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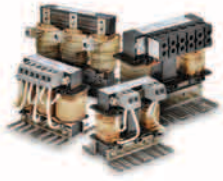

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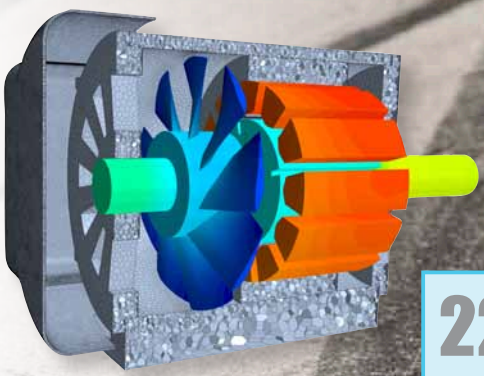

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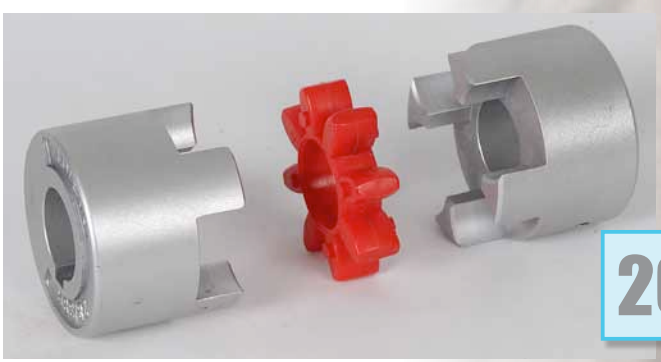

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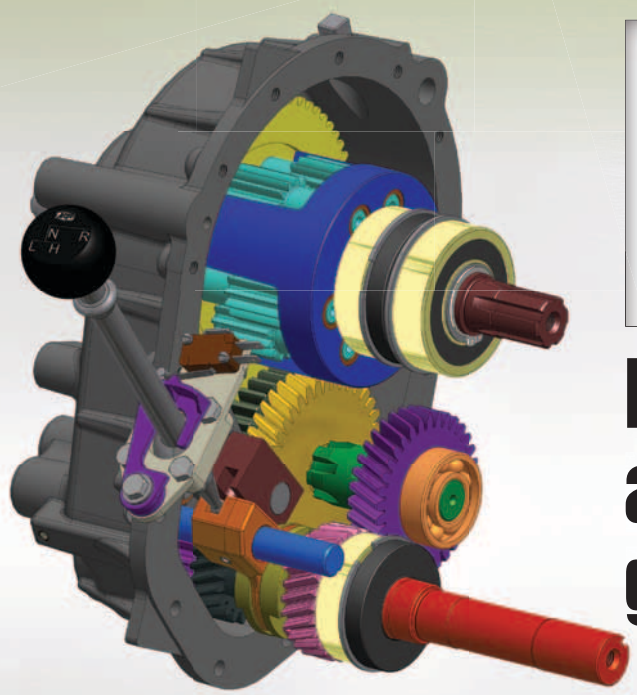

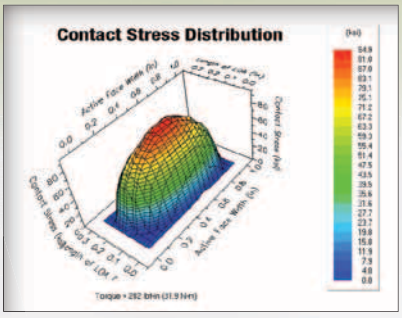

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IANA and the Increasing Relevance of IMTS

Many of you probably think of IMTS as just a machine tool show. Of course, it's hard not to. With the majority of the show focused on metalworking equipment, tooling and supplies, there's no doubt that IMTS *is* a machine tool show.

But this year, the show has partnered with Hannover Messe to include IANA—Industrial Automation North America—as a pavilion of IMTS and an integral part of the event. Now, buyers of power transmission and motion control products, as well as specifiers and designers of all kinds of industrial machinery, have more reasons to attend IMTS.

In the past, buyers of motion control and power transmission components had a much more limited selection of vendors to visit. Although there have always been sellers of servomotors, ballscrews, bearings and the like at IMTS, most of those exhibitors went to IMTS to support and sell to other exhibitors—namely, the machine tool manufacturers. And you can count on those exhibitors to be there again this year. But with the introduction of IANA, IMTS is becoming a much more comprehensive manufacturing technology event.

The IANA pavilion includes more than 100 exhibitors who are specialists in motion control, factory automation and systems integration. If you have a tricky machine design issue or a motion system that needs optimizing, IMTS will have a host of experts who can help. Suppliers from all around the world will be on-hand to discuss their latest technologies and services. To help you sort through it all, we've put together a listing of key exhibits, both inside and outside the IANA pavilion, on pages 30–33 of this issue.

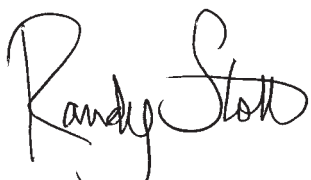
In addition to the exhibits, IMTS is host to a number of conferences and educational opportunities that should be of interest to power transmission and motion control professionals.

The Motion, Drives and Automation Conference takes place September 10–11, and it includes conference tracks on motion control and fluid power. Researchers, executives and engineering technology leaders will speak about boosting machine efficiency, predictive maintenance and industrial automation security.

The Global Automation & Manufacturing Summit is September 12–13. Speakers from leading automation companies will talk about data security, energy management, process optimization, sustainability and other topics. The summit will also feature case studies on plant automation for profitability, asset-performance improvement and maintenance cost reduction.

Finally, ISA—the International Society of Automation—will present training sessions September 13–14 on controls, industrial wireless systems, measurement and control fundamentals, manufacturing execution systems and safety instrumented systems.

This will be my tenth visit to IMTS. Because of the show's evolution, including the introduction of IANA and its strong focus on motion control, I expect this year's visit to be among the most interesting, educational and fruitful. If you are involved in designing, developing or maintaining industrial machinery, you should go, too. I hope to see you there.



Randy Stott,
Managing Editor

P.S. When you come to IMTS, stop by our booth **(N-7148)** to sign up for—or renew—your free subscription (it takes less than a minute), learn more about how you can contribute to the magazine, or just say hello. Speaking of free, you'll also have the opportunity to enter our drawing for a free iPad. Somebody is going to win it. It might as well be you.

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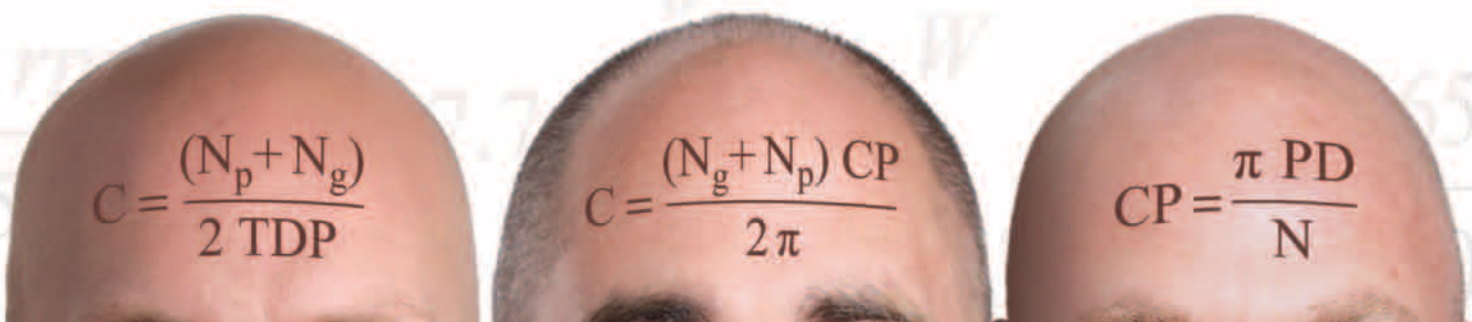


Industrial Reality Check
for Chicken Little: the Sky is *Not* Falling

Global capital spending cycle—with dents—is intact. Institutional investors entered the second quarter earnings season mulling three areas of intense interest: Europe, China, and fiscal cliff. We counseled our clients—correctly—that Europe would be important—to Europeans—and an annoyance to the broader industrial economy. Southern Europe is indeed a drag—but is more than offset by growth in Northern Europe and Russia.

It's not about Europe; it's about cash flow. Resource-rich regions (think Brazil and Russia—the "BR" in BRIC—which includes India and China) have it—or they sell to countries that have oil, gas, copper, etc., and need technology and capital to get it—think Germany, the Nordic region. What we expected—and have seen—is that Southern Europe is an annoyance and nothing more.

China: mixed bag—with upside. Current concern is underscored by continued overproduction of steel; it is already hurting steel producers globally and demand for material handling equipment and Caterpillar's well-publicized inventory overhang cast a shadow over many machinery companies. But reality will rule as second-half comparisons become easier and the combination of developing stimulus plans and a leadership transition are set to drive growth acceleration in 2013. This is positive for cranes, low-voltage equipment, rail and power generation.

Fiscal cliff—the wild card. Taxes are set to rise at year's-end on payroll, personal income and dividends—unless action is taken—but neither side is budging in front of elections. We think a deal gets done, but probably not until after the election. The impact would be felt in the March/April 2013 tax refund season, but is already impacting capital plans on the margin, according to several management sources.

Currency and materials offset. The steady drumbeat this quarter is: miss on revenue, make the numbers, modestly cut guidance. Companies are typically missing sales projections by 4–5 percent—mostly due to currency translation (strong dollar)—while benefitting from lower raw material costs. Markets have breathed easier as cuts in earnings guidance have been quite small.

Outlook varies by sector. Regionally, the U.S. economy is slowly improving—evidenced by improving demand for housing and autos—even as broader consumer spending is weak. As one very savvy client stated recently, "I've yet to see a recession when homebuilding is going up." For Europe—the weak parts stay weak—we anticipate synchronized acceleration in industrial automation, drives and power generation investment supporting Chinese reacceleration in 2013. Brazil has taken actions to stimulate its economy as well.

Key power transmission sectors:

Energy. Fossil-based power generation is poised for an upswing, with two straight quarters of positive order pricing—a benefit to GE, Siemens and Alstom. Gas-based generation will improve globally as will coal orders from emerging markets. A combination of wind (tax credits expire at year's end), global investment in energy efficiency and, in some cases, financing constraints, have held the cycle in check. For 2013 planning purposes, forget nuclear and solar. Moving into the exploration-and-production side, we are clearly seeing continued high activity—oil-focused—which on an energy-equivalent basis is priced at 3X gas. But some activity has been marginally hampered by logistics; moving equipment from Northern gas fields to oilfields takes time, money, and temporarily holds down parts activity, particularly in pressure pumping.

HVAC. Clearly improving residential activity seen; way below peak but going to 700K new builds from 500K is a 40 percent improvement, and California homebuilders, for example, are seeing new sub-divisions going up for the first time since 2007. Non-residential, new-build activity is limited to industrial usage—not commercial—but refurbishing and efficiency upgrades are strong and transactional activity for existing properties signals improvement.

Machinery. Varies by product; the agriculture cycle is mature but cash receipts are high, and both Deere and AGCO are pursuing global growth. In construction we see replacement driving demand for cranes and construction equipment—Caterpillar's China excavator overhang notwithstanding. There is a lot of **run way**—power generation cycle, non-res turn and, someday, a real highway bill—all of which is on the come. Truck builds have moderated globally, but age (U.S.) and global growth are unlikely to facilitate an actual downturn.

Consumer cyclical. Auto build rates, new program launches and increased

Brian K. Langenberg, CFA, *is a recognized 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.

OEM investment augur well for the sector, while residential housing, as noted, begins to improve.

General industrial. Industrial production remains below peak levels but, as a general rule, parts and aftermarket activity suggest continued demand. Short-cycle businesses have shown weakness the last two quarters—particularly in Europe—but by and large we think supply chains are tight and incremental demand acceleration—at least on a year-over-year basis—happens in the second half.

Aerospace. Build rates at Boeing, Airbus and business/regional jet manufacturers are increasing, limited only by supply chain stress that is being addressed as quickly as possible. Budget sequestration of up to 15 percent of military spend is possible but, we think, is ultimately resolved. Commercial spares orders and repair-and-overhaul dipped this quarter at both GE and UTX, as airlines chose to park older aircraft—757's for example—and part out their engines or put off optional upgrades. We see this as short-term. Oil prices have declined and typically this triggers better activity on a six-month lag.

***The global economic recovery is fragile—or* not.** While risks persist and high debt levels will likely hamper global economic growth for some time, we also think: global political leaders have done a decent job of managing—or at least slogging through—widely divergent economic, political and geopolitical interests; most economies continue to improve; and cash levels, investment plans and actual economic activity point to a continued, constructive outlook.

New-Generation Synchronizers from Oerlikon Graziano

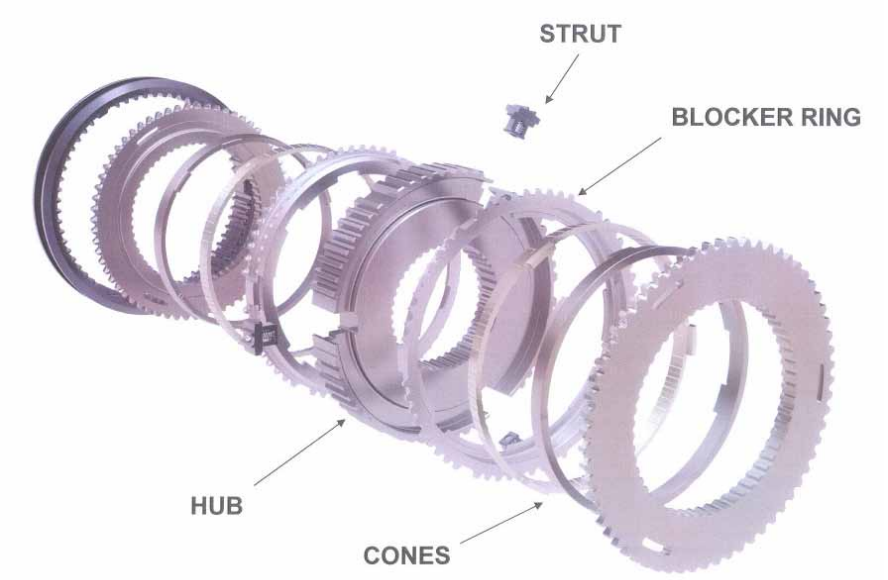
PROVIDE FUEL SAVINGS AND EASIER GEAR SHIFTING ON HEAVY TRUCKS

Oerlikon Graziano has developed a family of state-of-the-art synchronizers for heavy-duty truck transmissions that sets new standards for fuel efficiency and ease of shifting. The first application of the technology—on new 9- and 14-speed premium gearboxes—has improved transmission efficiency by approximately 10 percent, thus saving fuel and reducing CO_2 emissions. Already a leading supplier to the agricultural and construction industries, Oerlikon Graziano expects the high-efficiency synchronizers to generate significant new business in the heavy-truck market.

The new synchronizers save fuel in two ways: 1) by optimizing the shift to minimize torque interruption, and 2) by reducing steady-state drag torque in the transmission. They combine the high durability and high performance of Oerlikon Graziano's existing long-life synchronizers with a new internal activation system that uses optimized clearances and lubricant paths for higher efficiency.

"Most new transmissions carry over existing synchronizer designs that limit the scope for efficiency improvements," said Andrea Serra, product manager, synchronizer and power-shift design, Oerlikon Graziano. "Our new synchronizer technology offers a step-change improvement in fuel efficiency for the next generation of heavy-duty transmissions."

The new synchronizers are configured in single- and double-cone arrangements, each with the same external geometry to allow enhanced flexibility in transmission design. In all, four different synchronizer specifications are used on the 14-speed transmission and three on the 9-speed version. The synchronizers have exceptionally high torque capacity—as much as 18,000 N-m in the first applications—and use molybdenum-coated steel cones for high durability with optimum friction. Future developments include the potential for carbon coating.



Another key feature of the new technology is an activation system that is integrated with the synchronizer and optimized for smooth engagement. Applications are usually manual-shift—with air assistance—so any shift problems are immediately obvious to the driver. The new system ensures fast, smooth and reliable shifting under all conditions, making it an attractive alternative to power-shift systems because it packages into a much smaller space.

By increasing the speed of a manual shift, Oerlikon Graziano has reduced torque interruption,thus ensuring extended, optimum engine efficiency and reduced fuel-burning engine transients.

Whichever gear is selected, key differences in rotating speed may exist across the other synchronizers. With a conventional design, this leads to significant drag losses that impair efficiency; these new synchronizers greatly reduce this effect to further improve fuel economy.

The new synchronizers improve the shift process during three distinct phases:

Prior to synchronization, the integrated activation system provides optimized load characteristics that improve both consistency and durability, as compared to a standard design.

Synchronization has been shortened by virtue of multi-cone technology, best-in-class friction materials and optimization of geometries and tribological properties.

Synchronization-to-engagement has been improved by incorporating new, internal features that provide smoother travel of the sliding sleeve, avoidance of blocking problems, and friendlier engagement feel to the driver.

"Our priority is to develop transmission technologies that allow our customers to introduce more capable and competitive vehicles—whether for cars, trucks or off-road applications," said Serra. "The new synchronizers will support the next generation of truck transmissions with reduced fuel consumption and improved driver convenience."

Here's How It Works

During a gearshift, synchronizers manage the speed difference between the previous gear selected and the next one to ensure a smooth, quiet shift. In a typical transmission, all the gears are in constant mesh, but only one pair is driving because in each pair, one of the gears freewheels until connected to its shaft by a synchronizer.

The hub of the synchronizer is splined to the shaft and carries three equally spaced struts around its perimeter, on which the selector sleeve rides. In order to connect the synchronizer hub to the gear and engage the chosen ratio, the sleeve is moved towards the selected gear when the driver operates the gearshift lever.

Fine internal teeth on the synchronizer sleeve connect with opposing external teeth on the side of the gear to transmit power. But the sleeve is unable to engage the gear because they are rotating at different speeds. To prevent grinding or crashing of the synchronizer teeth, two additional elements are carried between the hub and the gear, i.e.—a synchronizer ring and one or more cone clutches.

