain simulation software *KISSsoft* (now embedded in *Adams/Machinery*), stiffness is calculated at every step based on the positions and velocities at the bearing location. Damping is based on user-specified factors. The bearing module enables an engineer to select from a library of more than 24,000 off-the-shelf bearings spanning a range of 14 bearing types, including deep groove ball bearing, cylindrical roller bearing, needle roller bearing, tapered roller bearing and so on. The library supplies characteristic geometry values for bearings from eight leading manufacturers, like Timken and NSK. The *Bearing Module* allows designers and engineers to build more realistic bearing models and systems (Fig. 1) early in the design cycle, with a level of detail that allows them to perform meaningful analyses, long before they get to the stage of building physical prototypes. To understand how the *Bearing Module* enables the engineers to study bearings from a system level, let's look at some of the application examples:

How Bearing Parameters Impact the Stress Distribution of the Input Shaft

A shaft is the component of a mechanical device that transmits rotational motion and power. Because of the simultaneous occurrence of torsional shear and normal stresses due to bending, the stress analysis of a shaft virtually always involves the use of a combined stress approach. In order to increase the simulation fidelity, engineers utilize the system-level dynamic model to capture the real loading of the shaft before they perform the stress analysis.

Normally, bearings are used to support a shaft. Different bearing parameters result in different bearing stiffness, which would impact the system performance, such as the radial and

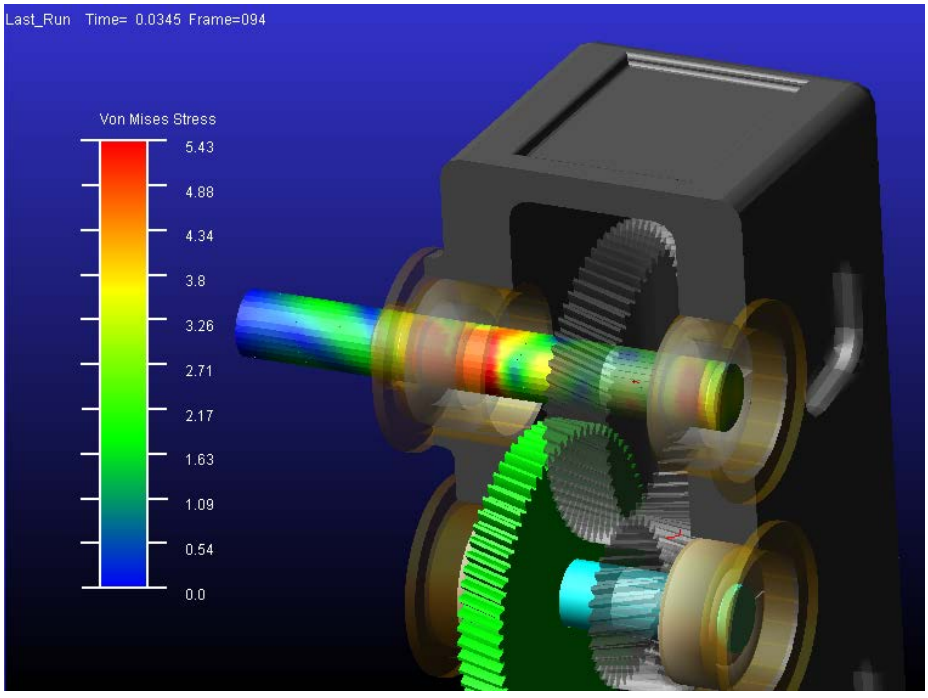

Figure 3 Stress distribution of the input shaft.

Figure 4 Gear mesh.

axial components of the contact forces between the bearing and the shaft. So, it is important to analyze how different bearings would impact the shaft stress distribution.

Each bearing has its unique set of parameters, such as inner diameter, outer diameter, number of rollers, roller radius, effective roller length and so on. All of those parameters can be defined in the *Adams/Machinery Bearing Creation Wizard* (Fig. 2), either by user input or by picking from the embedded bearing library.

In order to get an accurate loading condition for the shaft, shaft flexibility is usually taken into account in the transmission model. Engineers can choose either to import the MNF file of the shaft from FEA software or to directly generate the flexible body using the *Adams Viewflex* function.

After the flexible shaft is generated, engineers can get the accurate load history of the shaft based on different bearing parameters. And then, they can either export the load history of the shaft to the FEA software as boundary conditions and conduct the stress analysis, or perform the stress analysis within the *Adams* environment using the *Adams Durability* function (Fig. 3).

In this way, engineers can analyze how bearing parameters would impact the stress distribution of the input shaft

and choose the right bearing according to the system requirements.

How Bearing Clearance Affects Gear Mesh

A gear mesh refers to the way that the teeth from one gear engage with those from another gear. If this mesh is incorrectly set, by being either too tight or too loose, you will not be able to get optimal performance from your transmission, and this condition will contribute to premature wear of some components. Many things can cause the misalignment of the gear mesh, and bearing clearance definitely is one of them since it changes the center distance between the gear pairs.

In the *Adams Machinery Bearing* module, engineers can define their own bearing clearance, offset and misalignment when creating the bearing model using the wizard approach.

There are two ways to analyze the gear mesh in the system. Using a 3-D contact gear model created by the *Adams Machinery Gear* module, engineers can observe the gear engagement visually (Fig. 4). Also, one can create a measurement between the center markers of the two gears and get more detailed results for the center distance of the gear pair.

In this way, engineers can quickly study how the bearing clearance would impact the gear mesh.

How Loads Affect Bearing Service Life

Rolling element bearing life is determined by load, temperature, maintenance, lubrication, installation and other factors. These factors can all have a significant effect on bearing life.

Based on widely-accepted industrial standards ISO/TS 16281, the *Adams Machinery Bearing* module allows engineers to quickly evaluate the bearing service life under load/speed conditions of each output step. It also takes into account the operating temperature and the types of lubricant applied to the bearing when calculating the results (Fig. 5).

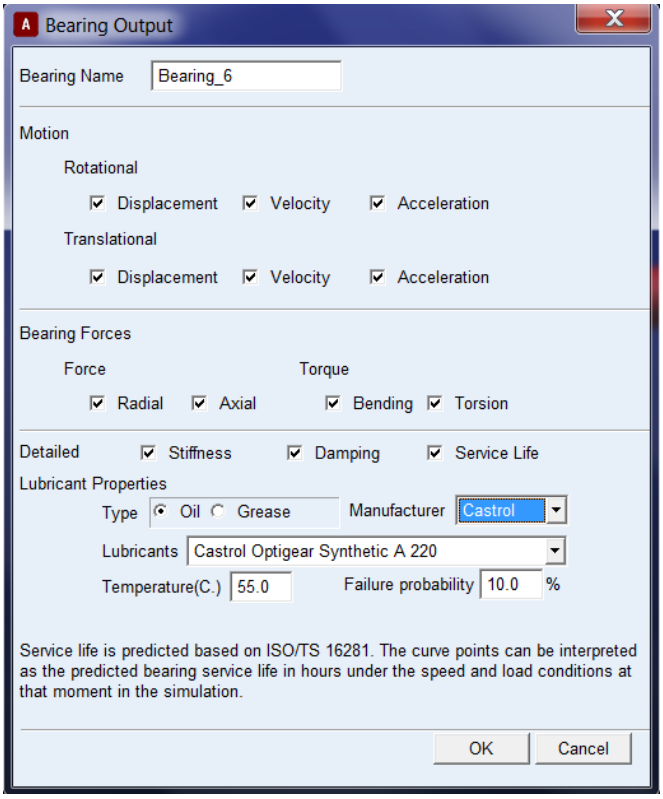

Figure 5 Bearing output window.

With this quick evaluation tool, engineers can easily tell how bearing loads or rotational speeds could result in different bearing service life (Fig. 6).

Conclusion

It is important to study the impact of the design and behavior of rolling-element bearings on overall system performance. The insight gained from the deep analysis capabilities of the *Adams Machinery Bearing* module lets you predict and correct design behavior problems much earlier. And, by predicting system-level functional performance, you are able to more accurately assess the load history of the part to perform more accurate stress analysis, and reduce risk. **PTE**

Yijun Fan is Adams Product Marketing Manager at MSC Software

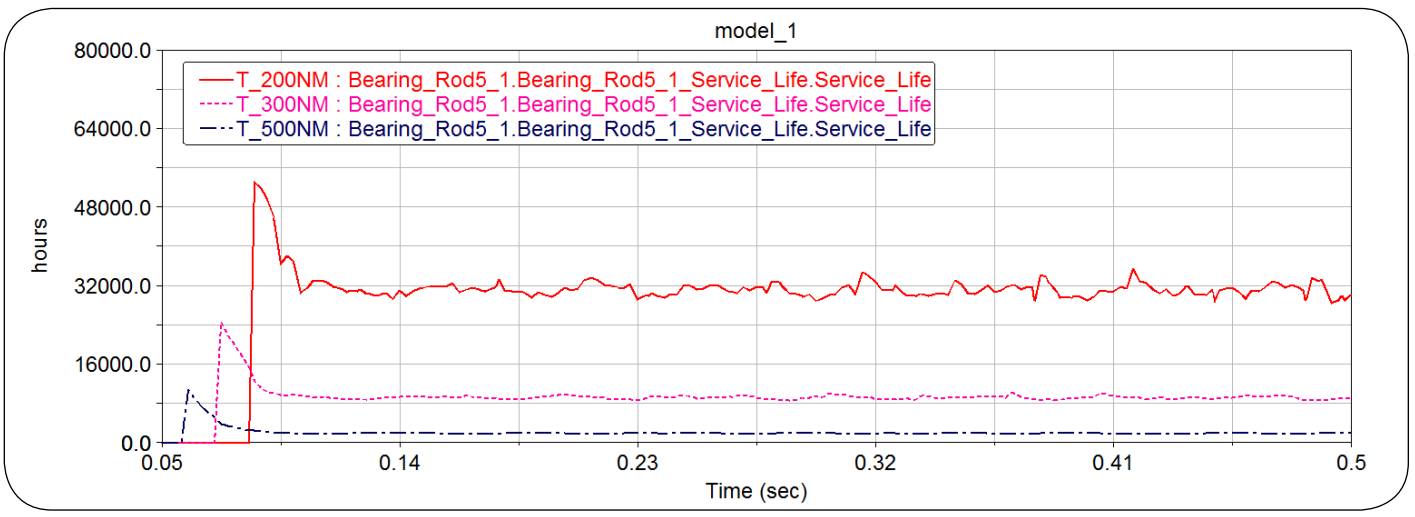

Figure 6 Bearing service life under different input torques.

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Power Loss and Axial Load Carrying Capacity of Radial Cylindrical Roller Bearings

Simon Söndgen and Wolfgang Predki

This paper is intended to enlarge the application range of radial cylindrical roller bearings by means of a more precise determination of thrust load capacity and more cost-effective design.

Introduction

Cylindrical roller bearings (CRBs) have a wide application range and a significant role in drive engineering. Due to line contact, CRBs have a greater radial load capacity than other rolling bearings of the same size. Their possibility for use in high-speed applications and an advantageous friction behavior are additional benefits (Ref. 1). Several designs, which vary regarding the quantity and arrangement of the lips, exist. The lips allow the application of axial loads in one (supporting bearing) or two directions (locating bearing). When, for example, axial forces are applied, they are transferred from the lip of the inner ring to the roller end faces, and from there to the lip of the outer ring. Alternating axial loads can be supported by a bearing of the NJ (cylindrical roller bearing)-type—in combination with an angle ring HJ (see previous)—or by a bearing of the NUP (see previous)-type with loose lip (Ref. 2).

Despite the fact that combined-loaded CRBs have been in use for more than a century, there had existed no standard for the calculation of the axial load-dependent friction torque and the axial load capacity until now (Ref. 3). While there are indeed equations presented in the relevant literature and bearing catalogues that enable the calculation of the axial load-dependent friction torque, these equations are mostly based on empiric approaches and the results of their use vary significantly.

Lubenow (Ref. 4) conducted extensive measurements on combined-loaded CRBs; Figure 1 shows the results from the equations of Schaeffler (Ref. 5), SKF (Ref. 6), Braendlein (Ref. 7) and the simulation according to Lubenow, as well as the latter's measurement results (Ref. 4). The results shown are valid for a run-in bearing of the NJ 210 type at an operation temperature of 70°C and using lubrication with a mineral oil of the viscosity class ISO VG 220.

The radial load amounts to $F_r = 5$ kN, whereas the axial load $F_a = 4$ kN is chosen. The axial load-dependent friction torque T_2 is illustrated in dependency of the inner ring speed n; Figure 1 shows significant deviations between the different determined axial load-dependent friction torques.

Particularly at low speeds, not only do the results from the equations of the bearing manufacturers and of Braendlein (Ref. 7) vary from the measurement results, but also from Lubenow's simulation results (Ref. 4).

The friction torque of thrust-loaded radial cylindrical roller bearings is an important parameter for the determination of the axial load-carrying capacity at medium to high speeds; the permissible thrust load can be determined by means of a heat balance (Ref. 4). At low speeds, the frictional losses decrease and therefore the theoretically permissible thrust load strongly increases. The bearing manufacturers therefore additionally impose a limiting ratio of axial-to-radial load, and a limit-

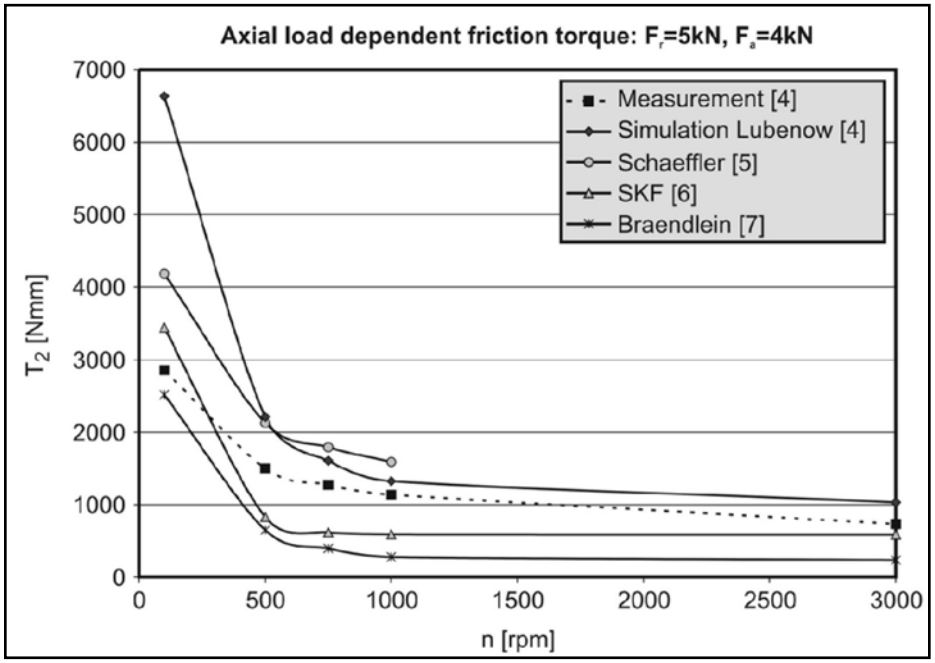

Figure 1 Axial load-dependent friction torque T_2 according to different calculation methods and measurement results.

Table 1 Examined bearings and lubricants			
Bore reference number	06	10	16
Bore diameter	$d = 30$ mm	$d = 50$ mm	$d = 80$ mm
Variant	NJ2206 E.TVP2	NJ2210 E.TVP2	NJ2216 E.TVP2
	N2306 E.TVP2	NJ2310 E.TVP2	
	NUP2206 E.TVP2	NUP2210 E.TVP2	
	NJ2206 E.TVP2 + HJ206	NJ2210 E.TVP2 + HJ210	NJ2216 E.TVP2 + HJ216
	SL182206	SL182210	
Mineral oil	Aral Degol BG 220		
Polyglycol	Tribol 800/220		

ing axial load in dependency of the size and design of the bearing.

However, these details are only valid for the bearings of one manufacturer, and considerable safety margins are applied.

Testing Program

For this investigation (Ref. 10), five different designs of CRBs in three sizes are considered. For the evaluation of size effect, bearings with the bearing diameters $d = 30$, 50 and 80 mm are chosen. Rolling bearings are produced in different series. These series feature varying load ratings independent of the outer diameter, quantity of rolling elements and bearing width. Besides the bearing series 22, series 23 is examined. Bearings of the NJ design normally provide friction-optimized lip geometries. The lip is not orthographic to the raceway, but inclined with the lip angle ϕ. Furthermore, the lip can be crowned. The loose lip of a NUP design and an angle ring in contradiction do not feature a friction-optimized geometry. Their evaluation will demonstrate the influence of the lip geometry on the friction behavior of axial-loaded CRBs. Full-complement bearings employ the maximum possible number of rolling elements, whereby the radial load is shared by a greater number of contacts and thus leads to greater load rating. These bearings can be used as a supporting bearing like an NJ design because they also feature three lips.

The lubricant has a large influence on the friction behavior and, therefore, on the permissible thrust load of radial cylindrical roller bearings. Within this study a mineral oil and a poly glycol of the viscosity class ISO VG 220 are tested (Table 1).

In addition, all bearings feature normal clearance. The cage material is Polyamide 66. The friction torque measurements are performed at different combinations of speed and load. The gaps between the different speeds in the low-speed range are chosen smaller than at high speeds because the lubrication film thickness in the lip-roller contact grows with speed. With the rise in lubrication film thickness, the rate of mixed lubrication decreases and the hydrodynamic friction increases. The focus of this study is on the operation with mixed friction, for which reason the test speeds are chosen according to Table 2.

The tests at constant speeds are supplemented by run-ups; the test program is completed with run-in and wear experiments.

Friction Torque Measurements on Rolling Bearings

For the assessment of the behavior of combined-loaded CRBs—as well as of bearings in general—the global-measure friction torque is of decisive relevance. On one hand, resulting bearing temperature is directly dependent on the friction; on the other, conclusions regarding the lubrication condition can be drawn. In past years extensive measurements of bearing friction torques on different test rigs have been performed at Ruhr University-Bochum's Research Center for Mechanical Components and Power Transmission.

Lubenow (Ref. 4) and Koryciak (Ref. 8) used devices that allowed measurement of the friction torque on the outer ring of the test bearing. For this study a new test rig has been designed that allows measurement of the friction losses of multiple bearings with a torque measurement shaft. The detection of the friction torque is effected on the inner ring. Figure 2 shows that the result is affected by the measuring position due to the splashing of the rolling elements and the cage in the lubricant.

While the outer ring is standing still, the inner ring is driven with the necessary driving torque T_{drive}. The friction of the whole bearing has to be overcome and therefore the driving torque T_{drive} complies with the absolute value of the measured friction torque on the inner ring T_{IR}. Due to the splashing of the rolling elements and the cage, the drag torque T_{drag} results on the cage that is retained in the lubricant. The measured friction torque therefore is reduced by the amount of the drag torque. In the following the influence of the different measuring techniques on the results is examined. With the help of a modified test rig, the influence of the measuring position dependent on speed and oil level is investigated. The testing bearings are applied with the minimum radial load according to SKF (Ref. 6). While operating with minimum lubrication, the drag losses vanish; both measuring positions should show the same results. Dipping the shaft into the lubricants leads to additional drag losses that would influence the results; therefore the maximum oil level is limited to the inner ring of the test bear-

Table 2 Test speeds	
Inner ring speed, n, rpm	20, 50 100, 500, 1000, 3000, 5000

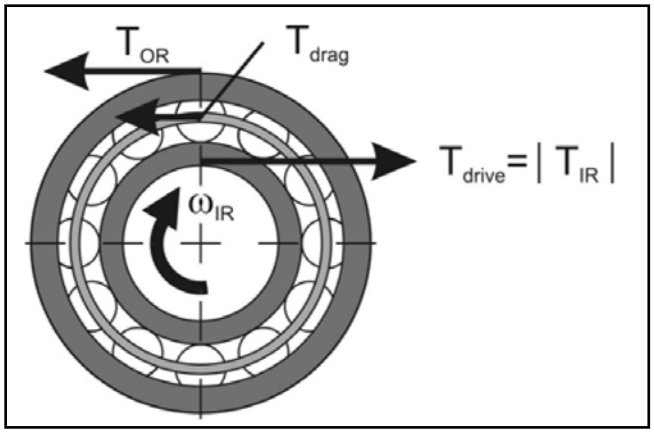

Figure 2 Measured friction torques of a bearing.

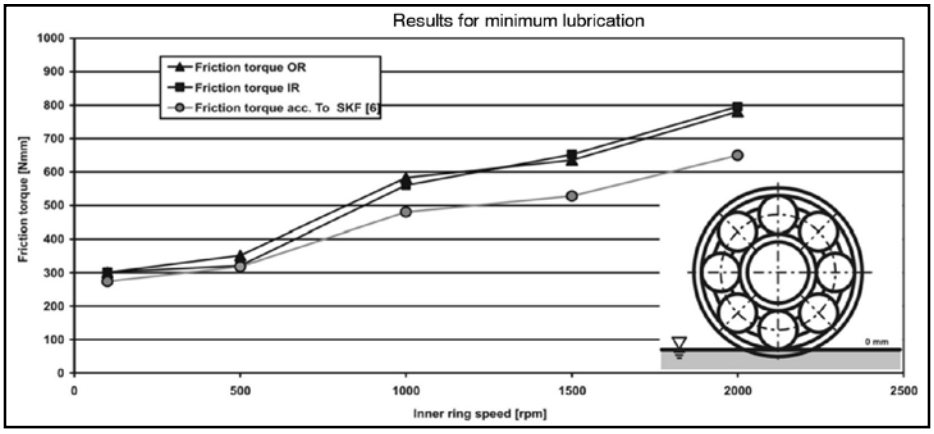

Figure 3 Friction torque at minimum lubrication.

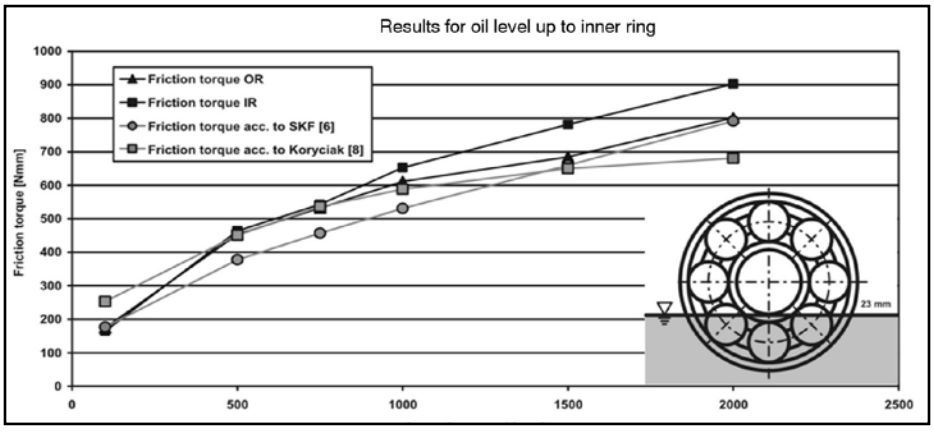

Figure 4 Friction torque at oil level "up to inner ring."

Table 3 Bearing geometry

	NJ2206	NJ2210	NJ2216
Bore diameter, *d*, mm	30	50	80
Outer diameter, *D*, mm	62	90	140
Bearing width, *B*, mm	20	23	33
Quantity of rolling elements, *n*	13	16	18
Rolling element diameter, d_w, mm	9	11	16
Rolling element width, l_w, mm	13	15	24
Static load rating, C_0, kN	50	88	245

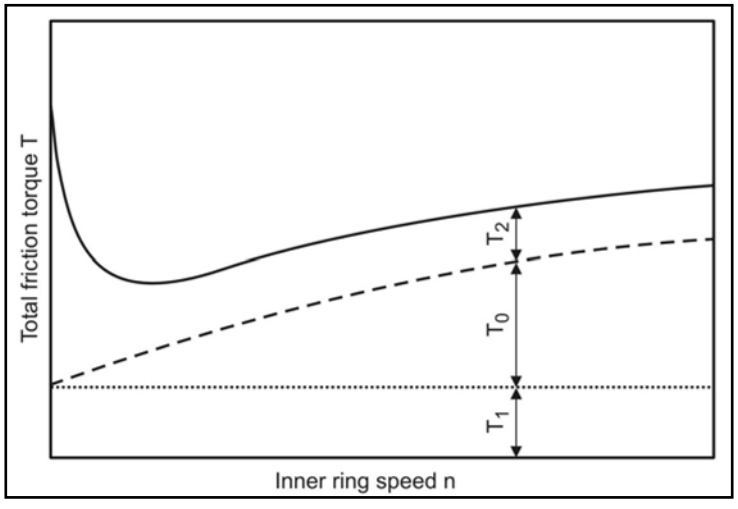

Figure 5 Distribution of friction torque dependent on inner ring speed.

ings. Between these extremes the levels "lowest-rolling-element-half-in-oil" and "lowest-rolling-element-in-oil" are defined (Fig. 3).