The synchronizer, or blocker, ring carries fine external teeth matching those of the sleeve and the gear. It blocks the sleeve from traveling into full engagement until such time that the speeds have been synchronized. The cones provide the necessary friction to adjust the rotating speed of the gear until it matches that of the shaft. At this point, the friction on the synchronizer ring decays and the ring's external teeth line up with the sliding sleeve, allowing it to complete its travel and fully engage the teeth of the selected gear.

For more information:

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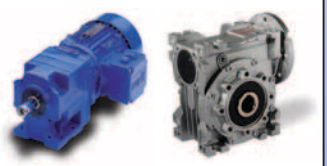
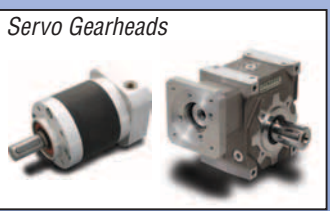


Servo Gearheads



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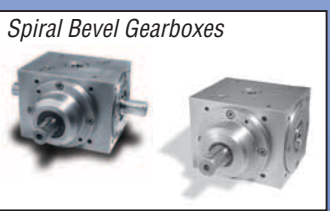

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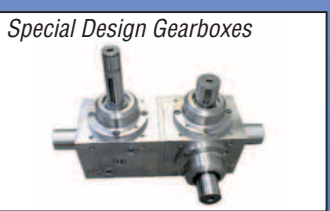

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AN OVERVIEW AND LOOK AT BASIC DESIGN

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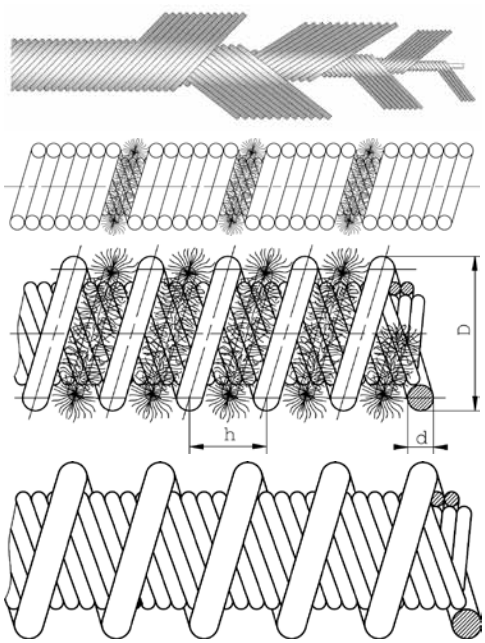
A flexible shaft is a cost-efficient way to transmit rotary motion. In flexible shaft design, it is important to know: how much torque must be transmitted; how small the minimum radius for the shaft must be; what RPM is required; the environment the flexible shaft will work in; and the preferred turning direction. Length is not critically important for the torque, but it does play a role in torsional deflection and, therefore, must be considered accordingly.

In flexible shaft design, not all parameters can be pushed or stretched in all directions. If more torque is required, for example, the minimum radius goes down—and with it the flexibility of the shaft. If the minimum radius can be made small, the torsional deflection will go up—not a good thing for remote control cable.

An array of flexible shafts with end fittings (all photos courtesy Suhner).



Flexible-shaft designs and styles.

Related to the basic "reality" of flexible shafts, two main design groups emerge; 1) torque-transmission shafts—mainly for higher speed, continuous speed and pure-torque-transmission applications like speedometer cables or shafts for drilling applications; and 2) torsion-stable flexible shafts for mechanically remote applications with low speed and which focus on low-torsional deflection.

An example is slide adjustments for stationary cutting machines. Beside these, there are special cables like flocked shafts, hollow shafts, shafts with helix wire and so on. We've provided some sketches showing some examples of special flexible shafts.

Direct influences to the detail of flexible shaft specifications include: the number of layers; the number of wires-per-layer; the diameter of the wire; the wire material (with higher or lesser carbon, different tensile strengths, different plating); and the manufacturing process (settings on the winding machines).

Considering influences related to shaft manufacturing processes, it must be understood that winding is a high-speed process in which gap settings will

influence the flexibility of the shaft. The winding speed and the gaps must be uniform and controlled. Gap settings are a key parameter, but not the only one. There are others, like tension of the wire, quality of the spooled-wire package, temperature of the operation, and so on. Experienced producers like Suhner— evidenced by the fact that their manufacturing operation in Rome, Georgia USA is the largest single flexible-shaft manufacturing operation in the world—effectively control their processes and assure highest quality flexible shafts, which, in turn, assures successful application.

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gy is not affected by speed fluctuation. It simply delivers the right amount of lubricant to the right place every time, lubricating more accurately, efficiently, reliably and reducing lubricant consumption.

Rotalube has a unique porting system that meters lubricant through precision ejectors incorporated within the sprocket assembly. Although simple in principle, the science is complex. The interaction from the chain rotates the sprocket applicator, and when the ports align within the sprocket body, the pressure within the system overcomes the back pressure of the ejector nozzles, resulting in lubricant delivered onto the link plates of the chain precisely and reliably. From then on the science of capillary action takes over and results in a lubricated chain that crucially extends chain life. The Rotalube is a controlled applicator that withstands excessive wear and maintains accurate lubrication, whatever the condition of the chain. Rotalube is available as standard in four sizes ½", ⅝", ¾", and 1"—the modular design extends the product offering from simplex to duplex and triplex. Bespoke solutions using Rotalube technology for other sizes are available on request.

Interlube has developed a new low-cost "ACR" pump specifically to operate with standard Rotalube applicators. The 24 V DC "ACR" pump has fully adjustable run and dwell settings and is pre-programmed to open and shut a solenoid valve that will allow air to mix with the metered oil output from the pump.

The system can be used throughout the food, automobile, steel, fiberglass and cement industries. Typical applications that can benefit include food processing machines, industrial dryers, tissue converting factories, waste paper conveyors, truck manufacturing plants, escalators and elevators.

Interlube offers full technical advice on design and installation for bespoke systems. The company recently designed and installed two such systems. One is an oil lubrication system that feeds six Rotalube applicators mounted inside an oven, first cleaning the chains with a constant air supply before the lubrication unit delivers a set amount of oil to each feed.

The second is a Rotalube for chains on a chocolate molding line. The Rotalube has an additional row of center nozzles that ensure lubricant is applied to the roller, thus coating the guides that support the chains. This application will not only improve the life of the chains; it has already shown an 81.5% reduction in cleaning time.

For more information:

Interlube Systems Limited
St. Modwen Road
Parkway Industrial Estate
Plymouth Devon PL6 8LH
Phone: +(44) 01752 676000
www.interlubesystems.co.uk

SKF

EXTENDS EXPLORER BEARING LINE

SKF has extended the growing family of the SKF Explorer performance class bearings product line to encompass the range of newly upgraded self-aligning roller bearings (spherical roller bearings, CARB toroidal roller bearings, and spherical roller thrust bearings). The bearings also benefit from innovative steel processing technology, offering higher performance.

The upgraded steel now used for SKF Explorer self-aligning bearings strikes a balance between hardness and toughness to significantly improve wear resistance. This enables the bearings to run longer, particularly under difficult operating conditions. Compared with previous versions, the upgraded Explorer bearings can provide up to twice the service life under harsh conditions where poor lubrication or high contamination levels exist.

All SKF Explorer bearings feature optimized internal geometry to reduce friction, wear, and heat generation and withstand heavier axial and/or radial loads. The rolling elements, which are manufactured to close tolerances, deliver suitable load distribution and run more smoothly with less vibration. Enhanced cages improve guidance of the rolling elements and maximize the effects of the lubricant to help reduce operating temperatures and extend lubricant life.

Among other features, SKF Explorer bearings incorporate an advanced surface finish to reduce friction and enhance formation of a hydrodynamic film, which promotes effective lubricant performance and reduces heat generation and wear. A unique heat treatment process reinforces bearing hardness, toughness and dimensional stability.

For more information:
SKF USA, Inc.
890 Forty Foot Road
Lansdale, PA 19446
Phone: (267) 436-6000
www.skfusa.com

Rexnord

LAUNCHES MOBILE BEARING APPLICATION

Rexnord recently launched *Bearing Mobile Pro*, its new iPhone app, to allow customers and distributors easier and better access to technical data and assistance for bearings, anywhere, at any time. The user-friendly app, which is supported by the Apple iOS platform (iPhone, iPad and iPod touch), is suit-

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able for anyone who purchases commercial grade bearings. It offers: technical information with more than 17 unique data points for Rexnord roller, ball and cylindrical bearings, and alternate Rexnord brands for similar products (Rex to Link-Belt roller bearing and Link-Belt to MB ball bearing); ability to interchange leading competitive manufacturer products to the appropriate Rexnord solution; instant answers to critical job site questions; ability for users to immediately share information via email; and direct access to live support via email and phone. "The new app will provide our customers with the convenience of real-time, accessible product data in a user-friendly platform, thus increasing efficiency on their end," said Aaron Loomer, commercial market manager, ball bearings.

For more information:

Rexnord Corporation
4701 W. Greenfield Avenue
Milwaukee, WI 53214
Phone: (414) 643-3000
www.rexnord.com

Ruland

OFFERS ZERO BACKLASH JAW COUPLINGS

Ruland zero backlash jaw couplings for start-and-stop machine vision systems can be utilized in industries such as semiconductor, medical, solar and packaging. The damping characteristics of Ruland's jaw couplings reduce settling time and shock loads, making them ideal for these environments.

Jaw couplings are a three-piece design comprised of two aluminum hubs and an elastomer element called the "spider." Made of an advanced polyurethane material, the spider provides damping of impulse loads that minimizes shock to the motor and other sensitive equipment. Available in three diameters, the spider allows the user to tailor the jaw coupling's performance, such as torsional stiffness, misalignment and dampening requirements, to their application. For added customization, metric and inch hubs (set screw, clamp style, keyed, or keyless) are interchangeable and can be combined into a single coupling.

Ruland jaw couplings feature a curved profile which press fits onto the spider. assuring zero backlash operation. The curved jaw profile concentrates the forces to the center of the spider's limbs, improving the effectiveness of the elastomer material. Raised contact points on the spider limbs help maintain proper spacing between the two hubs, assuring electrical isolation and full angular misalignment capabilities.

All Ruland products are RoHS- and REACH-compliant. Zero backlash jaw couplings are part of Ruland's complete product line which includes shaft collars, rigid couplings and motion control couplings: beam couplings, bellows couplings, oldham couplings, and disc couplings.

For more information:

Ruland Manufacturing Co., Inc.
6 Hayes Memorial Drive
Marlborough, MA 01752
Phone: (800) 225-4234
www.ruland.com

Newport

INTRODUCES AIR BEARING STAGES

Newport Corporation has introduced a line of high-performance air bearing stages specifically designed for the 450 mm semiconductor wafer initiative. The new DynamYX Datum 450 and 450GT are based on Newport's proven DynamYX 300-series wafer processing and inspection platforms with more than 1,000 worldwide installations. They are suited to handle the larger travel ranges, payloads, and increased throughput requirements of next-generation 450 mm tools. The DynamYX Datum 450 and 450 GT deliver high resolution, dynamic positioning of a wafer chuck or similar substrate in two orthogonal translation axes from a single-plane carriage. For added flexibility, a vertical Z-axis with tip/tilt function and a rotary axis for wafer offset correction can be added on the carriage beneath the wafer chuck. Other options are available for encoder and interferometer feedback, if required.

High-efficiency linear motors minimize heat generation and apply drive forces through the center of gravity of the stage, resulting in superior long-term repeatability and dynamic performance. The maximum velocity reaches 1.5 m/sec., with acceleration of 2 G (Y axis) and 3 G (X axis). With a rated payload of 20 kg, the new 300 Hz natural frequency stage features high accuracy (encoder feedback) at 50 N-m (3 sigma) and high repeatability at 10 N-m (3 sigma), making it suitable for tasks that require a high-performing positioning stage for 450 mm wafers.

Newport business development manager Walter Silvesky notes, "The all-new DynamYX Datum 450 and 450 GT feature unique performance characteristics that are achieved in part due to the highly differentiated and proprietary construction using advanced ceramics (SiC) that yield lightweight and incredibly rigid stage structures with high natural frequencies and exceptional thermal stability. This low-profile monolithic stage architecture with integrated pressure-vacuum air bearings provides unsurpassed stepping and scanning performance."

For more information:

Newport Corporation
1791 Deere Avenue
Irvine, CA 92606
Phone: (949) 863-3144
www.newport.com

BRAKING TOWARD THE FUTURE

Manfred Maiers
Electrohydraulics Group Director,
Mico, Incorporated

When assessing the future of a given industry, particularly one where technology plays a key role, it's typical to hear talk of the future being "here" or "now." Setting aside all metaphysical discussion of what constitutes a changeover from the present to whatever comes next, these conversations tend to take place in the context of what's currently possible. Sure, some ideas may be legitimately futuristic, but most are firmly rooted in present-day knowledge and capabilities. With this in mind, it would be incredibly underwhelming to simply say that the future of off-highway vehicle braking technology has arrived. It's more apt to say the present is always evolving, with new advancements constantly being developed. Ultimately, however, the changing world of braking has far less to do with *when*, and everything to do with *what*. That is because the braking industry has actually moved beyond the niche of brakes and related components, and is now focused on how brakes can become more integrally connected with the operation of a vehicle as a whole.

Getting Brakes Connected

In the past decade, electrohydraulic braking systems—including ABS and traction control—have grown increasingly popular, due largely to the vehicle design flexibility and performance advantages they offer. The industry has seen several other instances of intelligent machine controls, unrelated to braking, over the years as well. But what all of these technologies have typically had in common is that they've existed as standalone, point-to-point functions that have not been integrated together. The present and future of braking is all about taking the next logical step—getting fully connected and finding ways to embed intelligence throughout a machine so that vehicle systems are totally integrated and optimized.

ABS is a good example to examine. Historically, ABS has worked through a relatively simple form of connectivity. An ABS fault might send a message through a CAN bus, perhaps activating an ABS fault light on the vehicle dashboard. No interaction with other vehicle functions would take place. Everything occurring with the ABS would basically be self-contained.

Now, ABS can be programmed to exchange information with other vehicle systems, such as a hydrostatic drive. If one or more wheels start to lock up, the brake system can tell the hydrostat that an ABS event is occurring by delivering a message for the transmission to disengage, thereby increasing ABS performance and preventing the engine from stalling. The vehicle controllers can also use other status information like vehicle speed for interlocking and other safety features.

There are multiple benefits to machine integration. The first and most obvious is improved vehicle performance. Lower cost is another. Although it is unusual for a technology improvement to result in a cost reduction, using just one electronic system—instead of several—to collect and share all vehicle function information often results in cost savings. Fewer components and reduced weight also provide a tangible benefit.

Innovate to Integrate

In addition to enhancing integration for existing brake system technologies, engineers are branching out from their traditional areas of expertise. For example, rather than focusing solely on brake systems and components, manufacturers like Mico are expanding their services to cover the full gamut of vehicle stability control in order to better support their OEM customers.

The basic goal of designing a brake system is to achieve a specific stopping distance based on vehicle weight and other parameters. When looking at electronic stability control, more factors have to be taken into account. Stability control may be utilized to help a driver keep a vehicle under control

Components in Mico's electrohydraulic brake system (all photos courtesy of Mico).

in extreme driving situations like over- and under-steering. This requires an evaluation of a vehicle's dynamic capabilities through the use of accelerometers, gyroscopes and other sensors that aren't typically found on an off-highway vehicle. Manufacturers also prefer to perform a vehicle computer simulation to evaluate stability control performance prior to deploying the technology to a vehicle.

From there, integration can occur just as it does with technologies that are related strictly to braking. An electronic stability control system may communicate with a vehicle's electronic suspension system. It might apply a single brake or multiple brakes depending on whether the machine is following the driver's intention to move in a certain direction. Many other systems and information can also be utilized to assist with stability control.

Regenerative braking is another popular technology that is helping to make vehicles more energy- and fuel-efficient by storing energy generated during the braking process, and later re-using the stored energy for driving. The technology is an additional example of the need for vehicle integration and system communication, as regenerative brakes will encounter situations where standard service brakes must take over.

More Involvement

One side effect of the proliferation of total machine integration is that brake manufacturers must be willing and able to become involved earlier in the overall vehicle development, rather than entering the picture at a later point to implement a standalone braking system. Even for independently operating functions, controls and components usually need some degree of tuning along the way. Those tweaks can be related to actual performance or simply be a packaging modification to ensure that a component physically fits where it belongs. When these same components are required in an integrated scenario, it is clearly a more efficient design process to figure out how every vehicle system will work together from the start and then engineer those systems accordingly.

The move toward integration also means that in many cases, an "off-the-shelf" braking component will not be a viable solution for an intended application. But for companies that have spent decades providing specialized, custom braking components, the learning curve promises to be much shorter than for manufacturers who have historically delivered high-volume, generic options.

Rooted In Safety

Braking is inherently all about safety—mitigating risk to primarily prevent accidents, loss of life and injury, and to help avoid damage to expensive vehicles and equipment. Safety has been and always will be of the utmost importance, but for decades most off-highway vehicle industries were exempt from a large number of vehicle safety standards because machines simply didn't move quickly enough for certain braking guidelines to apply. With new technology advancements, off-highway vehicles are becoming faster. Clearly this fact has the attention of braking component providers, as increased speeds are creating new challenges for vehicle design Faster vehicles must conform to certain Safety Integrity Levels (SIL) and other safety standards that are not new, but are more critical for faster equipment.

Because such standards didn't previously apply when off-highway vehicles were slower, braking manufacturers actually have to educate their OEM customers about certain requirements. Things get even more interesting when factoring in the high degree of integrated software and other electronic capability built into an optimized vehicle. In essence, integrated vehicle design has created a two-way street where both brak-

J.H. Fletcher's Prime Mover diesel tractor features a Mico electrohydraulic braking system.

Mico's full-power brake system with ABS and traction control.

ing and equipment manufacturers need to become schooled in the other's traditional area of expertise.

Tomorrow Keeps Arriving

The off-highway equipment industry is extremely dynamic. Environmental pressures like Tier 4 requirements and wildly fluctuating markets can create daily challenges. Given the degree of difficulty in many cases, it's quite simple to see how decisions might be made because a particular solution is the easiest or cheapest available.