Figure 3 shows the total friction torque in dependence of the inner ring speed. The measuring results are compared with the calculation results according to SKF (Ref. 6). The deviation between the measured torques on the inner and outer ring are within the measurement precision. This proves the assumption that with the disappearance of the drag losses, the measuring position has no influence on the results. Furthermore, at low speeds the results follow the calculations according to SKF very well. At medium and high speeds, the calculated values are below the measured ones. Figure 4 summarizes the results for the maximum oil level. In addition to the SKF results, values calculated with the method of Koryciak (Ref. 8) are presented.

Figure 4 shows that with higher oil levels a rising difference of the measured torques can be observed from an inner ring speed of 1,000 rpm and higher. The measuring position on the outer ring also shows good correlation with the results documented by Koryciak (Ref. 8). Koryciak performed his examinations on test rigs which detect the friction torque on the outer rings of the test bearings. The conclusion is that with rising oil levels, differing friction torques are to be observed on inner and outer rings. Furthermore, the results show deviations in the range of 100 N-mm for the examined bearing. The measurements within this study were performed at considerably high radial and axial loads, which lead to much higher friction levels than observed in this presentation. In the range of high friction levels, greater deviations have to be taken into account, which easily can amount to several hundred N-mm. Considering this, the influence of the measuring position on the results can be ignored.

Results for Oil Level Up to Inner Ring

Influence of the bearing size. For the examination of the size effect, CRBs with 30, 50 and 80 mm bore diameter

are tested. Table 3 shows the relevant data of the NJ22 design.

Driven at constant speed, a rising bearing diameter induces a higher sum of velocities in the lip-roller contact. At a rising sum of velocities, the lubricant film thickness rises as well, meaning that the sum of velocities has great influence on the friction and wear behavior of the contact. At low speeds, the lip-roller contact is characterized by mixed lubrication, while at higher speeds the portion of hydrodynamic lubrication rises. For this reason there is a minimum at a certain speed range. Above the speed range with minimum friction, the drag losses grow larger (Fig. 5). The load-independent losses are represented by T_0, the radial load dependent friction torque is T_1, and the axial load-dependent friction torque is T_2.

Due to the differing sums of velocities and rising bearing diameters, the friction minimum is removed to lower speeds with rising bearing diameter. Concurrently, the axial load-dependent friction torque decreases, due to higher lubrication film thickness and attendant rising diameter, constant speed and load. The axial load-dependent friction torque is described as the product of the normal force in the lip-roller contact, a friction coefficient and the lever to the bearing axis. The lever grows with the bearing diameter, as does friction torque (Fig. 6).

Due to these described effects, the smallest bearing shows the highest axial load-dependent friction torque on the test rig. For the medium-size bearing, the lowest axial load-dependent friction torque can be observed, whereas the largest bearing has friction losses ranging exactly between the other ones (Fig. 7). To correctly interpret Figure 7, one must consider that the illustrated results are only valid for the axial load-dependent friction torque and that speed, temperatures and axial loads are held constant.

Influence of the Bearing Design

The examined bearing designs were introduced earlier in this presentation. Macroscopically, the different test bearings can be distinguished by the quantity and configuration of their lips.

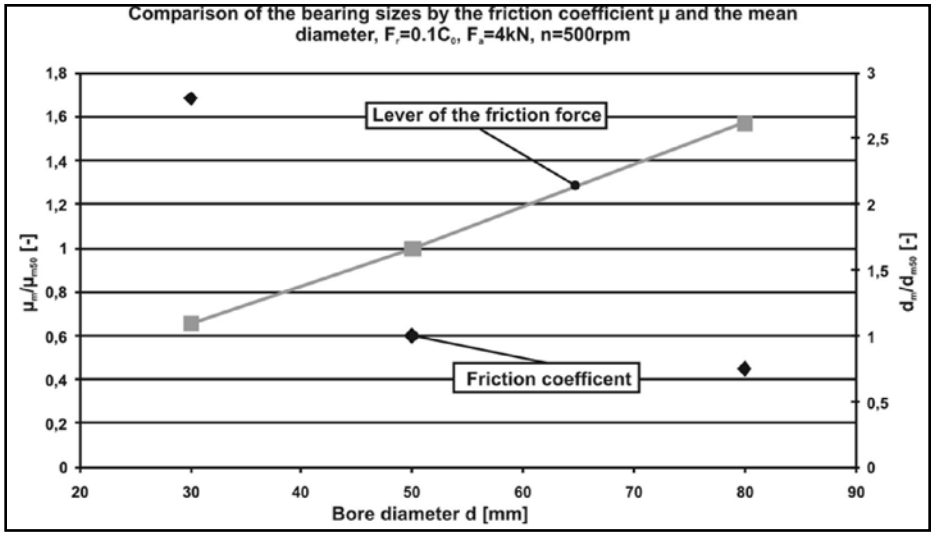

Figure 6 Friction coefficient and lever of the friction force on lip inner ring.

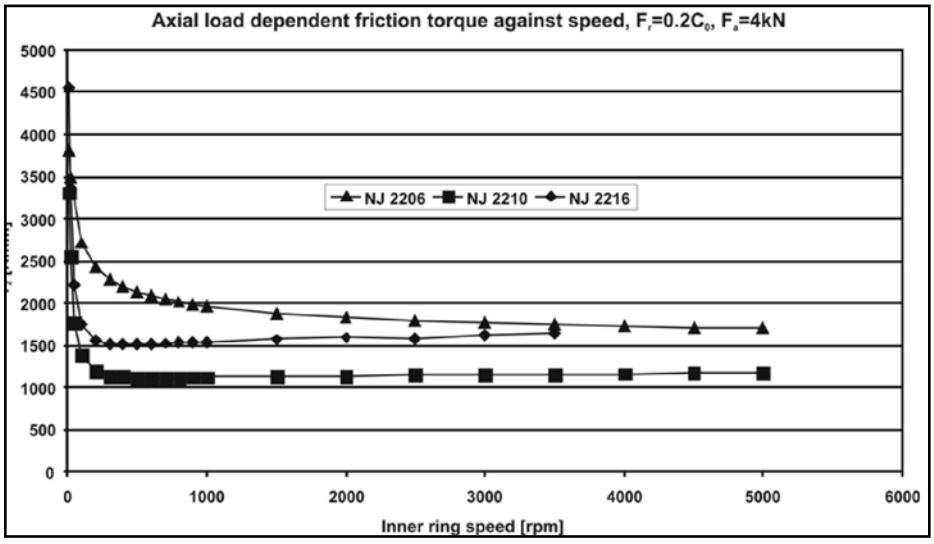

Figure 7 Axial load-dependent friction torque T_2 independent of speed and bearing size.

Additionally, full-complement CRBs and bearings of the "heavy" series NJ23 are investigated (Table 4).

As observed in Table 4, the full-complement bearing and the NJ2306 obviously differ from the remaining bearings. In this connection especially, the quantity of roller elements and their length are to be highlighted. Figure 8 shows measured total friction torques of the different bearing types determined in run-in tests. The test speed amounts to $n = 500$ rpm; the bearings are lubricated with mineral oil.

The bearing loads were chosen according to their static load rating C_0, for which reason the total friction torque of the variants NJ2306 and SL182206 exceeds that of the remaining bearing variants. In the matter of the full-complement bearing, the roller elements contact; this contact induces higher frictional losses due to their rotation in opposing directions.

Figure 8 shows a minor run-in of the NJ2206 during the first 50 operating hours. The reduction of friction amounts to approximately 500 N-mm and is considerably lower than observed in earlier examinations. This observation can be explained by lower roughness before the start of the test. As already mentioned, the loose lip and the angle ring do not feature an optimized lip geometry.

What's more, the roughness is higher than that of the NJ bearing lip. For these reasons these variants show a more distinct run-in effect. The combination of a NJ2206 and an angle ring reaches a similar friction level as a thrust-loaded NJ2206 without an angle ring.

The NUP bearing does not reach the full run-in state (Fig. 8). Tests with the larger bearing NUP2210 show that a complete run-in bearing with a loose lip can have friction torque similar to an NJ bearing. And like the NJ2206, the NJ2306 does not show a run-in effect. The full-complement CRB, despite its lower roughness, shows a significant run-in effect. This is not to be traced back to a run-in process in the lip-roller contact, but rather to a run-in process in the contact between the rolling elements amongst each other. To summarize, the axial load-dependent friction torque of all considered bearing designs is on the same level as if they were completely run-in.

Table 4 Geometry of tested bearings with 30 mm bore diameter

	NJ2206	NUP2206	NJ2206 +HJ206	NJ2306	SL182206
Bore diameter, d, mm	30				
Outer diameter, D, mm	62			72	62
Bearing width, B, mm	20			27	20
Number of rolling elements, n	13			12	16
Rolling element diameter, d_w, mm	9			11	9
Rolling element length, l_w, mm	13			18	14
Number of lips on the inner ring	1	2	2	1	2
Number of lips on the outer ring	2				1

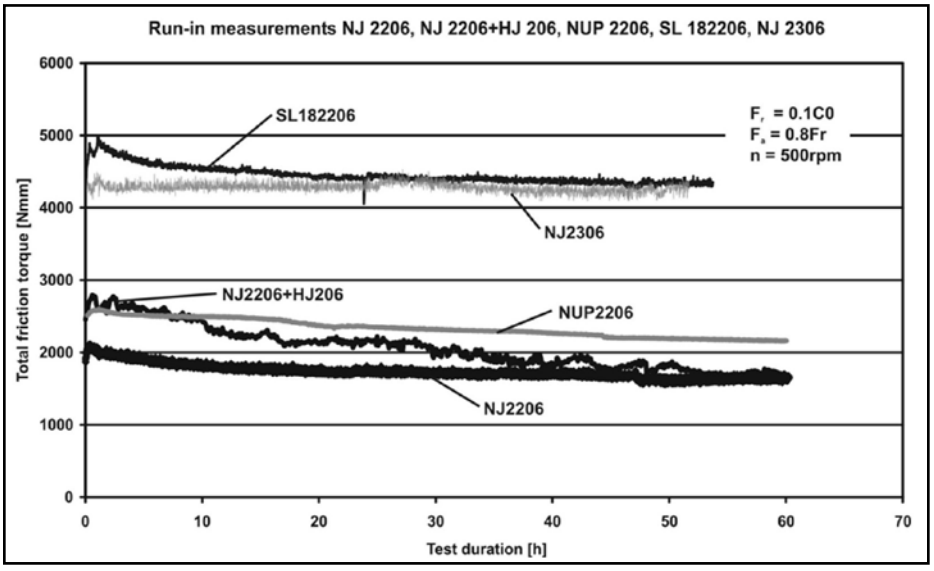

Figure 8 Run-in measurements.

Approximation Equations

In the scope of this study, approximation equations are developed that allow the calculation of the axial load-dependent friction torque of CRBs. Only common sense dimensions are used for these equations; the microgeometry of the bearings is omitted. Figure 9 shows a comparison of the results from the approximation equations and those from the simulation model (Ref. 9).

The left part of Figure 9 shows the results from the approximation equations, whereas the results from the simulation model are illustrated at the right. The calculations are based on an NJ2206 bearing that is operated in the experimentally investigated parameter range. Figure 9 displays good correlation among the simulations from the simulation model with those from the approximation equations. Only in the range of high loads at low speeds do the approximation equations lead to higher values than calculated by the simulation model.

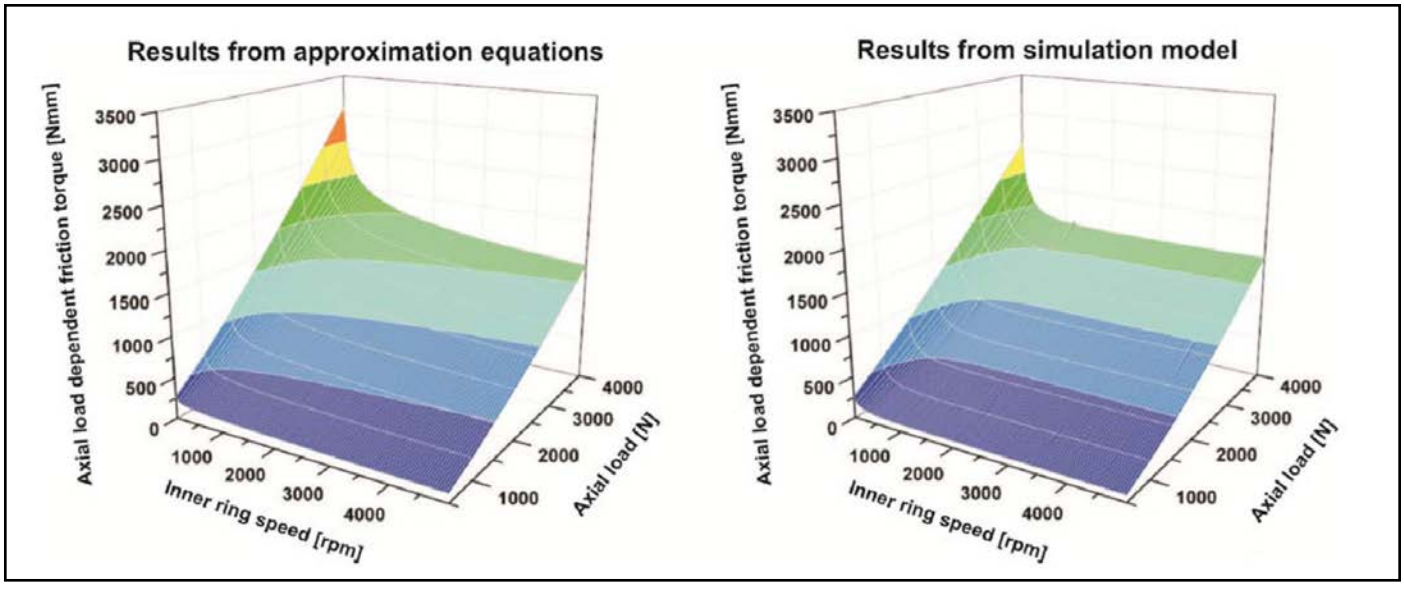

Figure 9 Results from the approximation equations vs. results from the simulation model (Ref. 9).

Summary

The aim of this study is the examination of the axial load-carrying capacity and of the axial load-dependent friction torque of cylindrical roller bearings. Extensive test runs are performed with five different bearing designs and three different sizes. The decisive measure is the bearings' friction torque. Besides size and design of the bearings, the operation parameters of speed, loading and lubricant are varied. The tests included comprehensive measurement of equilibrium, run-ups, running-in and wear experiments. A simulation model that has been developed at RUB allows the calculation of the axial load-dependent friction torque, load distribution, Hertzian stresses and lubrication film thicknesses (Refs, 4 and 9).

The results achieved within this study allow for the validation of this simulation model. This study is comprised of the development of approximation equations that allow the calculation of the axial load-dependent friction torque with parameters that are known to the designer. The results are the basis for the determination of the permissible axial load with a heat balance of the bearing. **PTE**

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DC Motor Protection

The purpose of DC motor protection is to extend a motor's lifespan by protecting it from conditions that can damage that the motor's windings—both electrically and mechanically. Motor winding damage can result from any of the following conditions (Ref. 1):

- Mechanical damage
- Excessive moisture
- High dielectric stress
- High temperature

While each of the above conditions can lead to winding damage, the *apparent* failure is "thermal degradation of the insulation or burnouts. Insulation life is reduced by about half for each 10° C increase in winding temperature" (Ref. 1). To avoid thermal degradation of the insulation, there are a number of methods, devices and circuits used to monitor potential motor hazards and fault conditions and to de-energize the motor when these conditions are met.

Potential Motor Hazards and Fault Conditions

A review of motor hazards and common fault conditions is useful in understanding the different approaches taken to protect motors. These fault conditions are divided into the following categories (Ref. 2):

- Motor-induced faults
- Load-induced faults
- Environment-induced faults
- Power source-induced faults
- Application-induced faults

Motor-induced faults (Ref. 2) are directly related to the motor and its associated wiring. Common motor-induced faults include burnt out insulation, bad bearings, loss-of-field and other mechanical failures. Wiring problems, chafed or exposed wiring, cabling faults or abraded insulation can cause "short circuits between power phases or between a power phase and earth ground in the motor winding or its connections" (Ref. 3). (*Note: Even though wiring or cabling faults are related to power source-induced faults, they are categorized as motor-induced faults.*)

Load-induced faults (Ref. 2) are "the prolonged overloading as a result of the application of excessive mechanical load" (Ref. 3). Jamming (locked rotor) is a common load-induced fault that causes an apparent overload or high inertia (Wk^2d). In pump applications, for instance, oil that is cold or highly viscous may cause a fault; oil heaters are a possible solution to correct this fault condition.

Environment-induced faults (Ref. 2) include high ambient temperature, cold/damp environment, high contaminant level and blocked ventilation, among others. These conditions can increase the temperature of the windings by collecting moisture, degrading by corrosion or insulating the windings from contaminants. Loss of ventilation—especially at low speeds—also increases winding temperature.

Power source-induced faults (Ref. 2) typically will cause high motor currents that can thermally degrade the motor windings from I^2R heating. These fault conditions are numerous and include over-voltage; under-voltage; phase reversal; open phase failures (Ref. 3); unbalances; ground-faults; power transients; harmonics; and loss-of-field.

Application induced-faults (Ref. 2) are caused by operating conditions that typically cause overcurrent or overload conditions. These conditions include high duty cycle; jogging; rapid plugging (or plug reversing); over-speeding (Ref. 4); and synchronization problems.

Motor Protection Methods

Motor protection methods include devices and circuits that are used within the motor or used with the motor's control circuitry to monitor fault conditions. They include:

- Thermal overload relays

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- Transient voltage protectors
- Ground fault relays
- Distance relays
- Fuses, contactors and circuit breakers
- Under-voltage protection
- Locked rotor protection
- Loss-of-field relays
- Reversed-current protection
- Isolation transformers
- Harmonic filters
- Power conditioners

Thermal overload relays (Ref. 5) protect motors from overload conditions. There are two main types: inherent and external. Inherent thermal overloads (Ref. 6) are bi-metal devices embedded in the motor's windings. They are essentially thermostats with two dissimilar metals bound together that will bend to open (in some cases, close) a trip switch (Ref. 7) at a temperature set-point, which is proportional to motor current in an overloaded condition. The switch is connected to the motor's control circuitry to alarm and/or de-energize the motor. External thermal overload protection (Ref. 5) involves heaters that are connected in series with the motor's windings and mounted on the motor contactor or circuit breaker. There are two types of overloads: solder pot and bimetal strip. Solder pot overloads will melt when the heat generated by the motor current in an overload condition occurs; this action opens the motor control circuit and trips the motor off the power line. Bi-metal-strip (Ref. 5) thermal overloads operate similar to inherent overload protection. While thermal overload protection is most commonly used, electronic and magnetic overload protections are also used to combat overload (Ref. 8). Electronic overloads are current sensors. They sense actual motor current; when the motor current reaches a predetermined level, a relay will trip and open the motor control circuit. Magnetic overloads use electromagnetism to sense an overload. When an overload condition is sensed, a relay coil will pull in (close) and trip the motor off the power line.

Fuses and circuit protectors are not overload protectors; rather, they are overcurrent protectors designed to "protect the motor from a direct ground or short-circuit condition" in the motor or its associated wiring and cabling (Ref. 5). Short-circuit protection is incorporated into a motor contactor with "high-breaking-capacity fuses" or a circuit breaker with "instantaneous attracted armature-type relays." Ground fault relays or interrupters are another type of overcurrent protection. They monitor "unintentional current paths between a current-carrying conductor and a grounded surface" (Ref. 9). For motors, ground fault current paths are typically found through dust, water, or worn insulation. Ground faults pose worker safety hazards (Ref. 10). Reverse current relays are a protective feature used in motor-generator applications where a standby battery is being charged by the generator. The reverse current relay prevents the battery from discharging and motorizing the generator (Ref. 11).

For DC motors, the loss-of-field can potentially cause a dangerous, overspeed condition (Ref. 12). Hence, loss-of-field relays are used to monitor the motor's field. They are connected in parallel with the field and monitor the DC motor's field current. In the event that the field current decreases below a certain limit (Ref. 13), the loss-of-field relay will drop out and de-energize the motor's armature.

When a motor fails to start or accelerate after it's been energized, it is exhibiting a locked-rotor condition. In this condition the "motor is subject to extreme heating, much more so than in an overload condition since the heat has very little time to be dissipated in the conductors and other parts of the motor" (Ref. 14). Locked-rotor conditions can be protected by an overcurrent relay set for permissible I^2t times and currents. But for large DC motors, another solution is to build a zero-speed switch into the motor (Ref. 15). If the motor does not accelerate to open the zero-speed switch, the motor's power supply is de-energized. However, there's a disadvantage to the zero-speed switch; in situations where the motor starts but locks up at less than full speed, the zero-speed switch can close and de-energize the motor's power supply. Locked-rotor protection can also be accomplished by a distance relay (Ref. 16).

Power source-induced faults include under-voltage, overvoltage, open phasing, phase rotation and phase imbalances. (*Note: Generally speaking, phase imbalances, phase rotation faults and*

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open phasing are associated with AC motors, and are not addressed in this article. But it should be noted that if a DC motor is powered by a DC converter, this controller protects the motor from these conditions.) (Ref. 17) Under-voltage faults can cause either high motor currents or a failure to start. Hence, most under-voltage protection is part of the motor starter. However, for prolonged under-voltage conditions, an inverse-time-under-voltage-relay can be used to protect from this condition (Ref. 18).

Rather than using discrete components to protect a DC motor from overvoltages or surges, DC drives, isolation transformers (Ref. 19) and power-conditioning equipment (Ref. 20) are typically used to provide this type of protection. However, MOVs (Ref. 21), arrestors (Ref. 22), harmonic filters (Ref. 23) and power factor correction capacitors can also provide overvoltage protection (Ref. 23).

Interlocks: Indirect Motor Protection

Interlocking is used to "prevent (motor) contactors from being energized simultaneously, or closing together and causing a short-circuit (Ref. 24)." In this respect, interlocking is an indirect type of motor protection and generally is used with motor starters for reversing and/or auxiliary control. There are three types of interlocks:

- Mechanical
- Electrical
- Auxiliary contact

Mechanical interlocks will physically prevent two motor contactors (forward and reverse) from closing simultaneously. "This interlock locks out one contactor at the beginning of the stroke of either contactor." On the other hand, electrical interlocks use a push-button control or auxiliary contact to electrically isolate one contactor while energizing the other contactor (Ref. 25). Auxiliary contact interlocking is a wiring modification of push-button interlocking. There are two types of auxiliary contacts: normally closed (NC) and normally open (NO). For interlocking protection in a reversing circuit, an NC auxiliary contact is wired in series with the opposing motor contactor coil. Thus, when a motor is running in the forward direction, the forward contact coil is energized through the NC auxiliary contact. When the reverse direction is selected, the NC contact will open and de-energize the forward contact coil while the reverse coil will energize through its NC auxiliary contact.

Environmental Protection

Environmental contamination can adversely affect normal motor operation. Dust, air particulates, explosive vapors, water, humidity and high ambient temperatures can all shorten the lifespan of a motor. To protect a motor from these environmental conditions, the National Electrical Manufacturers Association (NEMA) and the International Electro-Technical Commission (IEC) have classified motor enclosures based upon the level of protection they provide (Ref. 26). The two major classifications of motor enclosures are open and totally enclosed. Open motors are further classified as drip-proof, splash-proof, weather-protected, semi-guarded and guarded. Totally enclosed motors are classified as totally enclosed non-ventilated, fan-cooled, explosion-proof, dust ignition-proof, air-to-water cooled and air-to-air cooled. **PTE**

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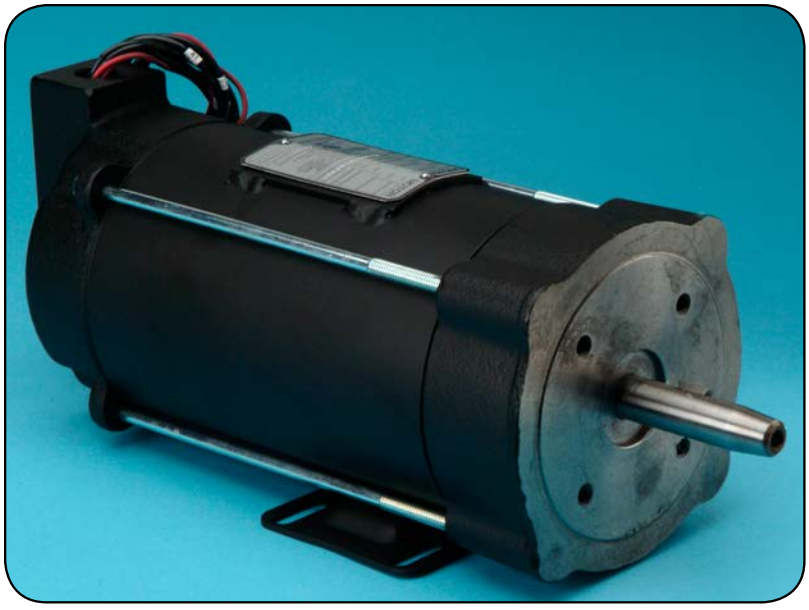

Alloying Strategy Boosts Powertrain Performance

Patrik Ölund and Garry Wicks

The development of a new, gas-carburized gear steel, necessitated by a customer-driven specification, has not only increased the power density in an existing gearbox design, but has done so without requiring any significant change to production processes or heat treatment equipment.