Fortunately it is also an industry that is full of problem solvers—engineers and other leaders who are driven to deliver a new wave of technology to improve vehicle safety and performance. Braking manufacturers are very much at the forefront of the current wave and will play a big role in what comes next. Upon seeing how far technology has come with electrohydraulics and other advances, it's ironic that even braking experts might have to admit that there's just no stopping what's coming tomorrow.

For more information:

Mico Incorporated
1911 Lee Boulevard
North Mankato, MN 56003
Phone: (507) 625-6426
www.mico.com

Great Lakes Power's ST35 straddle carrier also utilizes a Mico electrohydraulic braking system.

CUSTOM
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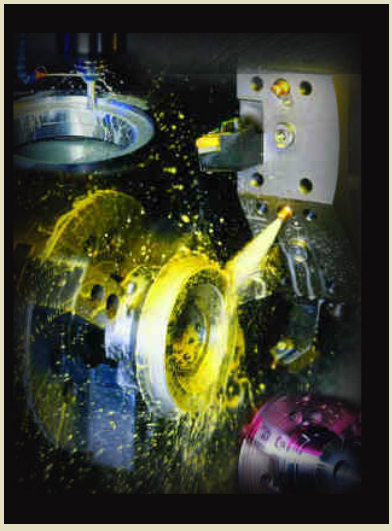

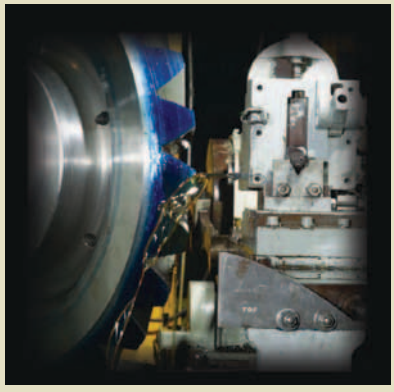

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Electromagnetic Know-How

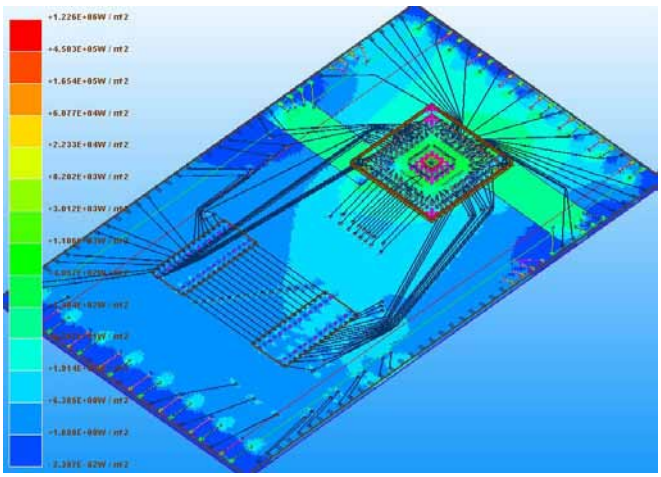
No Shortage of Software Options in PT/Motion Control Market

Matthew Jaster, Associate Editor

Finite Element Analysis (FEA) software can be used for a variety of mechanical engineering tasks, including injection molding simulation of plastic parts, analysis of aerospace components, impact and crash analysis of automobiles and the electromagnetic analysis of motors, actuators, transformers and sensors—aka the power transmission/motion control crowd. Because this market is flooded with software variations, it can be difficult to decide what features and capabilities best suit a given manufacturing operation. *PTE* has attempted to answer the "who, what, where, why and how" of electromagnetic software solutions in today's power transmission/motion control industry:

ANSYS Maxwell

ANSYS Maxwell is electromagnetic field simulation software for engineers tasked with designing and analyzing 3-D and 2-D electromagnetic and electromechanical devices such as motors, actuators, transformers, sensors and coils. *Maxwell* uses the accurate finite element method to solve static, frequency-domain and time-varying electromagnetic and electric fields. "Engineers throughout the world use *Maxwell* to simulate these devices and accurately predict force, torque, capacitance, resistance, flux density and other electromagnetic quantities that are critical to predicting a design's performance," says H. Mark Ravenstahl, director of product marketing, electronic business unit, at ANSYS. "*Maxwell* enables engineering teams to anticipate a device's performance before building a physical prototype, thus accelerating the design process and reducing development cost."



ANSYS solutions incorporate tools for an end-to-end electronics product solution, from chip to package and board design.

Maxwell is only one part of the *ANSYS* solution for motion control/power transmission. Although it is suitable for accurately solving electromagnetic fields critical to the performance of motors, actuators, transformers and sensors, there are also thermal and mechanical forces that must be taken into account. Moreover, these devices are integrated with power electronic circuits and control technology to create the synergistic, physical systems. "The *ANSYS* software portfolio includes *ANSYS Mechanical* for thermal and structural analysis and *ANSYS Fluent* to solve computational fluid dynamics (CFD). Each can be coupled to *Maxwell* to perform in-depth multi-physics studies of a device including electromagnetic-thermal-structural," Ravenstahl says.

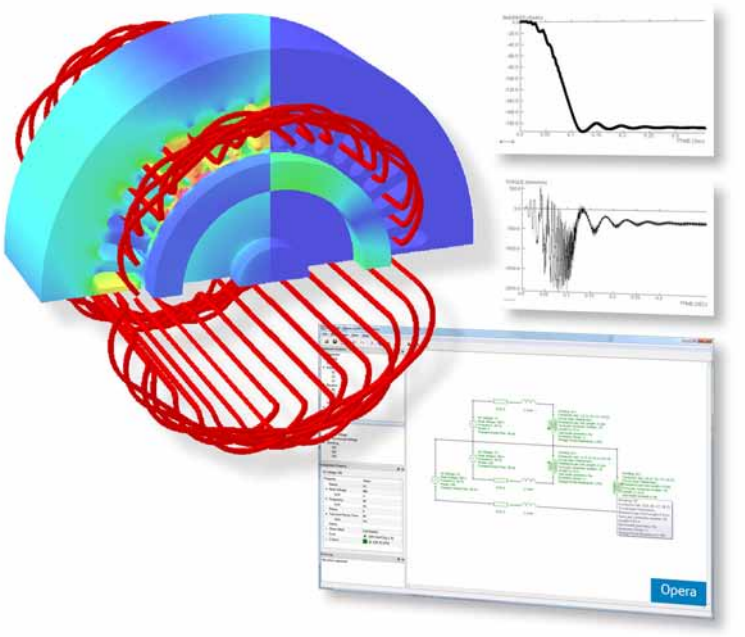
In addition, *ANSYS Simplorer* allows companies to solve motion control/power transmission system challenges with the requisite interoperability of components and circuits from the initial design stage. "This powerful multi-domain, multi-technology approach to design captures the underlying physics that governs a component's behavior, allowing engineers to accurately model, simulate and validate the component, circuit and system level performance required for a successful system design," he says.

Since the acquisition of Ansoft Corporation in 2008, *Maxwell* has been integrated to *ANSYS* technologies for structural and fluid dynamics simulations, which greatly expand the range of multiphysics simulations engineers can perform. "With these comprehensive multiphysics solutions, engineers can readily evaluate stresses, as well as assess the reliability of devices undergoing forces such as shock and vibration. They can also better understand phenomena such as heat flow and study various cooling strategies. All of this can be accomplished while also optimizing the design of electromechanical components. These various simulations can be tied together

within the *ANSYS Workbench* framework for a smooth exchange of data between field solvers and design tools and also with *ANSYS Engineering Knowledge Manager (EKM)* software for managing simulation data. This unified approach coupled with our breadth of engineering solutions and depth of multiphysics technologies gives development teams the tools they need to be successful in a competitive environment," Ravenstahl says.

Currently, mobile computing technologies are being evaluated at ANSYS by product management teams to determine if they have a role in electromagnetic and multiphysics designs. "Because simulation technologies have high computational demands, it would be quite a feat to have this technology running on a mobile phone or tablet in the near future," Ravenstahl says. "Cloud technology has promise of shared resources; however, due to concerns with Internet security, many customers are not interested in exposing sensitive engineering data to such solutions. Of greater concern to our customers is the ability to solve larger simulations in the least amount of time."

ANSYS has worked with its customers to develop high-performance computing (HPC) solutions to enable engineers to fully utilize existing clusters to achieve the fastest simulation solution time possible. The ANSYS HPC solutions ensure customers can optimize their designs by considering more alternatives and deliver them to market fast. "ANSYS will focus on continual development of its individual electromagnetic, fluid dynamics and mechanical products as well as the interoperability between the disciplines," Ravenstahl says. "Simultaneously, research and development efforts will focus at the systems level to provide customers with innovative multi-technology, multi-domain solutions that will deliver a competitive advantage and help them achieve their business goals." For more information, visit *www.ansys.com*.



Machines Environment **creates, analyzes and optimizes rotating machines (courtesy of Cobham).**

Machines Environment

The electrical *Machines Environment* is a graphical dialog-driven interface to Cobham's *Opera* FEA multi-physics software suite which provides an easy-to-use process for rapidly creating, analyzing and optimizing rotating machines. "It is a virtual design and test environment that is as accurate as conventional prototyping but which is extremely versatile, faster and more cost-effective than the conventional method," says Nigel Atkinson, business development manager at Cobham Technical Services. "It can be used to investigate many design variants that would otherwise be prohibitive in both time and expense. The environment captures the knowledge of our own electrical machine experts. It uses a series of templates, which allow the user to build and analyze designs of a wide range of industry-standard machine types that can be tested under real-life conditions, including fault conditions."

Atkinson continues, "The interface is written in the *Opera* scripting language and can easily be modified by the user to include any special or proprietary features. The process for making modifications is well documented. It enables users to customize or configure the environment to suit their needs, such as adding tests or producing documentation required by local processes. The *Machines Environment* is one of several application-specific environments for *Opera*. Another is the *Transformer* and *Reactor Environment*."

Cobham recently integrated the *Opera Optimizer* tool into the two-dimensional version of the *Machines Environment* software, allowing designers to specify multiple goals and constraints and to automatically hone in on global-optimal designs. The three-dimensional version has been upgraded with additional solution schemes such as dynamic machine analysis.

"*Opera* is a multi-physics FEA suite and circuit solver. It is bi-directionally integrated with both the Windows interface and Linux shared library API which means it can be linked to most third party software with similar interfacing capability," Atkinson says. "For example, we have customers using *Opera* with third party PLM and CFD packages. Specifically, there is a bi-directional link to the *Mathcad Simulink* product and to CD-Adapco's *Speed* program."

Mobile technology is currently not a priority with the *Machines Environment* software, but that could change, according to Atkinson. "There is little or no technological barrier to this relatively new technology, but only limited interest at present, though this may change in the future. FEA is relatively computationally intensive, so any implementation with mobile technology will need to take this into account. Most users currently run the software on a standard laptop or desktop, but some use larger multi-processor computers. The software can be installed for network or stand-alone use."

Immediate plans for *Opera* are to extend its multi-physics capability by extending the stress solver to include modes of

vibration. *Machines Environment* will be extended to allow co-simulation of the electromagnetic, thermal and stress/vibration solvers. This will allow engineers to analyze both the electrical and mechanical characteristics of the machine. "We have recently begun a three-year research program with Jaguar Land-Rover and Ricardo (U.K.) to address the need for improved electric drives for the automotive industry," Atkinson says. "This work is supported by the U.K. government's Technology Strategy Board and will lead to further enhancements and extensions to the *Machines Environment*."

For more information, visit *www.cobham.com*.

Speed 2012

Speed software allows users to design electric machines such as induction motors (polyphase/1-phase); brushless permanent-magnet motors (square wave/sine wave); DC brush motors; switched reluctance motors; and synchronous reluctance motors. Many of the new features in *Speed* are intended for generators as well. With over 1,500 customers using *Speed* for more than 20 years, they are among the leading manufacturers, designers, developers and users of electric machines.

Dr. Tim Miller, originator of *Speed* and now a consultant to CD-Adapco, commented, "While this is a great development for *Speed* and all our customers, we're wasting no time in making a complete new release of all the *Speed* software and its documentation. One compelling reason why we've joined forces with CD-Adapco is to make *Speed* even better." Miller continued, "An early sign of *Speed's* progress is the intense collaboration to share geometry and other design parameters with *Star-CCM+* (the CFD program of CD-Adapco). Another is the development of a 3-D electromagnetic solver in *Star-CCM+*. And a third is the intense training activity that *Speed* is running—two or three times the previous level."

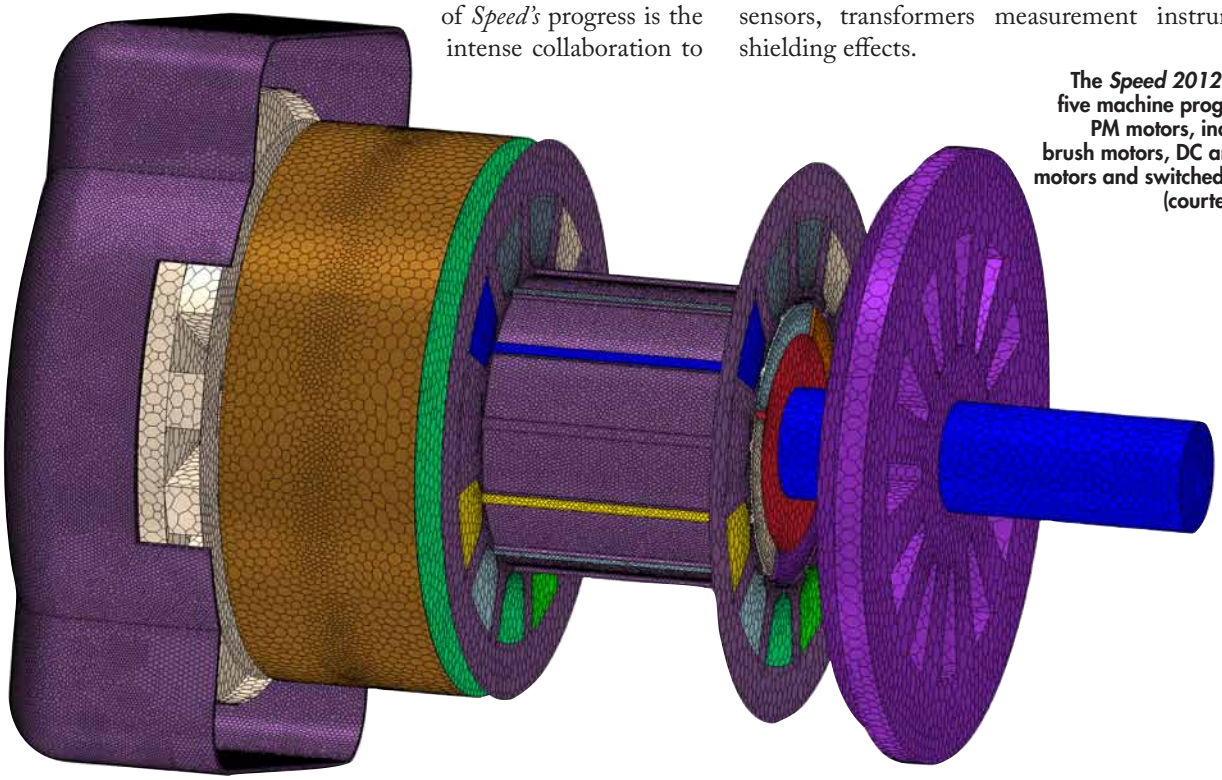
Speed offers several features for automotive, refrigeration, aerospace and industrial applications. "It's a specialized analysis tool for the design of electric machines such as motors, generators and alternators including the drive with inverters and their control," says Markus Anders, electrical machine sector manager, at CD-Adapco.

The *Speed 2012* release consists of five machine programs for brushless PM motors, induction motors, DC brush motors, DC and AC wound field motors and switched reluctance motors. These programs are available with a floating license system using *FlexNet Publisher* and a link that was established to *Star-CCM+* to exchange the data needed from *Speed* to *Star-CCM+* to set up the CFD 3-D model and run an advanced thermal calculation of the entire electrical machine.

"Today more and more individual software is merging like *Speed* and *Star-CCM+* to have a software chain from achievable designs to highly sophisticated simulation to get deep inside in the magnetic or thermal behavior of the electrical machine," Anders says. For more information, visit *www.cd-adapco.com*.

Additional Options

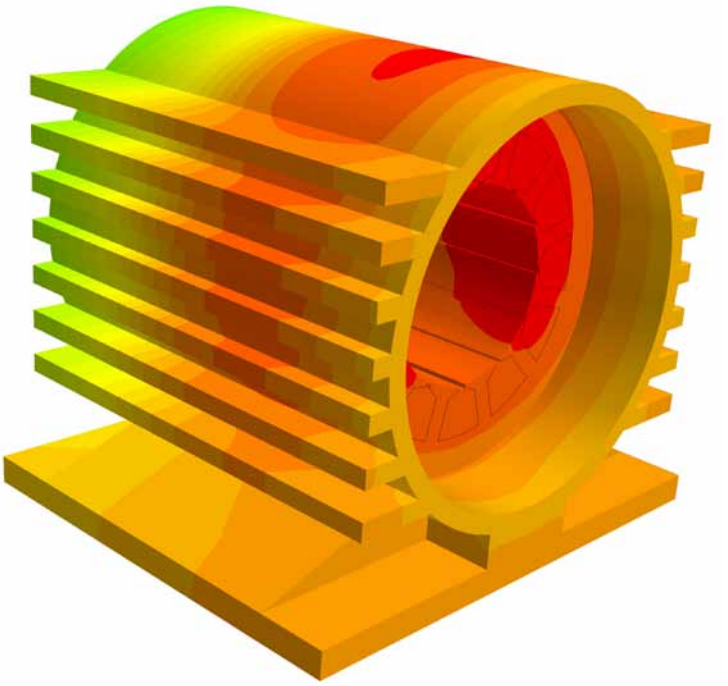
Software packages from CST and Electro Magnetic Works offer similar software expertise. *CST EM Studio* (*www.cst.com*) is dedicated to the simulation of static and low-frequency devices. Embedded in the same user friendly *CST Design Environment*, *CST EMS* features a variety of solver modules to tackle electrostatics, magnetostatics, current flow, low frequency and even stationary temperature problems. Applications include: actuators, brakes, EMC, generators, motors, sensors, transformers measurement instrumentation, and shielding effects.



The *Speed 2012* release consists of five machine programs for brushless PM motors, induction motors, DC brush motors, DC and AC wound field motors and switched reluctance motors (courtesy of CD-Adapco).

EMS (*www.emworks.com*) is a 3-D electromagnetic field simulator software suite, based on the powerful finite element method. Currently, it is the only electromagnetic add-in to *SolidWorks*. *EMS* is Gold Certified by SolidWorks and targets four main areas: electromechanical, electromagnetic, power electronics, and electromagnetic behavior. Each of its five modules—*Electrostatic*, *Conduction*, *Magnetostatic*, *AC-Magnetic* and *Transient*—has a built-in, fully integrated thermal solver. *EMS* empowers the designer to compute electric, magnetic, mechanical, and thermal parameters including force, torque, magnetic flux density, magnetic field, electric field, electric flux, current flow, eddy current, inductance, capacitance, resistance, flux linkage, core loss, saturation, induced voltage, force density, power loss, temperature, temperature gradient, heat flux and more.

The many software design options available in this field make it necessary to examine brochures, training videos, publications, testimonials and case studies to get a better idea of what's currently available on the market. To be sure, this is another area of software development that is constantly evolving. "There is increasing interest in, and use of, FEA for electrical machine design. This has been driven by the increasing performance of computers and similarly the increasing capability of FEA. The current situation is that electrical machines can be fully and accurately characterized using FEA for most situations. This includes testing the machine with its power supply and mechanical load," Atkinson says. "Coupled simulations allow the electrical, mechanical and thermal behavior to be investigated. With this level of realism and validated accuracy, FEA is becoming accepted as an integral part of the design process. It is more cost effective and quicker to evaluate a virtual machine than it is to build and test a prototype."



Today more and more individual software is merging like *Speed* and *Star-CCM+* to get deep inside in the magnetic or thermal behavior of the electrical machine (courtesy of CD-Adapco).

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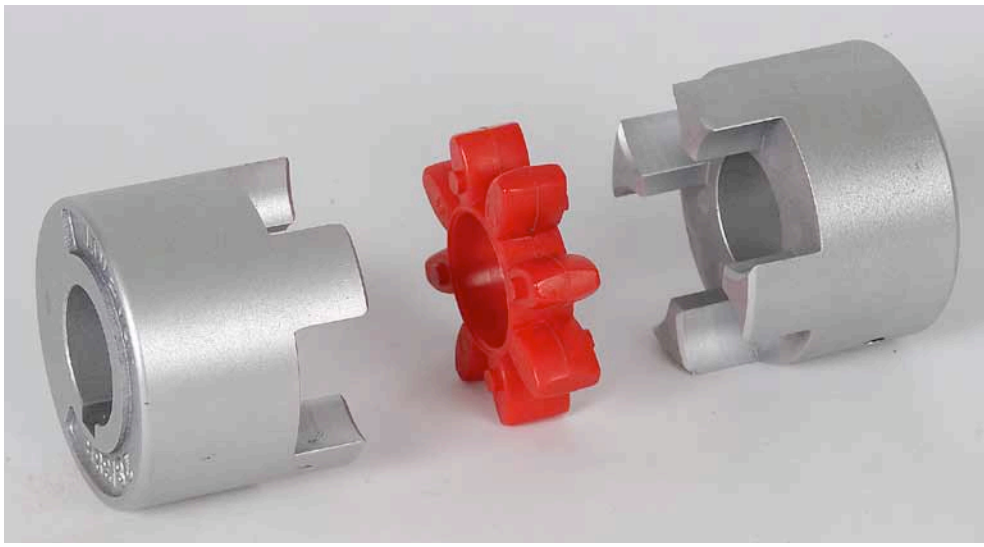
Sorting Out Flexible Couplings

Lovejoy, Inc.

All photos courtesy Lovejoy, Inc.



Introduction

When the time comes to specify replacements for mechanical power transmission couplings, it's human nature to take the easy path—i.e., simply find something similar (if not identical) to the coupling that failed, maybe apply a few over-sizing fudge factors just to be conservative. Too often, however, this practice only invites a repeat failure—or more costly system damage.

The wiser approach is to start with the assumption (or at least the *suspicion*) that the previous coupling failed because it was the wrong type of coupling for that application. Taking time to determine the right type of coupling is worthwhile, even if it only verifies the previous design. But it might lead you to something totally different that will work better and last longer.

If so, that result also will reward you by extending the life of bearings, bushings and seals, preventing fretted spline shafts, minimizing noise and vibration, and cutting long-term maintenance costs.

In most cases, industrial power transmission calls for flexible rather than rigid couplings in order to forgive minor shaft misalignment. For that reason, this article will focus solely on the selection of flexible couplings.

Determining the Right Type of Flexible Coupling

Determining the right type of flexible coupling starts with profiling the application as follows:

- Type of prime mover (electric motor, diesel engine, other)
- Real horsepower and/or torque requirements of the driven side of the system, rather than the rated horsepower of the prime mover (note the range of variable torque resulting from cyclical or erratic loading, "worst-case" startup loading, and the amount of start-stop-reversing activity common during normal operation)
- Driven-system inertia values in relation to prime-mover inertia (equipment vendors can supply data)
- Vibration, both linear and torsional (experienced vendors or consultants can help you evaluate vibration)
- Shaft-to-shaft misalignment; note degree of angular offset (where shafts are not parallel) and amount of parallel offset (distance between shaft centers if shafts are parallel but not axially aligned); also note whether driving/driven units are or could be sharing the same base-plate
- Axial (in/out) shaft movement, BE distance (between ends of driving and driven shafts), and any other space-related limitations
- Ambient conditions (mainly temperature range and chemical/oil exposure)

The next step is to review available types of flexible couplings to see which type best suits your application profile.

Initially, flexible couplings divide into two primary groups—metallic and elastomeric. Metallic types are all-metal designs that gain their flexibility from movement of loosely fitted parts that roll or slide against each other, or from bending of non-moving metallic parts. Elastomeric types gain flexibility from using resilient, non-moving, rubber or plastic elements to transmit torque between usually metallic driving/driven hubs.

Metallic types are best suited to applications that require or permit:

- Torsional stiffness (very little "twist" between hubs; in some cases providing positive displacement of the driven shaft for each incremental movement of the driving shaft)
- Operation in relatively high ambient temperatures and/or presence of certain oils or chemicals

- Electric motor drive (metallics generally are not recommended for gas/diesel engine drive)
- Relatively constant, low-inertia loads (generally not recommended for driving reciprocal pumps, compressors, other pulsating machinery)

Elastomeric types are best suited to applications that require or permit:

- Torsional softness (allows "twist" between hubs, absorbs shock and vibration, can better tolerate engine drive and pulsating or relatively high-inertia loads)
- Greater radial softness (allows more angular misalignment between shafts, puts less reactionary or side load on bearings and bushings)
- Lighter weight/lower cost, in terms of torque capacity relative to maximum bore capacity; quieter operation.

Another way to look at it: wrong applications for each type are those characterized by the conditions that most readily shorten their life. In metallic couplings, premature failure of the torque-transmitting element most often results from metal fatigue, usually due to flexing caused by excessive shaft misalignment or erratic/pulsating/high-inertia loads. In elastomeric couplings, breakdown of the torque-transmitting element most often results from excessive heat—either from ambient temperatures or from hysteresis (internal buildup in the elastomer)—or from deterioration due to contact with certain oils or chemicals.

The preceding overview should help establish which group generally looks best for a given application; the following discussion presents the basic alternatives available in both groups to further guide your selection.

Metallic coupling alternatives. Metallic flexible couplings group into three basic families:

1. Mated Parts
2. Membrane
3. Specialty

Mated parts couplings. Mated-parts designs include gear, grid and chain types, in which torque is transmitted across separate metal elements that push against each other. Generally, these designs offer high torque-to-outside diameter ratios, accommodate misalignment up to 2°, but allow little parallel misalignment. They provide relatively high torsional stiffness, but due to moderate backlash, they usually are not recommended for pulsating or frequent stop-start applications. All require routine lubrication and maintenance of seals.

Gear couplings consist of two shaft-mounted hubs with gear teeth around their external circumferences. Both hubs are enclosed within a common connecting sleeve that has gear teeth around its internal circumference, which mate with the hubs' teeth. Continuous teeth along the length of the sleeve allow generous tolerance for axial (in/out) shaft movement. In lower torque ranges, nylon sleeves can eliminate need for lubrication and provide quieter operation; higher torque and/or RPM ranges can be achieved with special models having heat-treated teeth.

Grid couplings are the only metallic type to offer moderate torsional shock/vibration damping capacity. This design employs a spring steel grid pre-formed to snake back-and-forth between two shaft-mounted hubs, nesting in slots formed around the external circumference of each hub. The beam effect of this grid as it spans the gap between the two hubs gives this design its resilience. The grid also forgives minor axial shaft movement, but movement that significantly shortens the gap between hubs reduces grid resilience. A common sleeve encloses both hubs and grid.

Chain couplings consist of two sprocket-like shaft hubs linked around their circumference by a continuous length of double roller chain, which is enclosed in sleeve-type cover. Low-torque applications can opt for a low-noise plastic chain; high-torque applications can be accommodated by special heat-treated chains and sprockets.

Membrane couplings. Membrane coupling designs comprise laminated disc, flexible link and diaphragm types, in which torque is transmitted through single, tightly fitted metal elements rather than across separate, loose metal elements pushing against each other. This assures positive displacement with zero backlash and no routine maintenance requirements. Membrane types cover a broad range of horsepower and torque capacities, with varying degrees of angular flexibility achieved by deflection of the metal elements. They generally do not allow parallel misalignment.

Laminated disc couplings transmit torque through a stack of thin, O-shaped metal discs suspended between two flange-type, shaft-mounted hubs. The disc stack is bolt-attached alternately to driving and driven hub flanges along a common bolt-circle diameter.

The beam effect of the disc stack's thin laminate construction, in free span between driving and driven bolts, allows an angular flexibility of up to 1 degree, but will not permit axial shaft movement or parallel offset.

Flexible link couplings are a variation of the disc design that uses three or more flat strip springs—called "flex-links"—in place of a laminated disc pack. The ends of the flex-links are attached (usually riveted) to carriers mounted on driving and driven shaft hubs, enabling

the driving carrier to pull the driven carrier in rotation. The carriers are shaped with radial arms that position their flex-link attachments near the circumference of the coupling to maximize flex-link length.

The beam effect of the flex-links, in free span between driving and driven carrier arms, gives the three-link design high angular flexibility of up to 6°, with low reactionary load on bearings. Designs using four or six flex-links can accommodate greater torque, but reduce angular flexibility. Flex-link designs do not allow axial shaft movement, but will tolerate slight parallel offset.

Diaphragm couplings transmit torque through a stack of thin metal diaphragms (full but typically perforated discs). The stack is attached to one shaft-mounted hub near its OD, and attached to the other shaft-mounted hub near its ID, so torque flows between OD and ID rather than around the OD. The free span of the diaphragm between OD and ID deflects to accommodate moderate angular misalignment of to 1ø and to allow minor axial shaft movement.

Specialty couplings. Specialty metallic couplings encompass a variety of designs such as wrapped spring, helically formed beam, bellows and offset types.

Wrapped spring couplings allow up to 4.5° of angular and up to .045" of parallel misalignment—plus high RPM ranges. These designs consist of three concentric, tightly wound, square-wire springs, with the inner and outer coils wrapped in the same direction opposing the direction of the center coil in order to enable coupling rotation in either direction. The spring pack is brazed to hubs at both ends, making a single-piece coupling that is very easy to install.

The spring coupling has no backlash, but it is not torsionally rigid and therefore may not be suitable for some positioning applications.

Curved beam couplings include two single-piece designs that feature high torsional stiffness and zero backlash, making them well suited for servomotor, encoder and other precise-positioning applications. They accommodate high angular misalignment with low reactionary loads on bearings and are good for applications with small-diameter shafts that could easily bend.

One curved-beam design—called the helically formed coupling—is machined from solid bar stock with spiral patterns cut through to its core, creating a long, curved beam. Its torsional stiffness varies in a linear fashion—i.e., the amount of "twist" is directly proportional to the torque load. In special high-speed designs, RPM can range up to 50,000 RPM.

The other curved beam design—the bellows coupling—is made from a single piece of tubular stock axially compressed into a series of rounded "accordion" folds. This design offers extremely high torsional stiffness, measured in arc. sec./in. oz.

Offset couplings are unique in their ability to accommodate extremely large, parallel misalignment between shafts—up to 17" offset in the largest coupling size—although maximum angular misalignment is limited to 0.5°. An alternative design allows up to 3ø angular misalignment, but will accept only up to 0.5" of parallel offset. These highly specialized and complex designs have many moving parts and must be very carefully specified.

Elastomeric coupling alternatives. Elastomeric couplings classify into two main categories by the way their elastomeric element transmits torque—i.e., the element is either "in compression" or "in shear."

When the element is in compression, parts of the driving hub push parts of the driven hub. The element separates driving from driven parts like a cushion, absorbing some of the torque force by being compressed between them.

When the element is in shear, the driving hub pulls the driven hub through their mutual connection to the element, which absorbs some of the torque force by being stretched through twisting.

Compression-type couplings generally offer two advantages over shear types. First, because elastomers have higher load capacity in compression than in shear, compression types can transmit higher torque and tolerate greater overload. Second, they offer a greater degree of torsional stiffness, with some designs approaching the positive-displacement stiffness of metallic couplings

Shear-type couplings in turn offer two general advantages over compression types. First, they accommodate more parallel and angular offset while inducing less reactionary bearing load; this makes them especially appropriate where shafts may be relatively thin and susceptible to bending.

Second, they offer a greater degree of torsional softness, which in some cases provides greater protection against the destructive effects of torsional vibration.

Compression-type designs. Elastomeric, compression-type couplings comprise three main designs: jaw, donut and pin-and-bushing.

Jaw couplings are distinguished by hubs that have two to seven axially oriented jaws (thick, stubby protrusions) arranged around their circumferences. Jaws of driving and driven hubs mesh loosely; filling the gaps between them are cushions of elastomeric material, usually molded into a single asterisk-shaped element called a "spider."

Permanent compressive set occurs as the element ages in service; a 25 percent reduction from original thickness signals replacement. In most applications, compression is applied only to the spider cushions forward of the driving jaws, so spider life can be doubled by advancing the unused trailing cushion into the driving position.

Jaw designs are considered "fail-safe" because if the spider breaks away, the driving jaws can contact the driven jaws directly, maintaining operation until the spider can be replaced.

Jaw couplings generally are recommended for electric motor-driven machinery, pumps, gearboxes, etc. Most jaw designs typically are limited to an-

gular shaft misalignment of 1° and tolerate very little parallel offset. Backlash due to spacing between jaws and element cushions usually makes jaw couplings inappropriate for true positive-displacement applications.

Donut couplings use a donut-shaped ring of elastomeric material installed with a set of bolts or pins alternately engaging the ring from the driving and driven hub. Torque is transmitted through the donut material via compression between driving and driven bolts. But, while the "leading" portion of the donut is in compression, the "trailing" portion may be in tension, depending on the donut/hub design. This feature eliminates backlash and allows the coupling to absorb torsional vibration.

Standard donut designs may vary in torsional stiffness and are rated for medium to heavy-duty service, with angular misalignment allowance as much as 3° in some cases, and good parallel misalignment allowance.

Pre-compressed natural rubber donut designs are torsionally softer than most compression couplings, and widely favored for high-shock, start/stop applications such as engine-driven systems, compressors, violent pounding or crushing equipment, marine and off-road equipment.

Pin-and-bushing couplings transmit torque through driving pins that project from both driving and driven hubs; each pin engages an elastomeric bushing, or "biscuit", suspended in a rigid disk between the hubs. Similar in concept to the donut design, this coupling is torsionally softer than other compression types and does a better job of absorbing torsional shock. It allows angular misalignment up to 2°, but not much parallel offset.

Shear-type designs. Elastomeric shear-type couplings include three main designs: sleeve, tire and molded-element.

Sleeve couplings are characterized by a tubular elastomeric element molded with serrated flanges at both ends. These flanges mate with serrated sockets molded into the coupling's hubs.

Sleeve types in some cases may twist as much as 15° between hubs, providing excellent protection against torsional shock and vibration. They accommodate angular misalignment up to 2ø, and parallel offset up to approximately .05", without imposing much reactionary load on bearings.

Because of their open-center construction, sleeve-type couplings allow shaft-to-shaft applications with very little clearance between shaft ends.

Tire couplings, named for their resemblance to an auto tire, consist of two flanged hubs equipped with clamping plates that grip the coupling's hollow, ring-shaped element by its inner rims. Furthering the similarity, tire coupling elements usually are rubber-derivative elastomers with layers of cord, such as nylon, vulcanized into the tire shape.

Design variations are available, including an inverted tire coupling in which the tire element arcs inward toward the axis, designed for higher RPM service.

The tire coupling is torsionally soft and can damp vibration. High radial softness accommodates angular misalignment up to 4° and parallel offset up to ⅛". Rare among elastomeric couplings is its capability to allow a certain amount of axial shaft movement. These properties afford tire designs a wide variety of applications, including those using internal combustion engines.

Molded-element couplings feature an elastomeric element that is molded into the metallic hub of the coupling, usually in a socket having a serrated perimeter. These designs are most often recommended for connecting internal combustion engine flywheels to pumps, transmissions, blowers, generators and compressors—especially where close coupling is desired.

A very broad range of element materials—from torsionally soft to stiff—allows wide latitude in adjusting natural frequencies of engine-driven systems to avoid inducing destructive resonance at critical RPM ranges. Angular misalignment ranges from 0.5°–2°—depending on coupling construction and element hardness—and parallel offset is generally limited to .05".

In general, the torsionally softer alternatives are used with high-inertia loads and where good coupling alignment is difficult to attain. Torsionally stiff alternatives are favored for low-inertia loads, but demand careful attention to alignment.

Flexible couplings have evolved into a rich variety of types, providing a wide range of performance tradeoffs. When selecting among them, resist the temptation to overstate service factors. Coupling service factors are intended to compensate for the variation of torque loads typical of different kinds of driven systems, and to provide for reasonable

service life of the coupling. If chosen too conservatively, they can misguide selection and raise coupling costs to unnecessary levels—perhaps even invite damage elsewhere in the system. Remember that properly selected couplings are supposed to serve as a fuse; i.e., if the system is overloaded, improperly operated or somehow drifts out of specification, the coupling should break—before something more expensive does.