Introduction

When a customer specified an increase in the power throughput of an existing gearbox design, they approached European steel maker Ovako AB with a request for a new-generation gear steel. Patrik Ölund, head of research and development at Ovako, and Garry Wicks, Ovako research engineer, demonstrate here how a novel approach to alloying strategy enabled them to increase the fatigue limit of the steel by 20 percent and still meet tough production constraints. Improvements in the surface fatigue strength of atmosphere-carburized steel gears have enabled a manufacturer to increase the power throughput of an existing gearbox design without any significant change to production or heat-treatment processes. Extensive testing of the gears revealed that when the load was increased, individual gear teeth were failing through fatigue fracture. The failure initiation points were in the area of maximum stress at the surface of the gear root (Fig. 1). Material and finishing defects were ruled out as the cause, but it was noticed that the surface of the gear root, which had no post-heat treatment finishing, showed clear evidence of internal oxidation resulting from the gas carburizing process.

Internal Oxidation

The level of internal oxidation of approximately 10 µm was in line with expectations, given the composition of the steel and the heat treatment process. However, it was known that internal oxidation could act as a stress raiser and initiate fatigue failure.

It was also known from published papers (Refs. 1 and 2), that internal oxidation could have a significant impact on the performance of steels tested under rotating bending fatigue conditions. The literature suggested that if the internal oxidation could be reduced to 2 µm, a potential gain of 100 MPa in the fatigue limit could be achieved (Fig. 2). The customer confirmed that if this increase in the fatigue limit could be achieved in the gear steel, the powertrain would be able to handle the increased power transmission levels.

The cause of the oxidation was depletion of the alloying elements near the surface during the carburizing process, which was reducing hardenability and fatigue resistance of the material by preventing a full martensitic transformation.

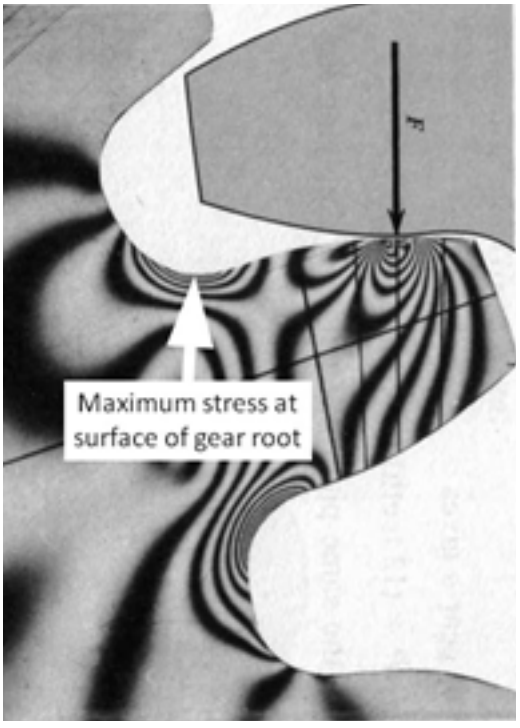

Figure 1 Failure initiation points.

Alloying Strategy

A strategy was developed to reduce the propensity of the alloy to form internal oxidation by lowering the Si content to a minimum, reducing Mn and Cr levels significantly and substituting Mo and Ni. The new alloy had to achieve both a hardenability and carburizing response equivalent to the existing steel grade. It was also decided to minimize the risk of failure from

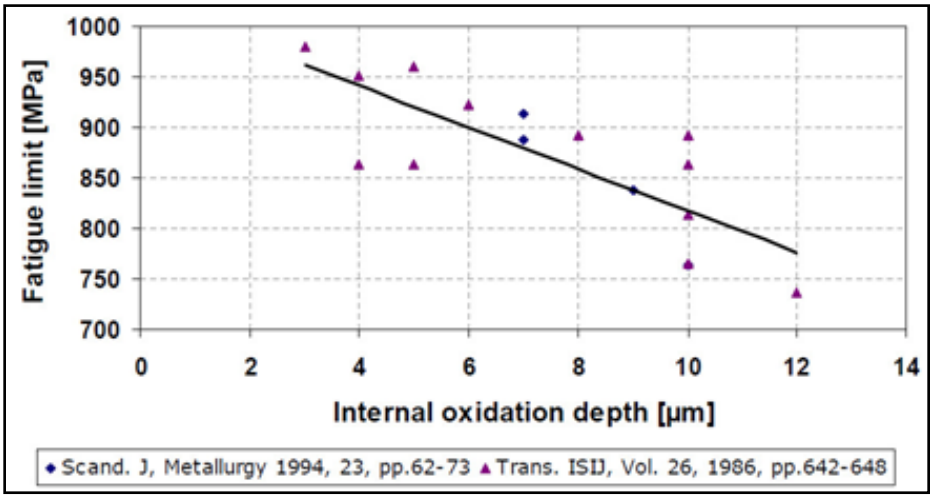

Figure 2 Internal oxidation and fatigue limit: literature indicated a potential gain of 100 MPa in the fatigue limit if the internal oxidation is restricted to 2 µm maximum.

sub-surface initiation by improving the cleanliness of the steel. This involved using the "IQ-Process" — i.e., a method of producing isotropic steels developed by Ovako. In "IQ steels," inclusions are reduced in number and size, producing a cleaner steel with improved structural fatigue properties.

This composition had to match the existing steel for hardenability and carburizing response, so a 50 kg test melt was produced and tested using a Jominy hardenability test. The results (Fig. 4) demonstrated that the new steel — Ovako 158Q — produced a favorable match on hardenability at depths up to 8 mm — i.e., sufficient to justify no further changes.

Response to heat treatment was measured alongside the current steel grade (Ovako 146S), and the widely used carburizing grade, EN 16MnCr5 (Ovako 234K). The chemical composition of the test materials is shown (Fig. 5).

The composition of the new steel was determined by using a predictive model, developed by Ovako, and by using real data collected over many years. The model uses actual heat analysis and measured hardenability values (Jominy) of a wide range of steel grades and chemical compositions; the results led to a nominal composition (Fig. 3).

Heat Treatment

The samples, machined from bar to a final dimension of 14 mm diameter with a length of 120 mm, were treated in a three-zone carburizing furnace for a total cycle time of 10 hours, after which they were directly quenched in oil, washed, and tempered in air at 170°C; the settings are shown (Fig. 6).

Following heat treatment, the hardness profiles of all three materials showed a very similar case depth of

	C	Si	Mn	Cr	Ni	Mo
Current grade - Ovako 146S	0.20	0.10	1.05	1.10	0.90	0.15
Proposed grade - Ovako 158Q	0.19	0.04	0.25	0.35	2.20	0.65

Figure 3 Nominal composition of existing and proposed steel grades (wt. %).

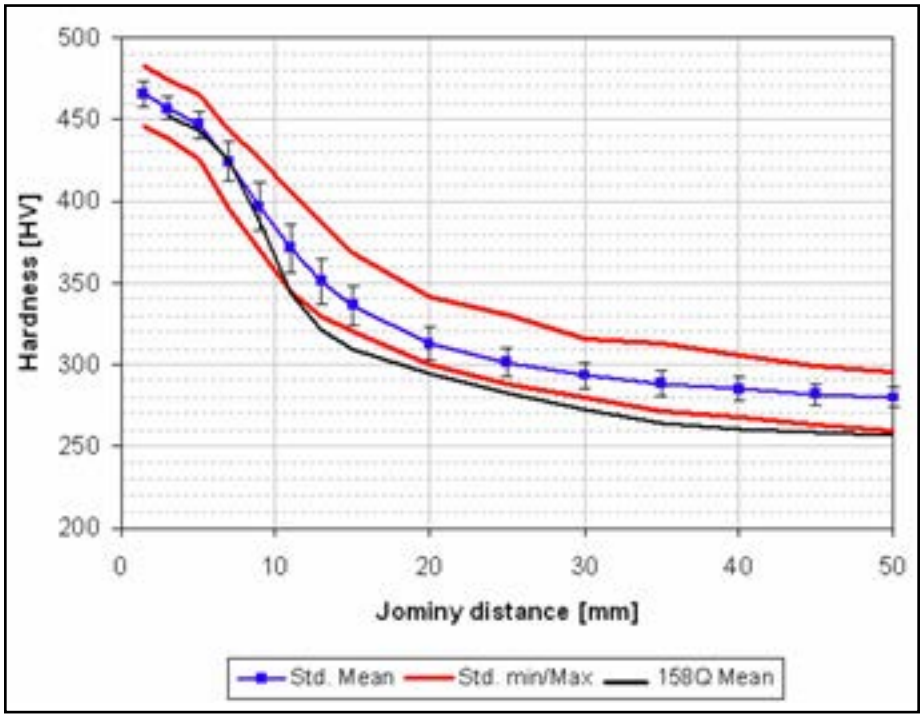

Figure 4 Jominy hardenability: measured hardenability of grade 158Q compared to existing grade.

	C%	Si%	Mn%	Cr%	Ni%	Mo%	
New grade	Ovako 158Q	0.18	0.05	0.25	0.39	2.28	0.69
Current grade	Ovako 146S	0.22	0.09	1.04	1.11	0.84	0.11
16MnCr5	Ovako 234K	0.18	0.24	1.20	1.02	0.13	0.03

Figure 5 Actual chemical composition of test materials (wt. %).

Zone	Temperature (˚C)	C-potential (wt%)
1	820	0.95
2	940	0.85
3	860	0.75

Figure 6 Settings for the 3-chamber carburizing furnace.

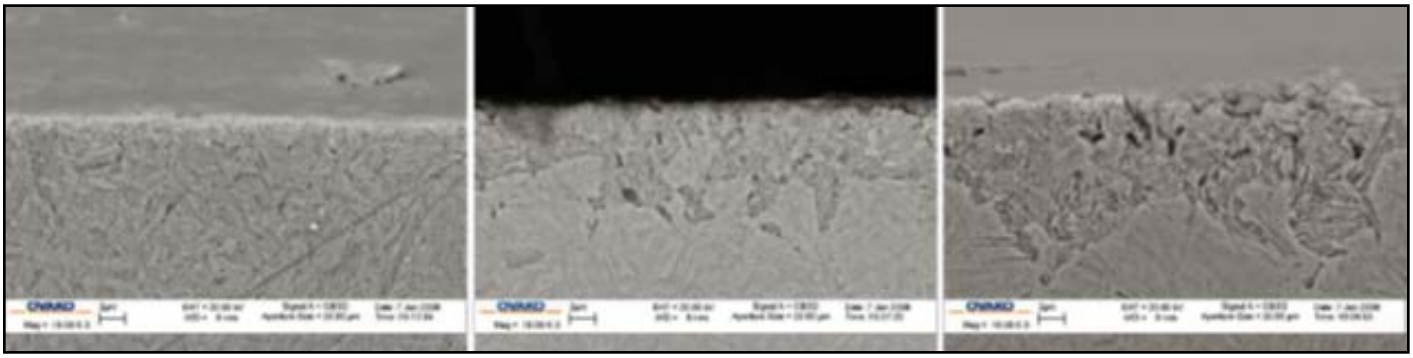

Figure 7 SEM micrographs of the surface microstructure — 2 percent nital-etched.