Thoroughly review the suggested application profile with your coupling vendors and seek not only their recommendations for the right type of coupling, but also the reasons behind those recommendations. With the variety of couplings available today, careful selection usually leads to a long-lasting match between coupling characteristics and the demands of the application.

For more information:

Lovejoy, Inc.
2655 Wisconsin Avenue
Downers Grove, IL 60515
Phone: (630) 852–0500
Fax: (630) 852–2120
info@lovejoy-inc.com
www.lovejoy-inc.com

IMTS 2012 Product Preview

ROLLON USA
Booth E-4351

Rollon USA has launched the ELM series of linear units, the first in the company's new family of Actuatorline products. The ELM series is available in several sizes, offering designers a range of stroke lengths, load capacities, and shuttling speeds to meet different application requirements. ELM units are made of anodized aluminum extrusions for high mechanical strength and low

weight, plus a steel-reinforced polyurethane timing belt with either an AT pitch or parabolic profile. All ELM units are equipped with polyurethane sealing strips to protect internal parts against dust and foreign matter, with an optional bellows for critical environments.

The ELM units feature a maintenance-free ball bearing guide fitted within the extruded body and offer speeds to 5 m/s, high load capacity and bending moments, low friction, and a service life of 20,000 km without re-lubrication. Body dimensions for ELM units measure from 50×50 mm to 110×110 mm and maximum axial loads range from 530 to 2,650 N, with stroke lengths from 100 to 3,700 mm, depending on the model. All units support loads in any direction and may be installed in any position.

Units may be fitted with a variety of drive systems based on application needs, with the driving pulley attached to the reduction gear shaft by a tapered coupling to ensure high accuracy and long life. Versions with a planetary gear are well suited to highly dynamic robotic, automation and material handling applications involving stress cycles and high-precision requirements. Standard models are available with clearance from 3 to 15 ft. and reduction ratios of 1:3 to 1:1,000. Versions with worm gears are suitable for applications involving low speeds and accelerations.

For applications where movement of two linear units in parallel is required, a synchronization kit is available for easy installation. Where multi-axis units are desired, a specialized set of fittings including brackets and cross plates connect ELM units to each other and to Robot units within the Actuatorline product family. Rollon Corporation will be located at booth E-4351 at IMTS.

For more information:
Rollon Corporation
101 Bilby Road. Suite B
Hackettstown, NJ 07840
Phone: (877) 976-5566
www.rollon.com

MOBIL INDUSTRIAL LUBRICANTS
Booth W-2504

ExxonMobil Lubricants and Petroleum Specialties, a division of Exxon Mobil Corporation ("ExxonMobil"), will showcase its range of expertly formulated machine shop lubricants that can offer potential energy efficiency benefits. ExxonMobil became the "Official Lubricant Supplier" for IMTS in 1960. "We look forward to once again serving as the Official Lubricant Supplier for IMTS and showcasing the range of performance benefits that our machine shop lubricants can provide," said David Scheetz, senior equipment builder engineer for ExxonMobil and former president for The Society of Tribologists and Lubrication Engineers (STLE). "As our customers seek new ways to improve their productivity and operational safety, as well as achieve increasingly aggressive sustainability targets, we are proud to offer Mobil-branded lubricants that are expertly formulated to deliver outstanding performance and can offer potential

energy efficiency benefits." A few of the key products from ExxonMobil's portfolio of machine shop lubricants that will be displayed at the company's IMTS booth, W2504, includes Mobil DTE 10 Excel, Mobil SHC 600 and Mobil SHC Gear. Based on test results, these oils have all earned ExxonMobil's official designation for industrial lubricants with energy efficiency benefits.

For more information:

Exxon Mobil Corporation
3225 Gallows Road
Fairfax, VA 22037
Phone: (703) 846-4467
www.mobilindustrial.com

IGUS

Booth E-5610

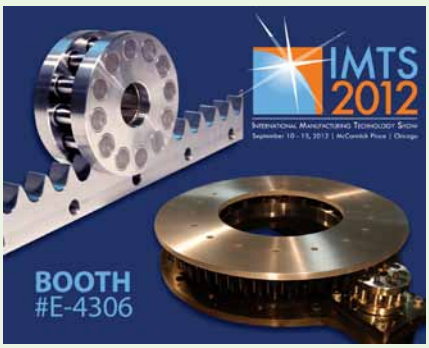
Igus has created an interactive booth where visitors can learn how to integrate a wide range of products to solve their most demanding manufacturing challenges. New products on show include new igus E4.1 Energy Chains and "e-spool", a direct replacement for cable drums. The company's IMTS theme for 2012 will be, "Improve Technology. Reduce Costs." Visitors to the company's booth will be able to experiment with interactive product displays, as well as take advantage of the company's free sample arrangement. Other noteworthy products to be displayed at the show include: plastic cable carriers with aluminum lids, and others with integrated rollers for exceptionally long travels, as well as new versions of igus' Triflex R multi-axis cable carriers for robots. Visitors to the show should also check out the company's Dry-Lin® slide tables and geared PRT slewing rings.

For more information:

Igus Inc.
PO Box 14349
East Providence, RI 02914
Phone: (800) 521-2747
www.igus.com

NEXEN GROUP

Booth E-4306



Nexen Group will be showcasing its innovative motion control products at the 2012 International Manufacturing Technology Show. This year, Nexen will be offering visitors an in-depth look at its latest Roller Pinion System (RPS) models, Precision Ring Drive (PRD) and will provide a preview of its new, first-of-its-kind technology. Specifically engineered to meet diverse and demanding motion control challenges, Nexen's RPS features a unique roller pinion/toothed rack combination that delivers high-accuracy positioning with zero backlash and virtually eliminates cumulative error. Constantly evolving in order to provide the widest range of high-quality motion control solutions, the RPS is offered in five distinct models, each 99 percent efficient, with low friction and minimal maintenance requirements. For indexing and rotary positioning applications, Nexen's PRD contains a roller pinion system that is 99 percent efficient and a gearbox that performs at a 96 percent efficiency rating for smooth, precise motion. Reaching speeds of 300 rpm and lasting for up to 60,000,000 revolutions, the PRD combines power, rigidity and durability to satisfy current industry demands for higher performance capacity at lower energy costs.

For more information:

Nexen Group, Inc.
560 Oak Grove Parkway
Vadnais Heights, Minnesota 55127
Phone: 651-484-5900
www.nexengroup.com

NACHI 2012 1962
50 years in America


Deep Groove Ball Bearings


High Efficiency Power Units


SG Drills


Specialty Materials


SRA 166/210 Robot

IMTS 2012
Booth W-2279

Nachi America Inc.
715 Pushville Road
Greenwood, Indiana 46143
317-530-1001

www.nachi.com

IMTS 2012

The following IMTS exhibitors are suppliers of products or services that may be of interest to buyers of power transmission and motion control components. The booth numbers include a letter (N=North, S=South, E=East, W=West) indicating a booth's building location.

Alphabetical Listings

COMPANY	BOOTH
Aerotech Inc.	N-6460
All World Machinery Supply	E-5026
Andantex USA Inc.	N-6035
Argo-Hytos Inc.	E-4438
Atlanta Drive Systems Inc.	N-6420
B&R Industrial Automation	E-4201
Baker Bearing Co.	N-6788
Baldor Electric Co.	E-5748
Baumueller-Nuermont Corp.	E-4115
Beckhoff Automation	E-4271
Boca Bearing Co.	N-6892
Bosch Rexroth Corp.	E-5030
CGI Motion	E-5080
Chieftek Precision Co.	E-4661
Concept Systems Inc.	E-4180
Delta Computer Systems Inc.	E-4403
Deutschmann Automation GmbH	E-4490
DMM Technology Corp.	E-4464
Dontyne Systems	N-6791
Dreisilker Electric Motors	E-5755
Edgewater Automation	E-4130
Elmo Motion Control	E-4588
EMA Electronics Corp.	E-4000
ErlinkKlinger Kunstofftechnik GmbH	E-4095
ETEL Inc.	E-5358
EZO SPB-USA LLC	E-4443
Fagor Automation Corp.	E-5230
Flair Industry Accessory Co. Ltd.	W-1085
Fraba Inc./Posital	E-4185
GBSA Inc.	N-6489
Gear Technology magazine	N-7148
GMN USA	N-7175
Halifax Rack & Screw-North America	N-6789
Harbin Bearing Manufacturing Co. Ltd.	E-4566
Hawe Hydraulics	E-4436
Heidenhain Corp.	E-5224
Hirschmann Engineering USA Inc.	E-5112
Hiwin Corp.	E-5040
Hoover Precision Products Inc.	N-7080
Houghton International	W-2382
Hunger Hydraulics	E-4407
IC Flow Controls Inc.	E-4401
IC Fluid Power Inc.	E-4405
IFPE Fluid Power Zone	E-4434
Igus Inc.	E-5610
IKO International	E-5685
Industry Controls Inc.	E-4445
Iraundi S.A.	E-4060
Isutami USA Inc.	E-4105
Jakob Antriebstechnik GmbH	W-1779
K+S Services Inc.	E-5151
LFK Bearing (America) Co. Ltd.	N-6481
Luoyang Bearing Science and Technology Co. Ltd.	W-1958, N-7186
Micromatic LLC	E-4070
Mijno Precision Gearing	N-7227
Mitutoyo America Corp.	E-5214
Nachi America Inc.	W-2279
Napoleon Engineering Services	E-5803
NB Corporation of America	E-5558
Nexen Group Inc.	E-4306
Nook Industries	E-5080
NSK Americas	E-5145
Oelheld U.S. Inc.	N-6668
Oerlikon Balzers AG	W-2283
Power Transmission Engineering magazine	N-7148
Promess Inc.	E-5076
Quality Bearings & Components	E-4085
Real Time Automation Inc.	E-4191
Revere Control Systems	E-4165
Rollon Corp.	E-4351
Rotomag Motors & Controls Pvt. Ltd.	E-4065
Schaeffler Group USA	E-5157
Schneeberger Inc.	E-5640
Setco	N-6520
Siemens Industry Inc.	E-5010
SKF USA	E-5842
Smalley Steel Ring Co.	N-6300
Sommer Automatic Inc.	E-4456
Steinmeyer Inc.	E-5751
Suhner Industrial Products	W-1073
The Timken Co.	N-7190
VDMA	E-4090
Vinko Auto Industries Ltd.	E-4080
Von Ruden Manufacturing Inc.	W-1306
Wangfangdian Industry Metallurgical Bearing Manufacture Co.	N-6590
WD Bearing America	N-7089
Wittenstein	E-5386
Yaskawa America Inc.	E-4140, N-6600

Listings by Booth Number

COMPANY	BOOTH
EMA Electronics Corp.	E-4000
Iraundi S.A.	E-4060
Rotomag Motors & Controls Pvt. Ltd.	E-4065
Micromatic LLC	E-4070
Vinko Auto Industries Ltd.	E-4080
Quality Bearings & Components	E-4085
VDMA	E-4090
ErlinkKlinger Kunstofftechnik GmbH	E-4095
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Edgewater Automation	E-4130
Yaskawa America Inc.	E-4140
Revere Control Systems	E-4165
Concept Systems Inc.	E-4180
Fraba Inc./Posital	E-4185
Real Time Automation Inc.	E-4191
B&R Industrial Automation	E-4201
Beckhoff Automation	E-4271
Nexen Group Inc.	E-4306
Rollon Corp.	E-4351

COMPANY	BOOTH
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Delta Computer Systems Inc.	E-4403
IC Fluid Power Inc.	E-4405
Hunger Hydraulics	E-4407
IFPE Fluid Power Zone	E-4434
Hawe Hydraulics	E-4436
Argo-Hytos Inc.	E-4438
EZO SPB-USA LLC	E-4443
Industry Controls Inc.	E-4445
Sommer Automatic Inc.	E-4456
DMM Technology Corp.	E-4464
Deutschmann Automation GmbH	E-4490
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Hiwin Corp.	E-5040
Promess Inc.	E-5076
CGI Motion	E-5080
Nook Industries	E-5080
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K+S Services Inc.	E-5151
Schaeffler Group USA	E-5157
Mitutoyo America Corp.	E-5214
Heidenhain Corp.	E-5224
Fagor Automation Corp.	E-5230
ETEL Inc.	E-5358
Wittenstein	E-5386
NB Corporation of America	E-5558
Igus Inc.	E-5610
Schneeberger Inc.	E-5640
IKO International	E-5685
Baldor Electric Co.	E-5748
Steinmeyer Inc.	E-5751
Dreisilker Electric Motors	E-5755
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SKF USA	E-5842
Andantex USA Inc.	N-6035
Smalley Steel Ring Co.	N-6300
Atlanta Drive Systems Inc.	N-6420
Aerotech Inc.	N-6460
LFK Bearing (America) Co. Ltd.	N-6481
GBSA Inc.	N-6489
Setco	N-6520
Wangfangdian Industry Metallurgical Bearing Manufacture Co.	N-6590
Yaskawa America Inc.	N-6600
Oelheld U.S. Inc.	N-6668
Baker Bearing Co.	N-6788
Halifax Rack & Screw-North America	N-6789
Dontyne Systems	N-6791
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Flair Industry Accessory Co. Ltd.	W-1085
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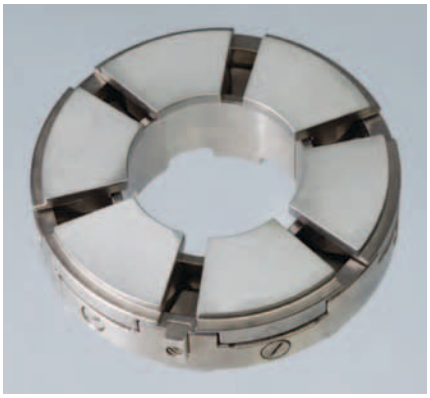


The Kingsbury EQH equalizing thrust bearing is the product of many years of design refinement and application experience. Based on Albert Kingsbury's original hydrodynamic bearing design, this example is just one of many tilting-pad thrust bearings manufactured by Kingsbury

QUESTION

Regarding bearings for a gearbox—between a gas turbine—13 MW@8,000 rpm—and a centrifugal compressor—11 MW@12,000 rpm: Can we use sleeve bearings instead of tilting pad bearings for radial bearings?

Rosli Abu Bakar, mechanical engineer
Worley Parsons

EXPERT NO. 1

The answer is that every application needs to be separately analyzed. In real machinery, steady-state conditions do not exist. There is relative motion between the fluid film bearing and the shaft as in starting, in stopping or changing the bearing load suddenly. Changes in bearing loads may result from meshing gears, engaging clutches, etc., or may be periodic as in reciprocating machinery. In addition, rotating loads superimposed on unidirectional loads result from shaft unbalance. The other issue is that whirl of the shaft can result in half-frequency whirl and loss of the hydrodynamic film thickness separating the shaft from the bearing and failure of the operating system.

My guess is that the original design using the tilting pad bearing was based on inhibiting whirl in the bearing system as a real or anticipated problem. My recommendation is if the system is working and not causing a problem by using the tilting pad bearing, continue to use it. However, if a straight sleeve bearing is to be substituted in the application, the entire system needs to be analyzed including a heat balance if the bearing behavior is to be predicted with any accuracy. In summary, you cannot substitute one bearing type for another without performing an engineering design analysis and parametrically testing the new design.

Bottom line: *Don't* fix it if it is not broke."

Erv Zaretsky

Erwin V. Zaretsky, *noted lecturer, writer and consultant to both government and industry, has over 45 years of experience in mechanical engineering related to rotating machinery and tribology. He has conducted pioneering research in rolling element fatigue, lubrication and probabilistic life prediction, with that work resulting in the first successful three million DN bearing and four IR–100 awards. Zaretsky, now retired from his position as chief engineer for materials and structures at Cleveland-based NASA Glenn Research Center, previously served as head of the NASA Bearing, Gearing and Transmission Section, with responsibility for most of the NASA mechanical component research for air-breathing engines and helicopter transmissions. Zaretsky has penned scores of technical papers and books, and has lectured extensively around the world.*

EXPERT NO. 2

Yes, it is possible to use sleeve bearings for this. Bearing selection for an application such as this—or any other—depends on a number of factors and desired performance results. Some of those include:

- Rotor-dynamic performance and stability
- Pad temperature limits
- Misalignment capabilities and requirements
- Overall safety margin

Tilting pad bearings generally outperform sleeve bearings in all of these categories, but are more expensive, larger in size, and may require more oil flow. A bearing expert can determine which bearing is most suitable, based on the requirements of the application.

Joseph Wilkes,
vice-president engineering
Kingsbury, Inc.

Joseph J. Wilkes, *Kingsbury vice president of engineering, is currently responsible for overseeing all aspects of the engineering department, including bearing design, analysis, troubleshooting, research and development, and testing. Wilkes has traveled around the world to give technical presentations and troubleshoot bearing problems. Prior to the 20 years he has worked at Kingsbury, Wilkes worked 10 years for Philadelphia Gear Corp., progressing to the position of manager of high-speed engineering.*

CALLING ALL EXPERTS

If you have expertise in a power transmission related field, and you are interested in participating in this column, we would welcome your contribution. Just send a note to Jack McGuinn, senior editor *(jmcguinn@powertransmission.com)*, outlining the subjects you'd feel comfortable covering. We'll send you some questions!

Wear-Resistant Bearings

Gary L. Doll and Michael N. Kotzalas

Reprinted courtesy The Timken Company

Management Summary

Since the late 1990s, the Timken Company has employed surface engineering technologies on bearing rollers to provide wear resistance and friction reduction to demanding customer applications. More than a decade of intensive research and development has resulted in two new technologies that, when used in combination, expand the performance of rolling element bearings well beyond previous limits.

Timken's new surface engineering technologies were not developed to be temporary fixes, but were instead designed to address the root causes of the mechanisms responsible for life-limiting bearing wear. When rolling elements with these surface engineering technologies are incorporated into roller bearings, the bearing assembly is referred to as a Timken wear-resistant bearing.

Surface engineering. Surface engineering is the practice of altering the chemical and/or topographical properties of the surface of a component or device. Timken has previously shown that an engineered surface, which has worked well at reducing wear in rolling element bearings, is a metal-containing diamond-like carbon coating applied to super-finished rolling elements (Refs. 1–2). It is sometimes beneficial to consider real surfaces as having roughness on different length scales. So, whereas, quantities—such as Ra and Rq—describe longer length roughness characteristics, shorter length roughness is better quantified by a quantity such as asperity slope Δq.

A standard finish on a rolling element—typically one that has been ground and honed— produces a surface with a long-length scale roughness that in cross-section resembles the illustration labeled as "Standard" (Fig. 1). Ra and Rq values of 100 nm and 140 nm, respectively, are commonly measured on these surfaces. An illustration of a surface produced by a super-finishing process is also shown (Fig. 1).

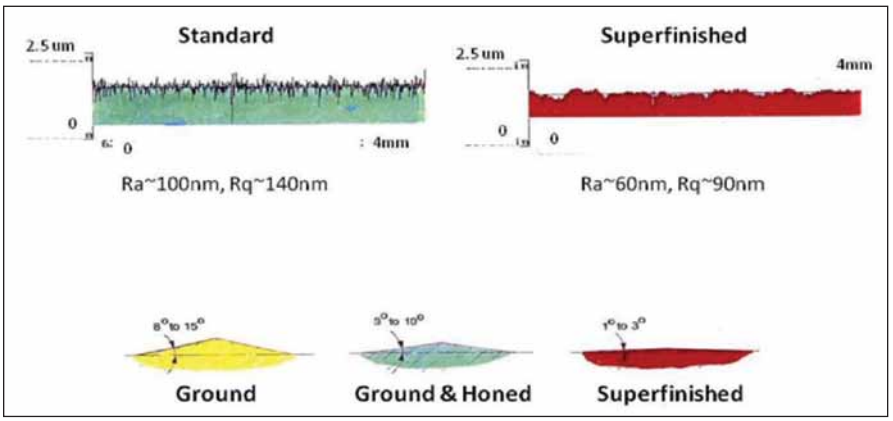


Figure 1—Roughness characteristics of finished rollers.

These surfaces have typical Ra and Rq values of 60 nm and 90 nm, respectively. Surfaces with smaller Ra and Rq values promote greater separation of contacting surfaces and larger load-bearing capabilities that produce a more desirable distribution of contact stresses in the material than surfaces produced by standard finishing processes.

Analysis of the short-length scale roughness from measurements of ground, ground + honed, and superfinished surfaces yields average asperity slopes (Fig. 1). Because asperity interactions in contacting surfaces play an important role in wear modes—micropitting and smearing, for example—the smaller the asperity slope, the smaller the interaction.

A super-finishing process described by Hashimoto, et al. (Ref. 3) can produce surfaces such as that shown (Fig. 2), in which most of the traditional machining features have been removed. For comparison purposes, a standard surface that has been ground and honed is also shown. 3-D topographical profiles of each surface obtained by a white light interferometer microscope are shown below the optical images.

Super-finished surfaces are especially beneficial to mechanical components operating in boundary layer lubrication because the opportunities for asperity interactions in the contact areas are greatly reduced.

Metal-containing, diamond-like carbon (DLC) coatings were first developed by Dimigen (Ref. 4). Later, these materials were found to be nanocomposites consisting of metal carbide pre-

cipitates in amorphous hydrocarbon matrices (Ref. 5). Since tungsten containing diamond-like (W-DLC) coatings can usually be deposited at temperatures below the tempering points of engineering steels, they are currently utilized in many mechanical applications (Ref. 6). Generally, W-DLC coatings are two to three times harder than steel, use Cr adhesion layers, are less than three micrometers thick and have low friction coefficients when sliding against steel.

Like some other bearing manufacturers, Timken has used commercial coatings, such as W-DLC, for many years to provide wear resistance to rolling element bearings. For example, W-DLC coatings have been successfully used as barriers to the adhesive wear mechanisms that cause false brinelling and smearing in roller bearings. However, in boundary layer lubricated environments, W-DLC coatings have not exhibited the durability to remain intact for the entirety of a bearing's predicted life.

The lubrication environment that a bearing or other mechanical device operates in is commonly defined in terms of the dimensionless parameter Λ which is the ratio of the lubricant film thickness to the composite surface roughness of the contacting surfaces. Fatigue life testing was performed on tapered roller bearings with a commercial W-DLC coating applied to the rollers. A standard test protocol was used where bearings were operated at 150%-rated load, based upon 90 million revolutions, in a $\Lambda = 0.5$ lubrication regime, and in non-additized oil. Although the bearings with W-DLC coatings achieve their predicted lives at this lambda value, the W-DLC coatings on the rollers exhibited non-uniform wear. Images of the bodies and ends of these rollers are shown (Fig. 3). Whereas the coatings are still strongly adhered to the steel, fracture within the coating has generated non-uniform wear. Since the W-DLC is much harder than bearing steel, uneven wear of the roller coating is detrimental to the raceway surfaces.

After a detailed investigation probing the microstructures of W-DLC coatings, Timken was able to identify the defect in W-DLC responsible for the fracture-type wear and eliminate it through an optimization of the coating deposition process conditions. Bearings equipped with rollers with Timken's new coating were tested to their fatigue limits with the standard life test protocol described above. Rollers removed from the bearings at the end of the serviceable life of the bearing are also shown (Fig. 3). No visible coating wear is observed on either roller bodies or ends. Furthermore, coating thickness measurements performed prior and subsequent to the fatigue life tests are the same within the capabilities of the measurement system. This indicates that no measurable wear of the coating has occurred in this highly loaded, low lambda bearing environment.

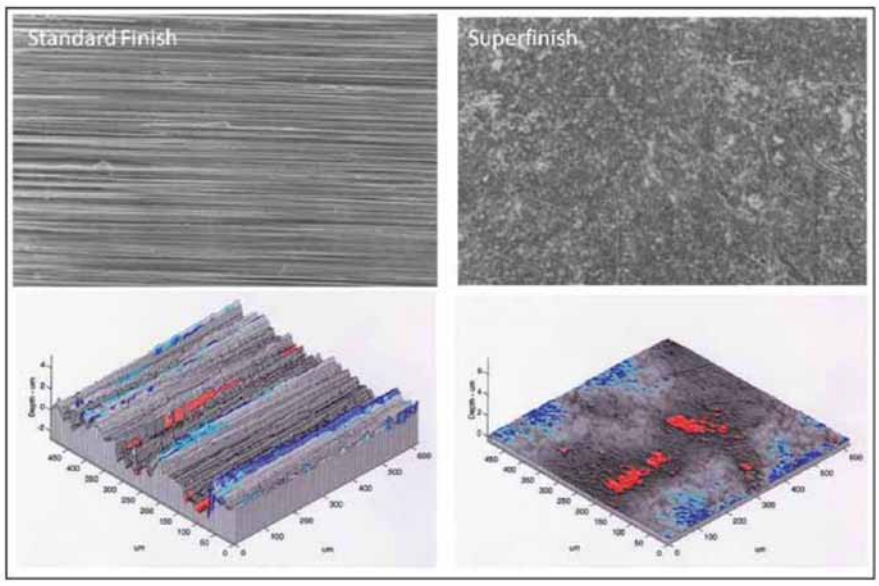


Figure 2—Optical images and their corresponding 3-D profiles of roller surfaces generated by standard (ground and honed) and super-finished processes.

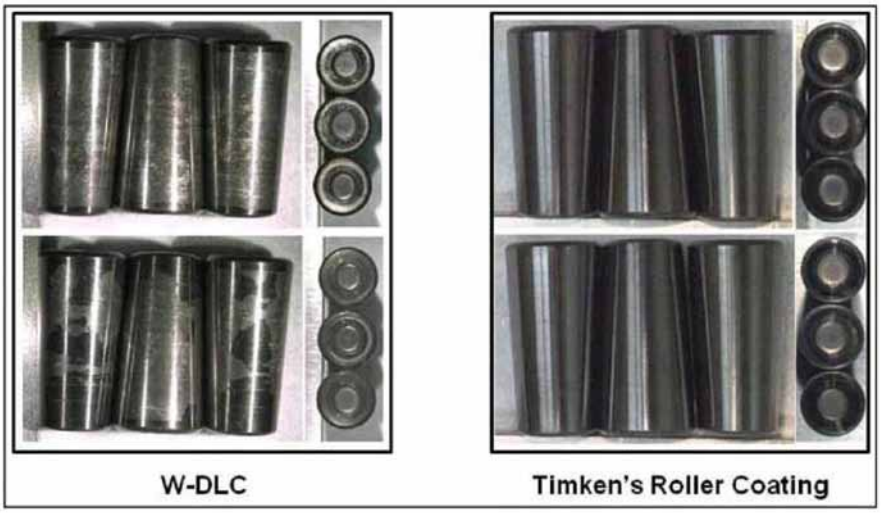


Figure 3—Comparison of the durability of commercial W-DLC and Timken's new roller coating.

Wear resistance of bearings with engineered roller surfaces. One of the life-limiting wear issues affecting main shaft and gearbox bearings in wind turbine generators is micropitting. Micropitting is caused by interaction of the raceway and roller residual finishing marks, or asperities, leading to high surface stresses in the contact. Normal stress alone is not typically sufficient to cause a crack to initiate at or very near the surface early in the lifecycle of a bearing. However, the addition of frictional shear stress increases the bulk contact stress values and brings the maximum values closer to the surface—as shown by Harris and Yu (Ref. 7)—allowing these localized stresses under the asperity contacts to become significant. This type of interac-

tion typically occurs when the lubricant film is insufficiently thick to separate the contacts and when there is relative sliding between the two contacting surfaces (Refs. 8–11).

Low-cycle micropitting is caused by high amounts of sliding between rollers and ring raceways, generating considerable shear stresses in the contact zone. From the viewpoint of an element-of-area on a ring raceway, the cyclic shear stresses imparted by each passing roller ultimately generate micro-cracks that propagate in the direction of the sliding shear stress on the slower moving component (Refs. 12–13). As these micro-cracks propagate, pieces of the raceway begin to break away from the surface, leaving micrometer-size pits.

The evolution of low-cycle micropitting to raceway spalling of a 230/600 main-shaft spherical roller bearing is shown (Fig. 4). Figure 4-A shows the onset of micropitting, where two distinct wear tracks have emerged in the center of the raceway. As the micropitting continues, more and more material is worn away, leading to a loss of the design contact geometry in the center and increasingly higher stress concentrations at the edges of the wear track. Fatigue spalls initiate at these areas of high geometric stress concentrations and propagate on raceways like that shown in Figure 4-B.

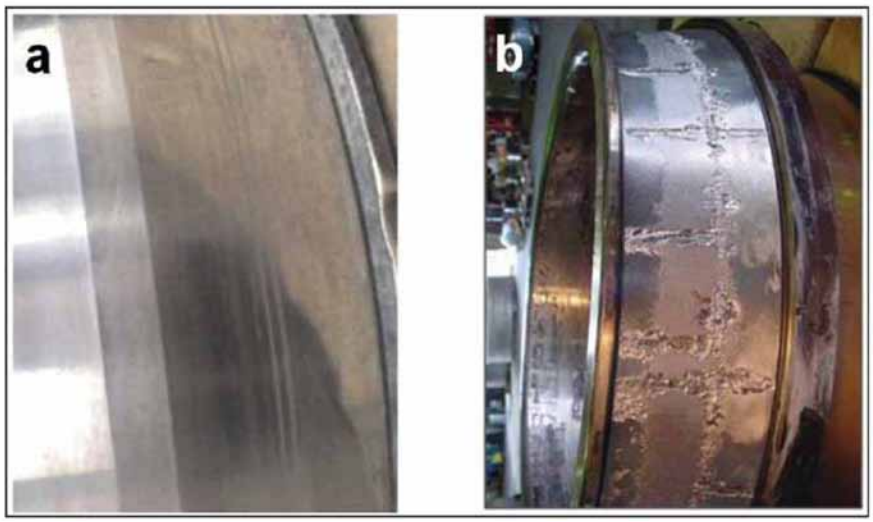


Figure 4—(A) Onset of micropitting leading to failure of a (B) wind turbine main-shaft spherical roller bearing.

Figure 5—Debris-damaged spherical roller bearings after fatigue life testing in low-lambda. Although micropitting is clearly evident on the ring raceways that ran against uncoated steel rollers, no micropitting occurred on the raceways running against rollers with Timken's engineered surfaces.

The raceway spalling of these bearings is not due to classic surface-initiated or inclusion-related fatigue on which the predicted bearing life is calculated, but is due instead to the loss of the designed contact geometry due to micropitting wear and a concomitant increase in geometric stress concentrations at the edges of the roller/raceway contact. Since there exists a high amount of sliding between the rollers and raceways in a spherical roller bearing, it is not unusual to observe micropitting wear of these bearings in low-lambda conditions. For example, images of spherical roller bearing raceways that have been fatigue life tested at low lambda (Λ~0.5) are shown (Fig. 5).

To stimulate early fatigue, both bearings were deliberately damaged with steel debris prior to life testing. The top image shows a raceway that ran against uncoated steel rollers, with the gray band of micropitting clearly visible. No indication of micropitting is observed on the raceway in the bottom image that ran against rollers with Timken's engineered surfaces. Clearly, a significant reduction in the shear stresses between rolling elements and ring raceways can eliminate the mechanisms responsible for low-cycle micropitting in roller bearings.

Another wear mode that damages bearings in applications like wind turbine gearboxes is smearing. Like micropitting, smearing in bearings also occurs when rollers are skidding against raceways in low-lambda conditions. But, whereas micropitting is a microscopic surface fatigue mechanism, smearing occurs when the heat from the friction between the sliding rollers and the raceways generates local temperatures in the contact zone high enough to melt the steel surfaces. The large-scale plasticization and localized melting generates a smeared appearance on the raceway surface. FeO is sometimes found in the smeared wear patch, which indicates that the local temperature in the contact zone exceeded ~550 °C.

A simple bench test has been performed to demonstrate the ability of

Timken's engineered surface (ES) to inhibit smearing or scuffing-type wear. In this test, two highly loaded steel rings were placed into contact with 150% slide/roll ratio and the lubricant entrainment velocity was reduced in stages until a spike in the frictional torque was observed. In one experiment untreated steel rings were used; in the other, a steel ring with an engineered surface was run against an as-ground ring. Images of the ring pairs are displayed (Fig. 6).

The pair of as-ground steel rings experienced smearing wear that progressed very rapidly to galling. However, since no frictional torque spike was observed while the ES-treated ring ran against the as-ground steel ring, it is concluded that smearing wear did not occur within the load and speed limits of this experiment. Examination of the ES-treated ring surface indicates no visual signs of wear. Since no smearing occurred when the ES-treated ring ran against the as-ground steel ring, the frictional heating at that interface must have been considerably lower than in the contact zone of the untreated steel rings.

Debris damage is another wear mode known to affect bearing life. As indicated (Fig. 5), the debris damage of the spherical roller bearings made from through-hardened AISI 52100 reduced the actual life of the bearings with untreated rollers by between 30–40%. However, the same debris damage on an identical spherical roller bearing with ES-treated rollers suffered no statistical reduction in life.

Another laboratory-scale test was constructed to quantify effects of debris damage on the actual lives of case-carburized tapered roller bearings. In this test, bearings were rotated under load for a specific duration in AISI 52100 debris-laden oil. The debris particle sizes were between 25 and 53 µm with a 0.5 mg/ml concentration in the SAE 10-weight lubricant. Next, the bearings were solvent cleaned to remove the debris. Finally, the bearings were life-tested using a first-in-four failure criterion in clean SAE 10-weight oil.

Statistically significant populations of bearings with untreated rollers and bearings with ES-treated rollers were tested. Results of those tests are shown (Fig. 7) where the L_{16} values and upper

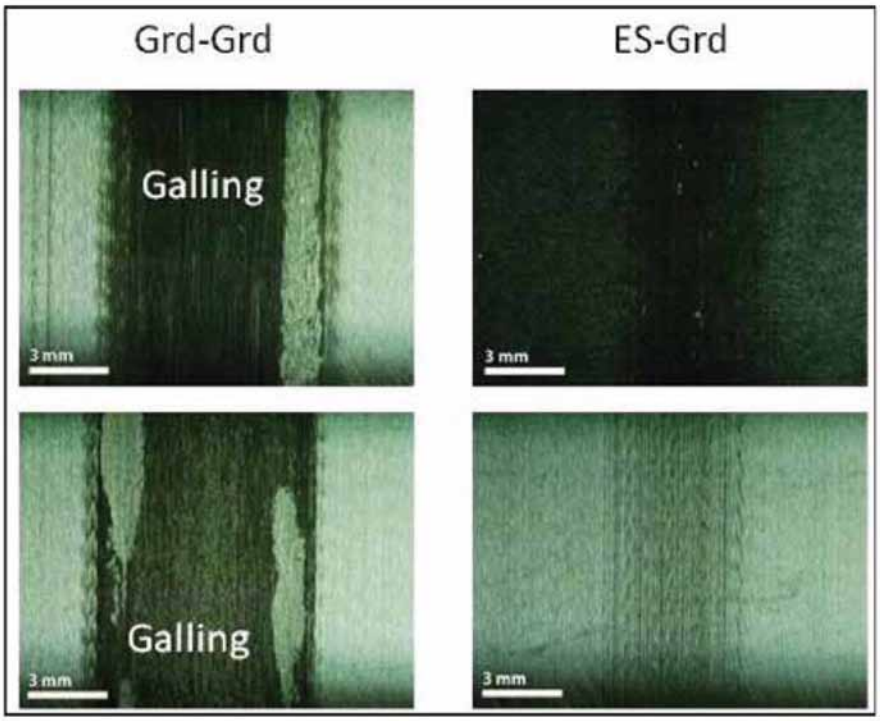


Figure 6—Smearing wear testing of ground steel surfaces against steel and ES-treated surfaces.