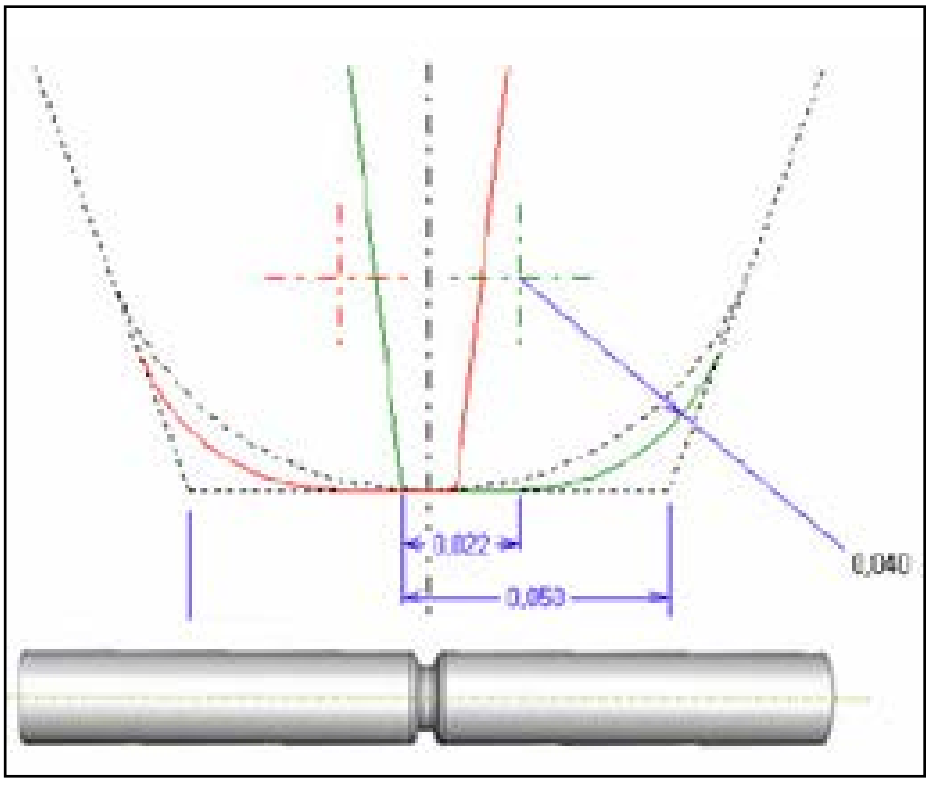

Figure 8 Notched test sample and gear root geometry.

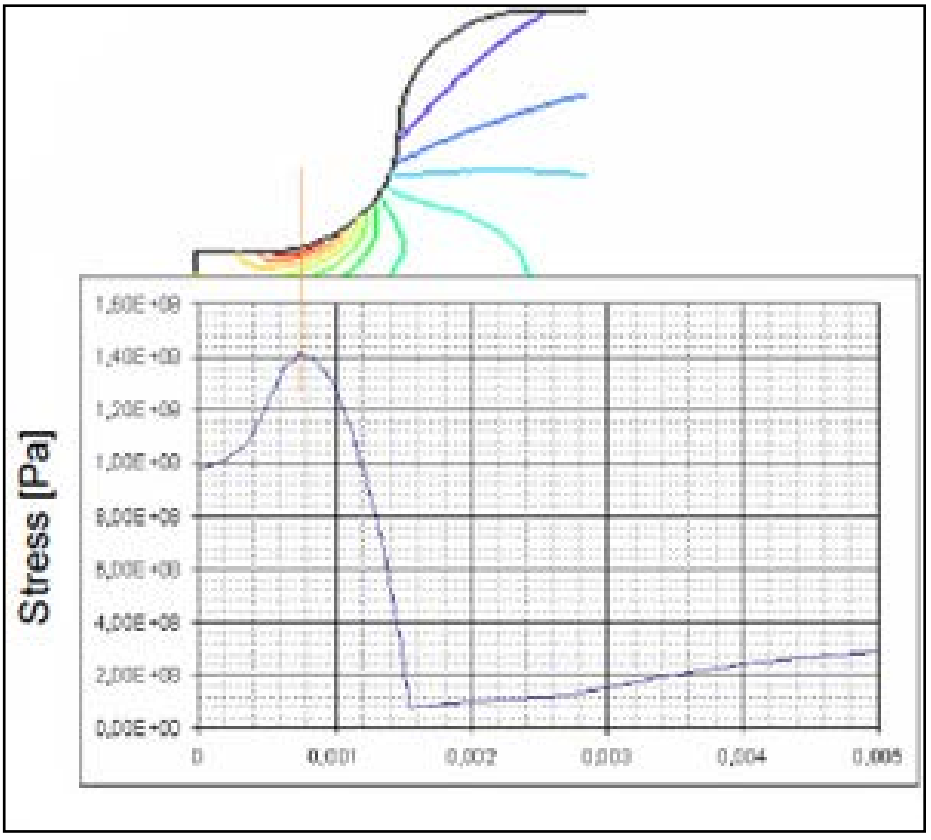

Figure 9 FEM calculation of highest-stressed region.

	158Q	146S	16MnCr5
Fatigue limit [MPa]	985	822	811
Upper 95% confidence limit [MPa]	997	852	829
Lower 95% confidence limit [MPa]	973	792	793
Number of results in evaluation	14	19	13

Figure 10 Results of RBF (radial basis function) testing.

0.60 mm (±) 0.05 mm. But the residual stress profiles showed a compressive residual surface stress for the new steel when compared to tensile stresses in the existing and carburizing-grade steels — indicating the presence of internal oxidation.

This was confirmed by examining the near-surface microstructures in high-resolution FEG-SEM (field emission gun-scanning electron microscopy). The micrographs (Fig. 7) show that the surface layer of non-martensitic material extends to 10 µm in the existing steel, and to 15 µm in the carburizing steel. The new steel, in which the surface residual stresses remained compressive, displayed a microstructure that was fully martensitic, right up to the surface.

Fatigue Testing

Rotating bending fatigue tests were carried out using samples of all three steels on four-point, rotating bending machines running at 3,500 rpm. The stress ratio was fully reversed- loading; i.e., $R = -1$, and the survival criterion was set to 10^7 cycles, or about 50 hours testing per sample. The applied load was changed according to the staircase test strategy.

The notches on the samples had been machined to the same geometry as the root of those gear teeth that had demonstrated fatigue failure. The stress concentration factor (Kt) for this specimen geometry was calculated to be $Kt = 1.7$. FEM calculations were used to determine the likely stress distribution and location of maximum applied stress (Figs. 8 and 9).

Results

The fatigue limit for Ovako 158Q was shown to be significantly higher than either the original Ovako 146S steel used in the powertrain, or the carburizing grade steel — 16MnCr5 (Figs. 10 and 11).

When the internal oxidation of the three samples, to the measured fatigue limits, was compared to the published data that had shown the correlation between the depth of internal oxidation and fatigue limits, the results were a good match (Fig. 12).

This clearly demonstrated that reduction of the internal oxidation depth can significantly impact fatigue limits, as published papers (Refs. 1 and 2) had proposed, and that the depth of internal oxidation resulting from a 10-hour gas carburizing cycle can be significantly reduced by a careful selection of alloys.

The end result was a steel grade with a reduced tendency to form internal oxidation and a fatigue limit 20 percent greater than the steel grade currently being used. **PTE**

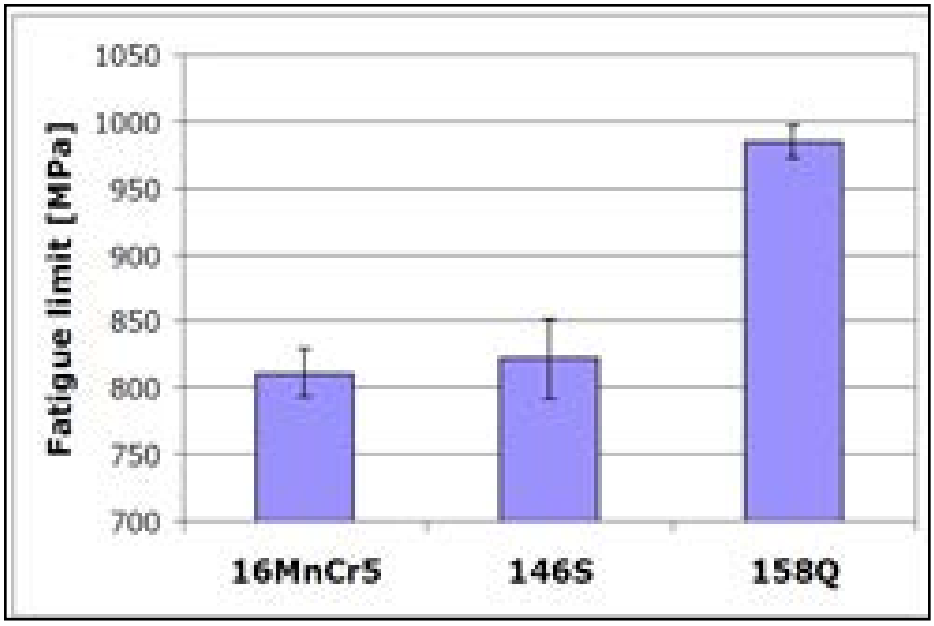

Figure 11 Fatigue limit for notched RBF samples; error bars show 95 percent confidence.

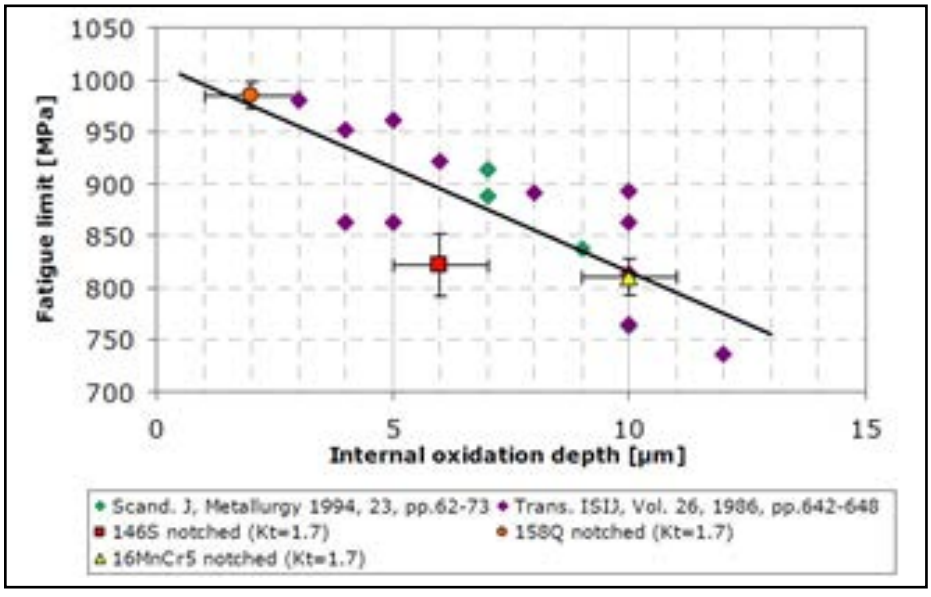

Figure 12 Effect of internal oxidation on the fatigue limit.

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Patrik Ölund is head of group research and development at Ovako. Educated at The Royal Institute of Technology (KTH), Stockholm, Sweden (1985–1990), he worked at the Swedish Institute for Metals Research (1990–1995) doing research relating to inclusions, fatigue and heat treatment. In 1995 he joined Ovako in the research department, which he now heads. Most recently, Ölund was this year's winner of the Kami Prize, presented to a distinguished scientist whose research has become the basis of a technical development within the Swedish steel and metal industry.

Global Industrial Outlook? Sideways.

Brian Langenberg, CFA

We have just returned from the **Electrical Products Group Conference** in Sarasota, Florida. This is our favorite venue because it allows us to speak with the CEOs of nearly 25 global industrial companies that include **General Electric**, **United Technologies**, **Honeywell**, **ABB** and **Emerson**, with combined revenue of perhaps $500 billion; clearly, they have a lot of spending power. We were also graced with the presence of a partner from **Clayton, Dubilier & Rice**—a major private equity firm with significant investments in the industrial sector. Based upon the presentations, but more importantly, on one-to-one conversations with these executives and their leadership teams, following are the key themes driving their strategies.

As an investment analyst, I go to these events looking for insight regarding how these companies' stocks will perform. But as a regular columnist for *Power Transmission Engineering*, I also look for insights that can help designers of machinery, buyers of components and industrial end users better understand the changes taking place in the global industrial marketplace. Here's what I found:

Economic debate? Minimal. U.S. sideways, Europe dead, and China improving (rate-of-change outlook varies). Only questions are mining (we say it will worsen; some executives are more optimistic) and whether Europe can step down further (most not really concerned). Very few sectors are materially strengthening.

Low-growth playbook. It's about supply chain efficiencies (cost); new products (push gross margin upward); and searching for deals that bring geography, product breadth, technology and (selectively) vertical integration (profit capture).

Capital spending will be flat—at best. Broadly speaking, the "big guys" are playing it close to the vest with respect to gross fixed investment. We see flat growth at best in 2013, and probably through 2014, given developed world constraints (debt, aging populations and lack of political and economic reform—or at least certainty).

Three areas of growth . 1) Aerospace (rising build rates, economic growth); 2) Appliances (residential recovery); and 3) Machinery (easy comparisons, but mining will remain down).