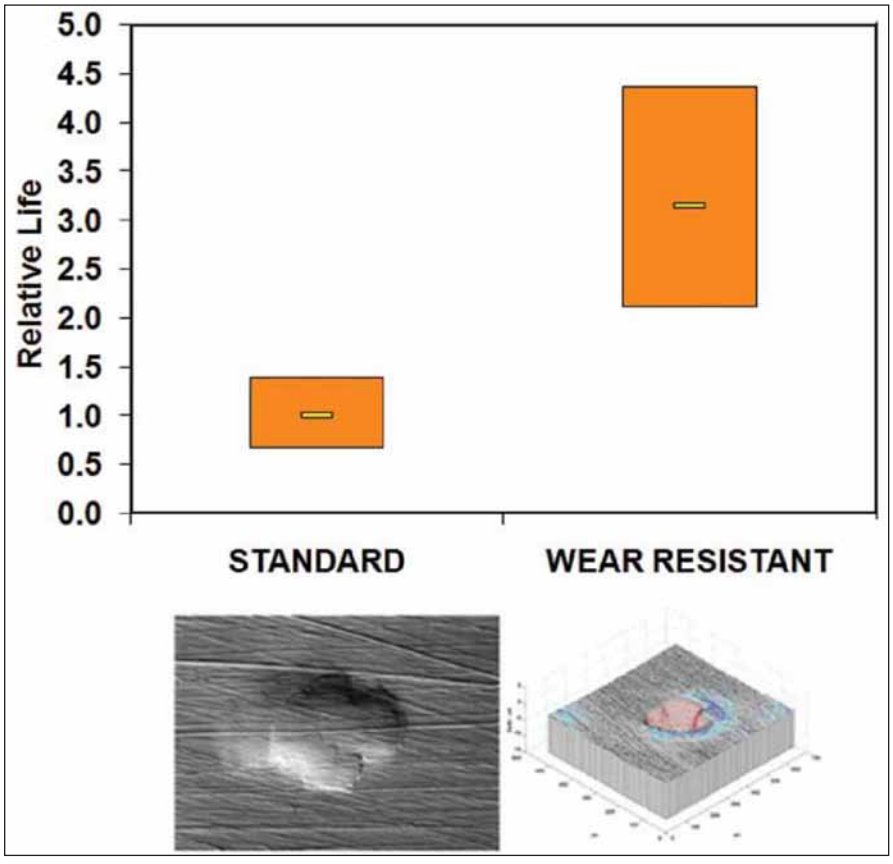


Figure 7—Life test results of debris-damaged, case-carburized standard and wear-resistant tapered roller bearings. Al so shown: (left) optical image of a debris dent in a raceway and (right) a 3-D surface profile of that dent showing raised crater rims resulting from plastic flow of the steel during the creation of the dent.

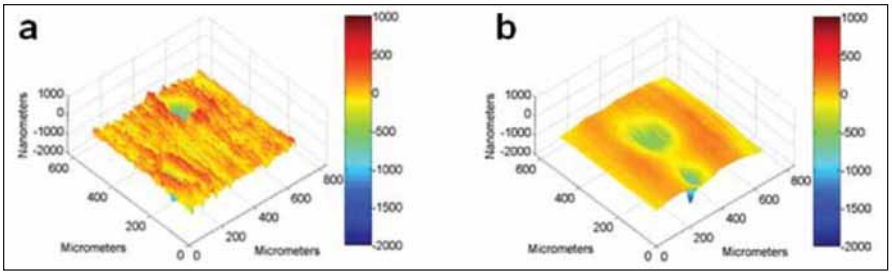


Figure 8—3-D profile topographies of debris dents on bearing raceways measured after life testing. The image of the debris dent in "A" is from a raceway that ran against untreated steel rollers, and shows that the raised edges around the crater formed from the debris are still in place. On the other hand, the image of the debris dent in "B" is from a raceway that ran against ES-treated rollers. All traces of the raised edges have been removed, as have the residual grinding lines. It is the ability of the ES-treated rollers' ability to remove the raised edges around debris craters that negates the fatigue life-reducing mechanism associated with debris-damaged raceways.

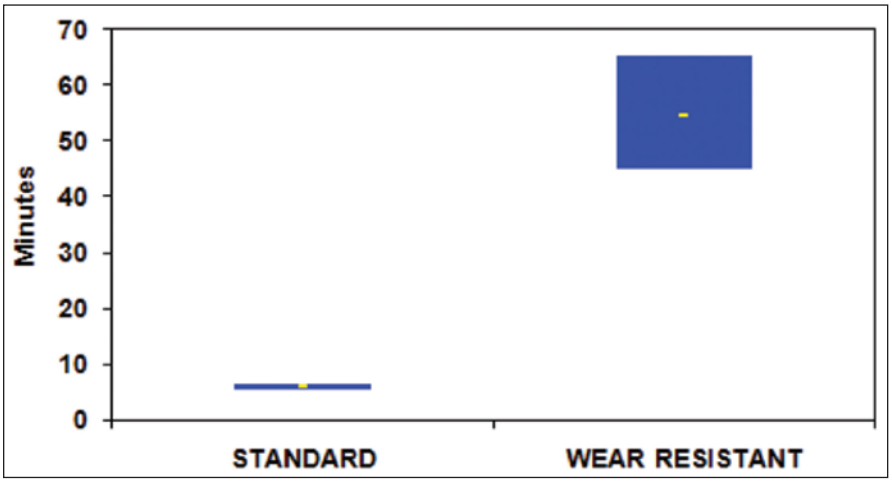


Figure 9—Results of a lubricant starvation test on tapered roller bearings with standard rollers and ES-treated roller ends. The ES treatments on the roller-ends provided a barrier to the adhesive wear that causes scuffing and scoring, and allowed the bearings to operate under full loads and speeds approximately nine times longer than identical bearings with standard rollers.

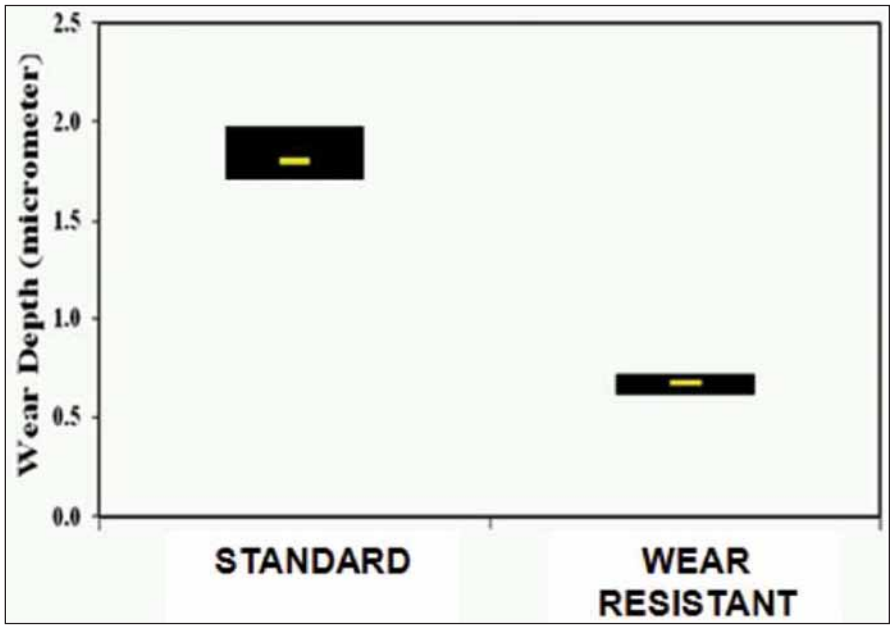


Figure 10—Result of a bench test designed to evaluate the ability of ES-treated rollers to address the adhesive wear that causes false brinelling. Unlike standard bearings, wear-resistant bearings with ES-treated rollers did not exhibit wear from false brinelling.

and lower 65% confidence bands (tops and bottoms of the bars) are normalized to the baseline test results. Since the fracture toughness of case-carburized steel is two to three times that of through-hardened steel (Ref. 14), the reduction in the lives of (equivalent) case-carburized bearings due to debris damage is less than that of through-hardened bearings. Also shown in the figure is an optical image of a debris dent in a bearing raceway and a 3-D surface profile of the dent. Statistically, the bearings with the ES-treated rollers had an L_{16} life more than three times greater than the life of identical bearings with untreated rollers.

The mechanism by which ES-treated rollers make bearings tolerant to debris damage is clearly illustrated (Fig. 8). The image of the debris dent (Fig. 8-A) is from a raceway that ran against untreated steel rollers and shows that the raised edges around the crater formed from the debris are still in place. On the other hand, the image of the debris dent (Fig. 8-B) is from a raceway that ran against ES-treated rollers. All traces of the raised edges have been removed as have the residual grinding lines. It is the ability of the ES-treated rollers to remove the raised edges around debris craters that negates the fatigue-life-reducing mechanism associated with debris-damaged raceways.

Due to large entrainment velocities, thick lubricant films usually exist at the rib-roller end-sliding contact of a tapered roller bearing. Situations occasionally occur where the lubricant film at this interface is insufficient to separate the asperities of the roller end and rib face. In these situations, adhesive wear between the asperities can lead to scuffing, scoring and, eventually, galling. Examples of situations where this adhesive wear can occur include the use of ultra-low-viscosity lubricants, large axial loads, highly loaded high-speed operation and lubricant interruption or loss.

A laboratory test was devised to measure the resistance to rib-roller end-failure of tapered roller bearings with ES-treated roller ends. The test was designed to mimic a field condition where bearings in gearboxes experienced an extended lubrication loss condition. Test bearings were immersed in

a solution containing 80% hexane and 20% GL-5 gear oil. Upon removal from the solution, the hexane was allowed to evaporate, leaving behind a thin oil film on the bearing surfaces.

Figure 9 displays the time to rib-roller end scuffing for bearings with and without ES-treated roller ends. At least 25 bearings were tested for each condition; results were analyzed using first-in-one Weibull statistics and 90% confidence bands were calculated around L50 lives. Whereas uncoated baseline bearings had an L50 value of about six minutes, bearings with ES-treated roller ends had L50 values of about 50 minutes.

The ES treatments on the roller ends provided a barrier to the adhesive wear that causes scuffing and scoring, thus allowing the bearings to operate under full loads and speeds of up to nine times longer than identical bearings with standard rollers. Wear-resistant bearings with ES-treated rollers are currently being used in the metal forming and agricultural industries, as well as in flight-critical aerospace systems.

False brinelling or fretting is an adhesive wear mechanism that can occur between rolling elements and races whenever a non-rotating bearing is subjected to external vibration. Under these conditions lubricant is squeezed from between the contacts and the relative motion of the surfaces is too small for the lubricant to be replenished. Natural oxide films that normally protect steel surfaces are removed, permitting metal-to-metal contact and causing adhesion of surface asperities.

Fretting begins with an incubation period during which the wear mechanism is mild adhesion and the wear debris is magnetite (Fe_3O_4). Damage during this incubation period is referred to as false brinelling. If wear debris accumulates in amounts sufficient to inhibit lubricant from reaching the contact, then the wear mechanism becomes severe adhesion that breaks through the natural oxide layer and forms strong welds with the steel. In this situation the wear rate increases dramatically and damage escalates to fretting corrosion. Relative motion breaks welded asperities and generates hematite (α-Fe_2O_3)—a fine powder, reddish-brown in color.

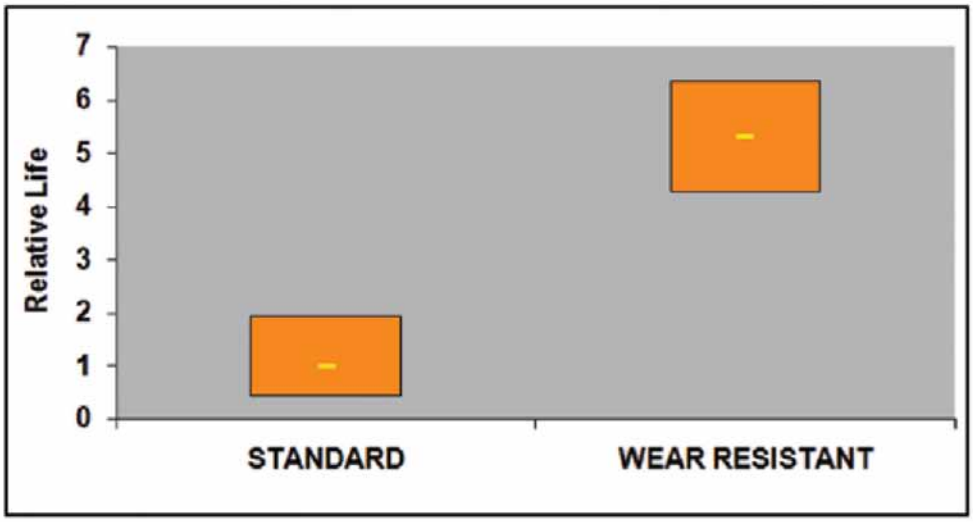


Figure 11—Results of life testing of standard bearings and wear-resistant bearings with ES-treated rollers in a low-lambda lubrication environment. The relative life of wear-resistant bearings is more than three times greater than standard bearings at $\Lambda = 0.5$ lubrication conditions.

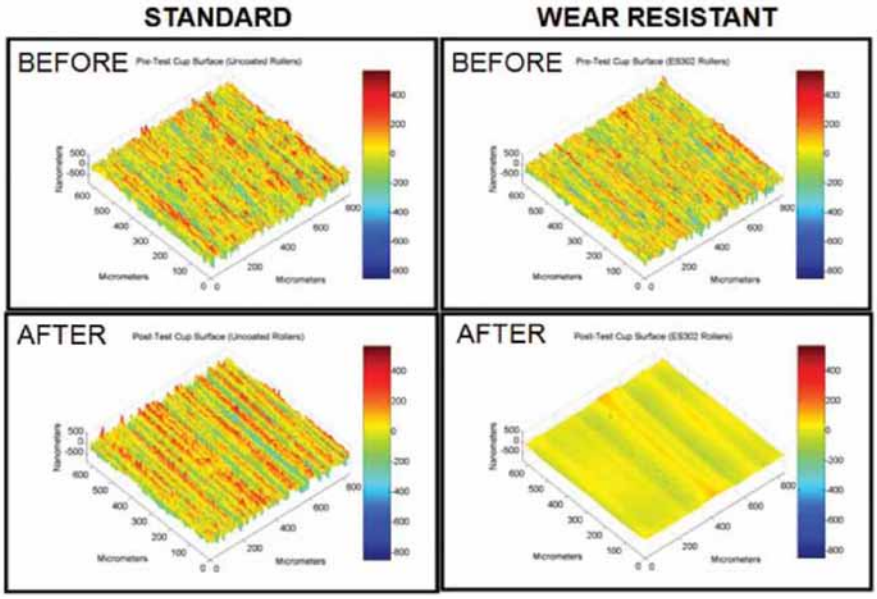


Figure 12—3-D topographical profiles of standard and wear-resistant bearing raceway surfaces before and after completing 44 million revolutions at 150%-rated loads.

A laboratory-scale testing apparatus was designed to evaluate the ability of ES-treated rollers to inhibit false brinelling in bearings. Standard bearings with steel rollers and wear-resistant bearings with ES-treated rollers were tested. All bearings were lubricated with GL-4 transmission gear oil before testing. The test apparatus applied an oscillating 18.7 kN axial load to the bearings for 500,000 oscillations—conditions identical to a bearing application that experienced false brinelling in the field.

Subsequent to testing, depths of the grooves produced on the outer race were measured. Figure 10 displays the average wear depths and standard deviations for the standard and wear-resistant bearings. After testing, the standard bearings exhibited grooves on the raceways with average depths of 1.85 µm. On the other hand, the wear-resistant bearings had average groove depths of only 0.68 µm. The wear of the raceway oscillating against the ES-treated rollers was very slight and appeared to be caused by gentle lapping rather than adhesive wear.

Examples of applications that use wear-resistant bearings to eliminate false brinelling include off-road truck

transmissions, rolling mills, tractors and wind turbines.

Low Λ fatigue life of bearings with engineered roller surfaces. Bearings have generally been selected according to the dynamic and static load ratings. The dynamic load rating C_1 is a measure of the bearing's ability to withstand rolling contact fatigue, which by typical industry practice is according to the ISO load and life rating standard (Ref. 15). The static load rating C_0 is a measure of the bearing's ability to withstand the maximum-applied load without function-reducing, permanent deformations or bearing ring destruction according to ISO standard 76 (Ref. 16). The dynamic load rating is used in the ISO 281 standard life rating equation for roller bearings:

$$Lnm = a_1 a_{ISO} \left(\frac{C_1}{P} \right)^{10.3} \quad (1)$$

where:

a_1 is the life modification factor for reliability,

a_{ISO} is the integrated life modification factor accounting for material, lubrication and hard particle contamination,

and L_{nm} is the modified rating life in millions of revolutions.

Nominally, roller bearing endurance is calculated as L_{10}, the rolling contact fatigue life in millions of revolutions that 90% of the bearings will survive. Detailed calculations to predict a_{ISO} are given by Harris, et al. (Ref. 17) and indicate that if a roller bearing is operated in low-lambda conditions ($\Lambda<1$), a_{ISO} and L_{10} become small.

Full-scale life testing has been performed on standard and wear-resistant bearings with ES-treated rollers in Λ 0.5 conditions. All bearings were life-tested using a first-in-four failure criterion in clean SAE 10-weight oil at 150%-rated load at 90 million cycles. Statistically significant populations of standard and wear-resistant bearings were tested. Results of the $\Lambda = 0.5$ tests are shown (Fig. 11) where the L_{16} values and upper and lower 65% confidence bands (tops and bottoms of the bars) are normalized to the standard bearing test results.

As indicated (Fig. 11), the relative L_{16} life of the wear-resistant bearing with ES-treated rollers is more than five times that of a standard bearing operating in low-lambda conditions.

The mechanism by which this large boost in low lambda bearing life is achieved is revealed in an examination of the 3-D topographic profiles of the raceway surfaces in Figure 12. In the low- lambda life test described above, one standard and one wear-resistant bearing were removed from testing after about 44 million cycles, and the raceways of the outer rings were measured by 3-D optical profilometry. Whereas the topography of the raceway of the standard bearing remained essentially unchanged after 44 million cycles, the raceway of the wear-resistant bearing has been highly polished.

Calculations based upon this highly polished surface and the Hamrock-Dowson (Ref. 18) lubricant film thickness yield a lambda value greater than two. Therefore, although the lambda value calculated from the initial surface parameters was 0.5, the ES-treated rollers have dramatically polished the raceways such that the wear-resistant bearing is effectively operating in an elastohydrodynamic Λ~2 regime.