Diving deeper, our ***Global Industrial Outlook (GIO)*** is built around a framework to track, organize, analyze and monitor demand trends in key end- markets and industry verticals. While we have carved out a ***PTE***-centric dashboard for this column, the full *GIO* is available by subscription at *www.langenberg-llc.com.*

Oil & Gas. We expect continued global strength upstream (rig counts will grow), even though North American overcapacity remains. Offshore is hot; offshore rigs and associated infrastructure and equipment to work in sub-sea. Companies like General Electric and **Dover Corporation** are acquiring and are globalizing their businesses. You would be well-served to follow their expansion plans. Near-term and closer to home, North American midstream activity (pipeline and infrastructure) should remain robust.

Mining. Managements remain "constructive," i.e.—optimistic of a near-term stabilization and rebound. They are wrong. The big four—**BHP, Rio Tinto**, **Glencore Xtrata** and **BHP Billington**—are rationalizing operations. BHP alone is cutting capital spending to $18 billion from $22 billion, and many junior miners (small, one-trick-pony, recent capital raises) are said to be slowing activity.

Power generation. Engineering & Construction companies are optimistic globally, but U.S. activity could remain weak through 2015–2016 as greater energy efficiency keeps reserve margin (excess generation capacity) from falling. The off-set is aging plants that must be upgraded or closed; but it always takes longer. International looks better; China is adding coal generation capacity, as will other coal-rich regions. Europe is obviously (still) dead.

Transportation (road, rail, marine). Offshore-related activity remains hot. Strength in LNG (liquefied natural gas) will drive specialized, ship-related capital spending (ties in with Oil & Gas). **Colfax Marine** orders remain positive—up 5 percent in 1Q. Road construction and repair will remain steady through 2014—owing to the two-year highway bill extension—and will support construction equipment demand and associated basic (steel, cement) industries.

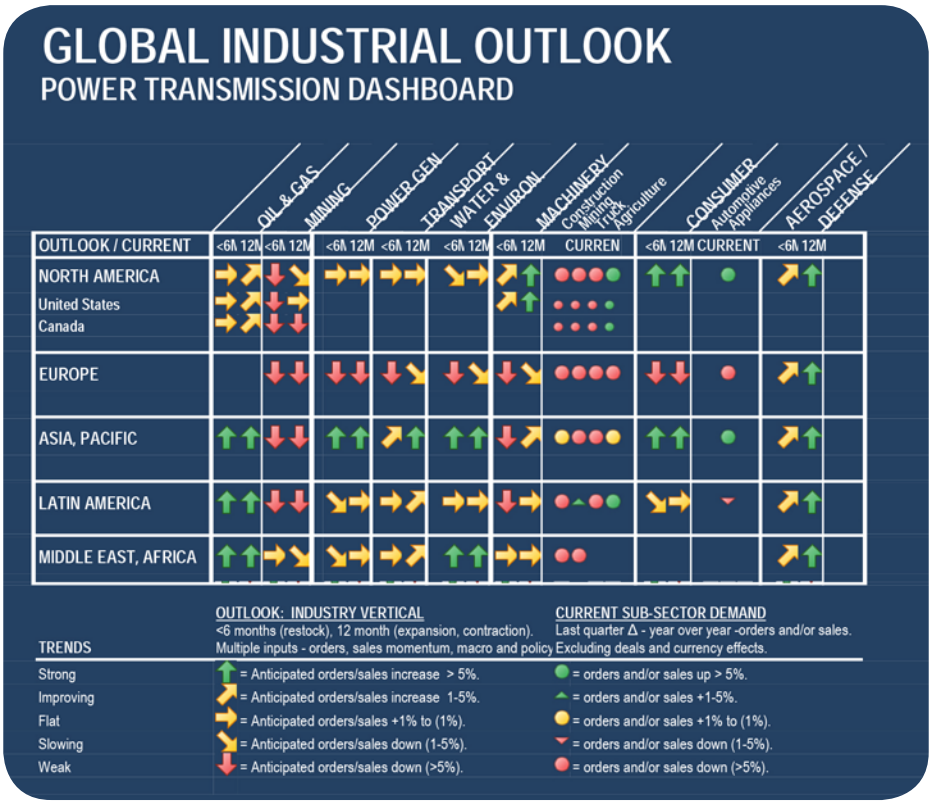
Water and environmental. Weak conditions likely to persist; **Xylem**, the No. 1 global player in water pumps, treatment and test, experienced a 7 percent decline in core revenue and weak orders in 1Q. With municipal budgets strained and industrial customers not investing, we expect continued weakness. One bright spot is desalination plants, where **Flowserve** reported orders up 12 percent in 1Q.

Machinery. The overall picture is improving (easy comparisons coming), but mining will remain a problem.

Construction—Excavator inventory at **Caterpillar** is finally being worked down and production levels are being increased sequentially (vs. 1Q). We expect at least stable-to-rising production through 2013 (up year-over-year against easy comparisons), as China growth (modest-to-solid) offsets European weakness.

Mining—We are less optimistic than manufacturers or equipment suppliers. The biggest mining companies all have new CEOs who replaced overly aggressive predecessors and who are working to rationalize what they have. Utilization remains high, which is good for spares and consumables. But new equipment demand likely remains weak for at least a year or so.

***Truck—*Cummins** delivered 27 percent fewer heavy-engine units in 1Q, and full-year demand should be flattish, owing to modest economic growth and aging fleet.



***Agriculture*—John Deere** sees full-year North American unit growth of 5 percent, which implies softening fiscal second-half demand (ending Oct. 31) with strength in larger tractors and combines. Internationally, Brazil remains strong—up 15–20 percent; Asia flat, and Europe (still) down (weak U.K., Western Europe).

Consumer (auto, appliances). Consumer spending is being supported by lower energy costs and slowly, modestly improving consumer balance sheets. Residential housing is up, and though it does not directly impact your business, the spill-on impact for auto and appliance purchases is positive. The appliance revenues of **Electrolux** provide a decent global picture of consumer investment in their homes; 1Q by region: North America plus-8 percent; Asia plus-6 percent; and EMEA (Europe, Middle East and Africa) plus-8 percent; with Europe worse than overall and Latin America 5 percent.

Aerospace/Defense. Commercial aerospace remains the "sure thing" growth market, given high current airline profitability, global growth and the imperative to replace older jets with new, higher-efficiency aircraft. MRO activity and associated parts pull-through have been weak for several quarters, driving pent-up demand.

Expanding on a theme: capital spending will be flat—at best. Senior managements were taken by surprise by further deterioration in Europe, which affected everybody except the resource-rich areas (Russia, Nordics), and they too will have to deal with softening investment in mining and resources. The second derivative impact has proven to be weak Chinese export activity (Europe is a large customer), and the reality of a new political leadership group in China seeking to take the reins. Transitioning to a consumer-led—or at least balanced—economy will take time, involve mistakes, and pose challenges.

Focus company: Emerson (EMR). We chose Emerson to give you a broad view of how economic trends end up affecting your customer and, in turn, orders. Emerson has five segments; these three interest you: *process management* (controls, sensors and instruments that run refineries and chemical plants); *industrial automation* (40 percent of sales are to **CAT Power Systems**; remainder is factories in Europe, the US, China), and *climate technologies* (compressors for HVAC markets).

Emerson recently cut guidance on broad weakness in orders, particularly for industrial automation (CAT, weak Europe), but also their own **Network Power**. Climate is slow, but can turn quickly on warm weather (cooling season). With three straight months of negative overall orders, their June quarter "will" be down. They are also seeing more projects being "pushed to the right." As you can imagine, capital spending is being reined in to a range that suggests 5–10 percent lower investment over the next six months. Granted, much of the impact may be offshore, but indirectly we expect a trickle-down impact in the U.S. What could push it higher?—Nothing obvious, near-term.

Other segments of interest to you:

Process management: Solid to up; North American MRO was weak against tough comparisons, but that will pass. Big refinery projects are coming in 2014–2015.

Industrial automation: Weak next 6 months; need CAT Power Systems upturn (easier comparisons are coming) and/or European recovery (*still* not happening).

Climate technologies: Residential is up; weather could/should help (June is the key month). Bigger upturn is further out and needs non-residential recovery.

But they, as with other companies, will seek ways to refresh their product offerings and innovate upward. Which makes this is a good time to ensure you are very focused on their new product development. **PTE**

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*.

Bosch Rexroth

EXPANDS RUSSIAN AUTOMATION MARKET

The modernization of the Russian industry is picking up speed. In 2011, Russia imported machines, plants, and equipment worth €29 billion and assured its position among the ten largest machine markets in the world. Despite these increased import levels, factories and plants still have a significant amount of catching up to do. Russia will thus continue to be a growth market for machinery construction in the years ahead.

At present, raw materials exports constitute 80 percent of Russia's exports. To reduce dependency on fluctuating raw materials prices, the Russian government is pursuing a modernization strategy for its industry, much of which is outdated. Surveys conducted by the Russian Union of Machine Builders have shown that over one million machines 20 years or older are in use at Russian factories. At the same time, the demographic trend increases the need for modern automation solutions due to the fact that the Russian population is estimated to decline by eight million individuals by 2020. The result is an ongoing high need for automation, especially for tasks which are very physically demanding.

The initial steps toward modernization are to import machines and plants. "But the modernization plans themselves also mean an exceptional opportunity for Russian machinery construction, if they are able to develop state-of-the-art modern machines very quickly," emphasizes Dr. Karl Tragl, chairman of the executive board of Bosch Rexroth AG. "To do so, they are looking for support from globally leading automation manufacturers, such as Bosch Rexroth." Russian universities and research institutions with whom the drive and control manufacturer works in close collaboration, also play a key role. Bosch Rexroth founded a country unit back in 2001 and covers the most important industrial regions of the Russian Federation at seven sites.

But raw materials extraction will also remain a key pillar for the Russian economy in the future. There is also an urgent need for modernization when it comes to raw materials extraction, the heavy industry, and power plants. For this purpose, operators preferably commission regional engineering companies, but these often still have little experience when it comes to modern industrial manufacturing equipment. Bosch Rexroth industry specialists support these companies in such projects with their global experience.

The company also develops modules and system solutions tailored to regional needs. Climatic conditions require all components to be suitable for use in very low temperatures for all outdoor applications. "Out in the natural gas fields in Siberia, workers have had to manually adjust the majority of controls and instruments on individual drilling equipment, even in temperatures as low as -50 degrees," as Dr. Tragl describes one of the many challenges. "We have developed arctic-ready adjustment units that now allow technicians to make the necessary adjustments from the heated control center with the click of a mouse."

Russia is also trying to reduce CO_2 emissions: in 2009, the Duma passed a law to increase energy efficiency. Bosch Rexroth offers several system solutions for more energy efficient processes for machines and plants. Ready-to-install drives for control fittings increase the efficiency of gas power plants as well as gas and steam power plants for power generation thanks to their dynamics and precision. Electrohydraulic system solutions for mobile machines such as tractors or excavators increase performance while offering low levels of diesel consumption. The Chairman of the Board is sure of one thing: "The modernization of the Russian industry has only just begun and will be one of the major growth drivers for international machinery construction in the intermediate term."

Siemens

LAUNCHES MANUFACTURING LEADERSHIP TOUR

Siemens Industry Sector has launched its "Manufacturing in America: Making Things Right" tour, a series of thought leadership events designed to explore the trends shaping America's next industrial evolution, and the challenges that still exist.

More than 2,000 online users joined a recent Siemens-sponsored "America's New Manufacturing" forum, presented by Washington Post Live. The forum brought together government officials and leading industry experts to discuss topics such as the new era in manufacturing, expanding manufacturing hubs, trends in manufacturing, workforce training, and innovations and advanced technology.

"Across the globe, and particularly in the U.S., the manufacturing sector is undergoing an evolution where innovation and manufacturing are merging, driving both product and process innovation. This is making industry more competitive and taking productivity and efficiency to levels never

(Left to right) Treasury Secretary Jacob Lew tours a Siemens manufacturing plant with Helmuth Ludwig, CEO, Siemens Industry Sector North America and Shujath Ali, plant manager (photo courtesy of Siemens).

experienced before," says Helmuth Ludwig, CEO of Siemens Industry Sector, North America.

"This industrial evolution is highly based on software and companies that have embraced this concept are experiencing a shorter time-to-market through efficient innovation cycles and enhanced flexibility using more data to individualize mass production. Advanced manufacturing is an important part of Siemens growth, and will provide the U.S. an edge in the future of our manufacturing sector."

On April 30, *IndustryWeek*, in collaboration with Siemens, presented the results of a manufacturing leadership survey that examined both tactical (i.e., hiring, improvement programs, and technology) and strategic (i.e., capital investments, supplier re-alignment, new product development) trends related to the manufacturing renaissance.

Smalley

RELEASES 50TH ANNIVERSARY PARTS AND ENGINEERING CATALOG

Smalley Steel Ring Company announces the release of the new 50th Anniversary Parts and Engineering Catalog for 2013. The new catalog combines previously existing Spirolox Retaining Ring and Wave Spring series with newly released series. Smalley's recently released Metric Hoopster and Laminar Seal Rings catalog have been incorporated into the new catalog, offering a comprehensive look at all of Smalley's 10,000 standard parts.

Smalley has manufactured Laminar Seal Rings for years; however, the increased popularity in metal seals allowed for the series to be incorporated into the catalog for the first time. Smalley Laminar Seal Rings are an alternative means of sealing components in assemblies from contamination. Laminar Rings can withstand higher temperatures and more corrosive environments than common O-rings or conventional rubber seals.

Smalley is pleased to offer the new catalog to its customers. George Nisbet, Smalley's vice president of operations, says, "The 50th Anniversary catalog celebrates 50 years of Smalley Steel Ring Company's commitment to excellence in quality, service and products that offer extreme value. For over 50 years Smalley Steel Ring Company has been the industry leader, setting the standard for on time delivery and product innovation."

Durst

APPOINTS VICE PRESIDENT BUSINESS LEADER

Durst recently announced that Terry McCormick has been promoted to vice president business leader, succeeding Bernie Nielsen, vice president and general manager, who retired effective March 31. Durst, a division of Regal Beloit America, Inc., meets the mechanical power transmission needs of the agricultural, construction, oil and gas, and industrial markets with innovative, cost-effective gearboxes.

McCormick comes to Durst by way of Regal's corporate headquarters in Beloit, Wis., where he had served as director of customer quality since 2012. He joined the global manufacturer of motors and related products in 2010 as director of quality for the Regal mechanical group, which includes Durst. At that time, he was based in Clinton, Wis.

McCormick is responsible for the day-to-day operation and profit and loss of the Durst division, as well as the strategic direction of its brands and products. An expert in the development and implementation of Lean Six Sigma and quality initiatives, he brings a lean approach to business management.

"By approaching quality from a manufacturing standpoint, you can design a process to achieve the highest yield with minimal defects," McCormick said. "You can apply that approach to business and yield the same desired results. One of the qualities that sets Regal apart is its process-based approach to every aspect of business. My own background and experience run parallel to Regal's philosophy."

Before joining Regal, McCormick was manager of manufacturing engineering and quality assurance at PBC Linear, a Pacific Bearing company. McCormick also spent 10 years as manager of manufacturing engineering at Haldex Hydraulics Corp. Earlier in his career, he worked for John S. Barnes Corp. He earned a degree in mechanical engineering from Michigan Technological University in 1986.

"The lean business process is all about operating at the most efficient and most proficient levels," McCormick said. "It is focused on driving waste out of the system, from order entry to shipment, with the people and processes you have in place. Regal has expanded through a combination of organic growth and targeted acquisitions. Durst is poised for further organic growth by producing the best brands in the market and selling more products. That is how we will surpass our competition."

Forest City Gear

LAUNCHES ROSCOE WORKS

Forest City Gear has begun operations in a new state-of-the-art facility designed to greatly improve lead times and quality for the production of precision gear blanks. This new division of Forest City Gear, called Roscoe Works and dedicated solely to the production of precision turning, operates from its own highly productive new 8,500 sq. ft. facility in close proximity to Forest City Gear's main facility in Roscoe, IL. That's very good news for Forest City Gear customers, says Roscoe Works General Manager Larry Cass. "Roscoe works gives us complete control over the quality and delivery of the blanks (and slugs) that are the 'near net shape' starting point for many of the gears we produce," Cass says. "The types of projects we take on here at Forest City Gear for customers around the world have never been more demanding from a quality and delivery standpoint. If we start off a project with turned blanks out of tolerance, or waiting for blanks from a supplier, this can ultimately create a devastating production bottleneck in our KanBan system where operations upstream are sitting idle waiting for product to arrive."

According to Cass, the new facility easily meets current capacity requirements, and gives the company much additional room to grow. For example, a new Hardinge Quest RS 51 MSY (Super Precision) Turning Center with 16 station turret, sub-spindle, and live tooling with C-Axis and Y-Axis gives Roscoe Works the ability to completely machine blanks and slugs in a single setup that includes all turning, milling and drilling operations. For faster production of larger blanks (up to 6" in diameter), Roscoe Works has installed a new Takisawa TT200G Twin Turret, Twin Spindle Turning Center. This machine can perform simultaneous turning of either identical, or first and second operations, simultaneously on twin spindles. A new Tsugami Swiss-Style Lathe and an Okuma CNC Vertical Lathe will soon replace two older machines and add still more capacity.

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June 24–27—Siemens Automation Summit. New Orleans. This event will cover the complete spectrum of automation from process and discrete manufacturing to motion control and drives. The Summit will feature Version 3.0 of the popular Connect Event where attendees can network in-person and virtually with Siemens employees, solution providers, integrators, distributors and end-users. Siemens will offer hands-on training courses, provide input for future enhancements and provide more than 50 end user best practices. Attendees will see how innovation is driving a manufacturing renaissance in America. They will also have an opportunity to meet Siemens management to help solve daily manufacturing challenges. For more information, visit *www.industry.usa.siemens.com*.

July 8–11—InterSolar 2013. San Francisco. Intersolar North America is a continuation of the world's largest series of solar exhibitions including shows in Munich, São Paulo, Mumbai and Beijing. The trade show strives to offer the best possible product to its exhibitors, visitors and the worldwide solar industry each and every year. Intersolar North America focuses on photovoltaics and solar thermal technologies. Exhibitors include PV cell, module and inverter manufacturers, components and mounting systems suppliers, manufacturing system suppliers, service companies as well as manufacturers of solar thermal applications including heating and cooling, among others. Highlights at the event include a spotlight on energy storage as well as a diverse conference program that offers sessions and workshops on every aspect of the solar community. For more information, visit *www.intersolar.us*.

August 5–8—CAR Management Briefing Seminar. Traverse City, Michigan. The CAR Management Briefing Seminars is an annual gathering of more than 900 auto industry, academic and government leaders addressing critical issues and emerging trends in an atmosphere designed to build relationships. For more than four decades, the event has featured thought leadership focused on all facets of the business, and included C-level speakers from throughout the automotive world. This year's Automotive Strategy sessions will discuss "Mobility, Sustainability, Profitability," while targeted sessions focus on global manufacturing strategies, lightweighting, connected vehicles, powertrain developments, sales forecasting, purchasing, policy, designing for technology, and capital investment. The schedule allows plenty of time for networking and socializing with colleagues. The social hours each evening are renowned for their friendly atmosphere, and offer attendees a great opportunity to meet key people from throughout the industry. The week's networking activities kick-off with a scramble golf tournament on Sunday, August 4. For more information, visit *www.cargroup.org*.

August 19–22—Power Transmission Principles. Indianapolis. IDC University's Power Transmission Principles (PTP) course is a four-day intensive study of the world of power transmission. PTP instills students with confidence in themselves, their company and the power transmission products they represent. The course is designed for inside and outside sales people, from beginners to seasoned employees. Throughout the course, major power transmission products are displayed, discussed and selected until each student knows how and why specific products help their customers. For more information, visit *www.idc-usa.com*.

September 10–12—Essential Concepts of Bearing Technology. Duke University Conference Center, Durham, North Carolina. The American Bearing Manufacturers Association (ABMA) continuing education program will get attendees up to speed on bearing basics. This course will offer knowledge in rolling bearing types, bearing loads and applications, mounting methods, contact stresses, bearing load sharing, bearing pre-load, materials for ball and roller bearings, concepts in friction, ball and roller bearing deflections, failure modes and life standards. Attendees will receive a copy of Rolling Bearing Analysis, Essentials Concepts of Bearing Technology, 5th Edition as well as continuing education units upon successful completion of this course. For more information, visit *www.americanbearing.com*.

September 17–19—Gear Expo 2013. Indiana Convention Center, Indianapolis, Indiana. Gear Expo is a biennial event and the world's only conference and expo designed exclusively for the gear industry. For three days, gear buyers and manufacturers network and build relationships that benefit their respective companies. Attendees see firsthand the latest technology on the market and discuss trends in the industry with experts. Exhibitors have the opportunity to meet face-to-face with attendees and other exhibitors and will display more than 750,000 pounds of machinery on the show floor. Thousands of professionals from around the United States, international manufacturing hubs, and emerging markets conduct profitable business transactions and collaborate on the innovations that make their operations more streamlined. The ASM Heat Treating Society Conference and Exposition is co-located with Gear Expo 2013. For more information, visit *www.gearexpo.com*.

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You Go (Goldie) Girl!

New doll and toy set geared for inspiring young engineering misses—not misters

Are you familiar with the *Bob the Builder* or *Jimmy Neutron* franchises? How about *Lego Man* or *Sid the Science Kid*? No matter. But notice they are all male-focused? Indeed, these kiddie icons are representative of the fact that most anything pop-culture-related having to do with instilling in youngsters an interest in engineering and manufacturing is directed towards boys. It is therefore not surprising that about 90 percent of America's engineers are male gendered.

Well, forget all that and meet Goldie and her start-up "engineering firm" GoldieBlox (*www.goldieblox.com*) — the alter ego, if you will, of Debbie Sterling, a San Francisco-based engineer and entrepreneur with industrious plans and grand vision.

As reported in various newspaper and online reports, Sterling's vision entails turning the tide in the boys club better known as the field of engineering.

A Stanford-educated engineer, Sterling was one of among 181 women — and more than 500 men — graduating in 2005 from the university's engineering school. The eye-opening disparity in those graduation numbers inspired her to strike a blow for the distaff side of engineering.

So is Sterling more entrepreneur than engineer? "Engineer first," she says, "although, I did have a pretty impressive raspberry stand in front of my house growing up. This is my first company. I haven't done anything like this before."

Sterling adds that the GoldieBlox venture has been a daily learning experience; learning, for example, that there's a grassroots passion in the country regarding the apparent disregard for women in high-tech manufacturing. "There are so many people that are passionate about this cause, and they are springing up left and right to help out," she says. "It takes a village to build a company."


Debbie Sterling, GoldieBlox creator.

What sort of toy experience will engage girls in engineering, you ask? What could distinguish it from the male mainstays like Lego, Lincoln Logs, Tinker Toys and the venerable Erector Set? Sterling reportedly spent more than a year researching these questions and, eventually, Goldie — Sterling's female engineer persona was on the job — supported by a GoldieBlox tool set that includes an accompanying storybook about its heroine (also available as an iOS app); a line of interactive, build-oriented book chapters; plastic "parts"; some ribbon; and a group of five toy friends.

As Goldie's story progresses, the book instructs participants to design and build a series of increasingly complex devices that will help Goldie accomplish certain tasks. Every time the "build" icon is displayed, girls are required to replicate Goldie's illustrated construction efforts; failing to do so ends the "round" (story). A good example is the book's first scenario — Goldie must create a spinning machine for her dog. Sterling believes that by getting girls to build for Goldie, they'll come to see design-and-build as functions with their own social value. Not much of a reach, actually, given the long history of social reform initiatives credited to women.

In a 2012 *Atlantic* online piece by Rebecca J. Rosen, Sterling explains that "Girls really want to help people and they care about nurturing," Sterling says. "And engineers are solving some of the world's biggest problems and helping people."

The *Atlantic* story relates that one big highlight for Sterling during her research was "when (the girls) wrap this ribbon around this wheel and they pull it and it spins. It's such a basic engineering principle of a wheel spinning on an axle, but it is this magical moment for every girl (that was) tested."

To date, Sterling says her company has shipped "over 35,000 toys and we are now launching into retail stores. We're expanding into a series of book-and-construction toys that will take Goldie on new adventures and introduce new engineering principles."

Speaking of principles, it appears that Sterling's reasons for creating GoldieBlox transcend profit alone. Yes, turning a profit is important — financial success is sure-fire verification of Sterling's belief that there exists an untapped pool of would-be female engineers. But she also believes the fate of U.S. manufacturing lies in encouraging *all* of our young people to put down the joystick and pick up a slide rule.

"The reason I've created GoldieBlox is to get more potential engineers into the pipeline," she says. "I worry we lose kids before they even enter middle-school. As young as age four, kids start to form opinions on what gender belongs in what career path. We need engineering as part of the core elementary school curriculum — at the time when kids are forming their identities, what their interests are, what they want to be when they grow up. I didn't discover engineering until my freshman year of college and sort of fell into it accidentally. We need to spark that interest and passion (when they are) much younger." **PTE**

(Sources for this story: *theatlantic.com; parenting.com; time.com; forbes.com.*)

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