Summary

Table 1 summarizes the application advantages of wear-resistant bearings with ES-treated rollers. Since bearings seldom operate in fully lubricated environments, they rarely experience the number of cycles for which they were designed. In low-lambda situations the ES-treated rollers in wear-resistant bearings polish the ring raceways— effectively increasing the separation of the contacting asperities. This polishing action continues until the contacts are fully separated by the lubricant film and the bearing is no longer operating in a low-lambda situation.

Interruption of the supply of lubricant to bearings can result in adhesive wear between the rollers and contacting surfaces on rings. Depending upon the loads and speeds, the adhesive wear rates increase until scuffing, scoring or galling occurs. ES treatments on rollers will not participate in adhesive wear with raceway asperities, but if the loads and speeds in the contacting areas are large enough and the lubricant interruption is long enough, the coating on the rollers will wear through graphitization. However, once the coating is worn away, adhesive wear ensues; while the coating is wearing, it allows the bearing to remain operational.

Abrasive particles that pass through worn seals that were not removed after manufacture—or are generated by wear of other components—can damage bearing surfaces if the particles are larger than the lubricant film. Depending on the hardness and brittleness of the particle, they can generate dents on the raceway and/or roller surface. During the denting process, displaced material creates shoulders around the debris crater. When these raised shoulders come into the contact zone of a bearing, very high, sub-surface stresses are generated and fatigue cracks initiate at low stress cycles (Ref. 19).

Because the ES treatments on the rollers of wear-resistant bearings are twice as hard as the steel raceways, they remove these shoulders through the same kind of polishing action described above. As a result, the stress risers that

Table 1—Summary of advantages ES-treated rollers provide to wear-resistant bearings

ADVANTAGE	WEAR-RESISTANT BEARINGS
Enhanced low Λ fatigue life	Specially designed rollers polish the raceways, reducing Ra and increasing Λ.
Scoring resistance from loss of lubrication	Rollers in wear-resistant bearings form barriers to adhesive wear during periods of lubricant starvation.
Debris tolerance	Rollers in wear-resistant bearings remove shoulders around debris generated craters on raceways and reduce surface roughness of ring raceways.
Resistant to smearing, micropitting, and fretting	Wear-resistant bearing rollers defeat the adhesive wear mechanisms that cause smearing, micropitting, and fretting.
Increased efficiency	Wear-resistant bearing rollers polish ring raceways, reducing surface roughness, increasing Λ, reducing rolling torque, and increasing efficiency.

can cause early fatigue crack initiation are removed, thereby allowing the bearing to operate much longer than it otherwise would.

When lubricant film is insufficient to keep loaded steel surfaces in relative motion from coming into contact, adhesive wear occurs. If high loads are applied to skidding rollers, the frictional heating from the adhesive interaction of contacting asperities can increase the temperature in the contact zone to the point where the steel actually melts. This melting and subsequent re-solidification process weakens the steel and creates a smeared appearance when it occurs on bearing raceways.

The shear stresses from moderate loads applied to skidding rollers can create bearing damage known as micropitting. Very high transient loads applied to skidding rollers can generate near-surface stresses on non-metallic inclusions, creating cracks that propagate and remove thin pieces of the raceway. This type of damage is known as brittle flaking. ES treatments on wear-resistant bearings provide a barrier against the ability of raceway asperities to bond to the roller and reduce the shear stresses and frictional heating from skidding rollers that cause these bearing damage modes. By decreasing the shear stresses of skidding rollers, the maximum contact stress is driven deeper into the raceway, well beyond the region where cracks that cause brittle flaking originate.

Roller bearings with smooth raceways exhibit less frictional torque than bearings with rougher raceways. Since the ES-treated rollers in wear-resistant bearings continuously polish the raceways, the contribution of frictional torque from contacting asperities is eliminated in operation. Depending upon the application and the type of bearing, raceway polishing by ES-treated rollers can reduce parasitic bearing losses between 5–10%.

References

1. Doll, G.L. and B.K. Osborn. "Engineering Surfaces of Precision Steel Components," *Proceedings Annual Technical Conference—Society of Vacuum Coaters,* 44, pp. 78–84, 2001.
2. Doll, G.L., C.R. Ribaudo and R.D. Evans. "Engineered Surfaces for Steel Rolling Element Bearings and Gears," *Materials Science and Technology*, 2, pp. 367–374, 2004.
3. Hashimoto, F., S.N. Melkote, R. Singh and R. Kalil. "Effect of Finishing Methods on Surface Characteristics and Performance of Precision Components in Rolling/Sliding Contact," *International Journal of Machining and Machinability of Materials*, v. 6, pp. 3–15, 2009.
4. Dimigen, H. and H. Hubsch. Carbon-Containing Sliding Layer, US Patent No. 4,525,417, 1985.
5. Sjostrom, H., L. Hultman, J.-E Sundgre and L.R. Wallenberg. "Microstructure of Amorphous C-H and Metal-Containing C-H Films Deposited Onto Steel Substrates," *Thin Solid Films*, v. 23, pp. 169–179, 1993.
6. Holmberg, K. and A. Matthews. *Coatings Tribology: Properties, Mechanisms, Techniques and Applications in Surface Engineering, Second Edition*, (Elsevier, Amsterdam), pp. 383–435, 2009.
7. Harris, T. and W. Yu. "Lundberg–Palmgren Fatigue Theory: Considerations of Failure Stress and Stressed Volume," *Transactions ASME Journal of Tribology,* v. 121, n. 1, pp. 85–89, 1999.
8. Averbach, B. and E. Bamberger. "Analysis of Bearing Incidents in Aircraft Gas Turbine Mainshaft Bearings," *Tribology Transactions*, v. 34, n. 2, pp. 241–247, 1991.
9. Ueda, T., K. Ueda and N. Mitamura, "Unique Fatigue Failure of Spherical Roller Bearings and Life-Enhancing Measures," *Proceedings of the World Tribology Congress*, Washington D.C., Sept 12–16, 2005.
10. Webster, M. and C. Norbart. "An Experimental Investigation of Micropitting Using a Roll Disk Machine," *Tribology Transactions*, v. 38, n. 4, pp. 883–893, 1995.
11. Chiu, Y. (1997), "The Mechanism of Bearing Surface Fatigue: Experiments and Theories," *Tribology Transactions*, v. 40, n. 4, pp. 658–666, 1997.
12. Ueda, T., K. Ueda and N. Mitamura. "Unique Fatigue Failure of Spherical Roller Bearings and Life-Enhancing Measures," *Proceedings of the World Tribology Congress*, Washington D.C., Sept 12-16, 2005.
13. Webster, M. and C. Norbart. "An Experimental Investigation of Micropitting Using a Roll Disk Machine," *Tribology Transactions*, v. 38, n. 4, p. 883–893, 1995.
14. Burrier, H. "Bearing Steels," *ASM Handbook Vol. 1*: *Properties and Selection*: *Irons, Steels and High-Performance Alloys*, ASM, Materials Park, Ohio, 380–388, 1990.
15. Rolling Bearings: Dynamic Load Ratings and Rating Life, International Organization for Standards: International Standard ISO 281, 2007.
16. Rolling Bearings: Static Load Ratings, International Organization for Standards, International Standard ISO 76, 2006.
17. Harris, T. A., J.H. Rumbarger and C.P. Butterfield. "Wind Turbine Design Guide DG03: Yaw and Pitch Rolling Bearing Life," Technical Report NREL/TP–500–42362, U.S. National Renewable Energy Laboratory, Golden, CO, 2009.
18. Hamrock, B. J. and D. Dawson. *Ball Bearing Lubrication*, Wiley, London, 1981.
19. Biboulet, N. "Influence of Indentations on Rolling Bearing Life," Doctoral Thesis in Mechanical Engineering, INSA Lyon, 2008.

Bearing Protection Needed If Inverter-Duty Motors Are to Live Up to Their Name

Adam Willwerth

Introduction

All major manufacturers of 3-phase AC induction motors offer "inverter-duty" or "inverter-ready" models, but while these motors have inverter-rated insulation to protect the windings, the bearings—their most vulnerable parts—are too often ignored. Unfortunately, many customers who purchase these motors do not understand this. The National Electrical Manufacturers Association (NEMA) has yet to recommend that new motors have bearing protection against damaging electrical discharges.

It is now common knowledge that inverters, also known as variable frequency drives (VFDs) and adjustable speed drives, can induce unwanted motor shaft voltages that, without effective mitigation, can destroy bearings, causing premature motor failure.

Although current NEMA standards highlight the possible need for extra bearing protection for VFD-driven motors, the language is often not specific enough to guide motor manufacturers and has not been updated to include new research results and developments in shaft grounding technology. Stronger, reworked standards, calling for effective mitigation in the form of reliable long-term shaft grounding technology, would go a long way toward cautioning motor users of the need for such mitigation and would help to clear up common misconceptions.

Elusive Sustainability

VFDs can save 30 percent or more in energy costs. Because of this, they have been cited as a key technology for those wishing to make their commercial HVAC systems, automated assembly lines and other processes more energy-efficient (green). But, whether used to control a motor's speed or torque, VFDs often induce voltages and currents that can damage bearings. In fact, the costly repair or replacement of failed motor bearings can wipe out any savings that a VFD yields and severely diminish the reliability of an entire system. And, when a VFD-controlled motor fails, warranty claims against motor and VFD manufacturers may not pan out. Because systems that use VFDs are so varied, the liability question is a hot potato.

Advances in Bearing Grounding Technology

In virtually every case, the most reliable and cost-effective way to minimize electrical bearing damage and make these systems sustainable is a motor shaft grounding ring (combined with insulation for motors greater than 100 hp).

Unlike older single-point contact brushes, new grounding rings encircle a motor's shaft with contact points for far greater effectiveness. One model, the Aegis SGR Bearing Protection Ring, has continuous circumferential rows of specially engineered microfibers to boost electron transfer rates and provide very low impedance from shaft to frame. These rings safely bleed damaging currents to ground, bypassing a motor's bearings entirely. And because the microfiber brushes work with little or no contact, they do not wear out like conventional brushes. Aegis rings have been proven effective in over half a million installations worldwide.

Recognizing that the best solution is to design motors from the ground up to survive the damaging effects of VFDs, a few forward-looking motor manufacturers have recently added the Aegis ring as a standard or optional feature on certain models.

For example, Baldor Electric Company (now part of the ABB Group) has introduced a line of inverter-ready Super-E NEMA Premium motors with the Aegis ring installed inside. These include HVAC motors that run fans in air handlers, defusers, diverters, etc., or pumps such as chill water pumps, condensers, and variable-flow refrigerant pumps; conveyor motors for airport baggage handling systems and other materials handling; and general-purpose and brake motors for machinery in many manufacturing applications. Baldor offers models from 1–100 hp in open drip-proof (ODP) and totally enclosed fan-cooled (TEFC) configurations with the Aegis bearing protection factory installed.

In addition, General Electric equips its A$D Ultra constant torque variable-speed-drive motors (1.5–300 hp) with internally mounted Aegis rings and offers the ring as an externally mounted option on its Energy Saver ODP and TEFC motors. These motors are designed for metal processing, material handling and other tough-duty applications as well as HVAC and other general purpose applications.

But these motors are exceptions to the rule. And while many motor manufacturers will, at a customer's request, add Aegis rings to their motors before shipping them, for motors already in service the rings must be retrofitted by the customer or contractor.

How VFDs Cause Motor Failure

Damage to windings and bearings alike is caused by repetitive and ex-

tremely rapid pulses applied to the motor from a modern VFD's non-sinusoidal power-switching circuitry. The names used to describe this phenomenon include harmonic content, parasitic capacitance, capacitive coupling, electrostatic buildup, and common mode voltage. Regardless of the name used, high peak voltages and fast voltage rise times can cause cumulative degradation of insulation, bearings, coil varnish, etc. If the load impedance is higher than the line impedance, current is reflected back toward the VFD, creating voltage spikes at the motor terminal that can be twice as high as the DC bus voltage.

The cumulative bearing damage caused by VFD-induced currents is often overlooked until it is too late to save the motor.

Types of Bearing Damage

Without some form of mitigation, shaft currents discharge through bearings, causing unwanted electrical discharge machining ("EDMing") that erodes the bearings and race walls (Fig. 1) and leads to premature bearing/motor failure. Before long, these frequent discharges can leave the entire bearing race riddled with pits known as frosting (Fig. 2). In fact, electrical damage has become the most common cause of bearing failure in VFD-controlled AC motors.

In a phenomenon called fluting (Fig. 3), the operational frequency of the VFD causes concentrated pitting at regular intervals along the race wall, forming washboard-like ridges. Fluting can cause excessive noise and vibration, which, in an HVAC system, can be magnified and transmitted by ductwork throughout the entire building. By the time this is noticeable, bearing failure is often imminent.

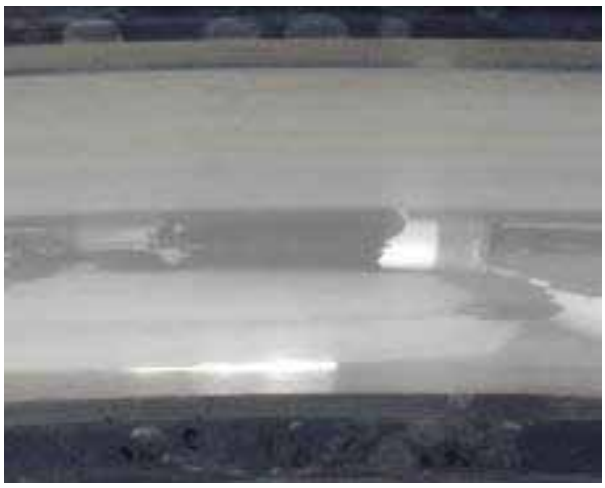


Figure 1—Viewed under a scanning electron microscope, a new bearing race wall is a relatively smooth surface, marked by nothing but mechanical wear where bearings contact the wall.

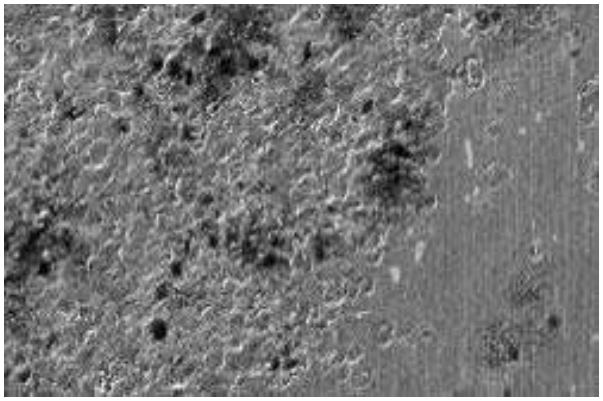


Figure 2—Pitting of a bearing race wall (magnified).

Figure 3—Taken from a failed motor, the fluted bearing race wall (left) resulted from VFD-induced bearing currents. Protected by an Aegis SGR bearing protection ring, the race on the right is undamaged.

The Need for Updated Standards

In its key role as information provider, NEMA is in the unique position to update its MG1 standard to more clearly state that common mode shaft voltages are present in virtually all motors fed by pulse-width-modulated (PWM) VFDs. Since no other entity is in such a position of authority, NEMA could at the same time address the overall problem of electrical bearing damage more clearly and firmly.

The association's current standards acknowledge the potential damage from VFD-induced voltage spikes. The standards state that motors controlled by modern VFDs containing insulated gate bipolar transistors (IGBTs) should be designed to withstand repeated spikes (at the terminals) of up to 3.1 times the motor's rated voltage, at rise times not less than 0.1 microsecond. Yet, when addressing the potential for bearing currents the language is far less prescriptive.

NEMA Standard MG1–2009 (Revision 1–2010), Section IV, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors, correctly states: "Shaft voltages can result in the flow of destructive currents through motor bearings, manifesting themselves through pitting of the

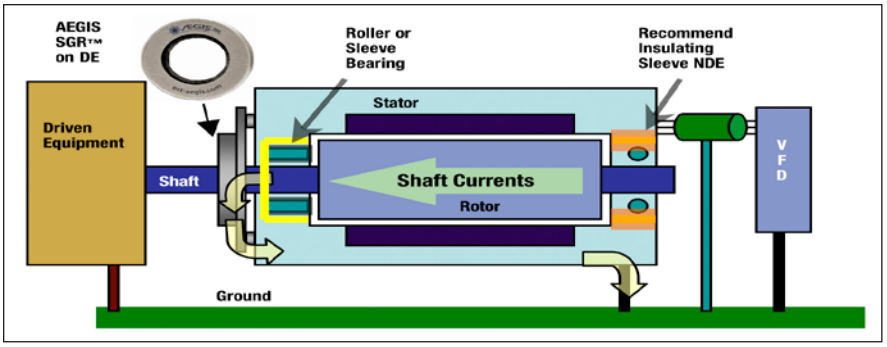


Figure 4—Combining an insulated bearing on one end with a shaft grounding ring on the opposite end provides the best protection from electrical bearing damage.

bearings, scoring of the shaft, and eventual bearing failure."

Subsection 31.4.4.3 of Part 31 recommends bearing insulation at one end of a larger motor (defined as "usually 500 frame or larger," horsepower unspecified) if the peak shaft voltage is greater than 300 millivolts. Unfortunately, the paragraph dealing with these larger motors only mentions circulating end-to-end shaft currents caused by magnetic dissymmetries under sinusoidal operation. It fails to add that the bearings of large motors can also be plagued by VFD-induced, high-frequency capacitively coupled common mode voltages.

In a paragraph on "much smaller motors" (frame size and horsepower unspecified), the same subsection recommends insulating both bearings or installing shaft grounding brushes to divert damaging currents around the bearings. For these motors, the standard correctly explains, a VFD can generate high-frequency common mode voltage, which shifts the three-phase-winding neutral potentials significantly from ground. Because the damaging voltage oscillates at high frequency and is capacitively coupled to the rotor, the current path to ground can run through one bearing or both. But here the standard neglects to mention that high-frequency circulating currents may also be present in VFD-driven motors as small as 100 hp.

To summarize, NEMA omits common mode voltages from its paragraph on larger motors and omits circulating currents from its paragraph on smaller motors. Another problem with NEMA's current language is that neither a grounding brush nor insulation is a reliable, long-term solution to the problem of electrical bearing damage at the system level, which includes motors and attached equipment.

To its credit, the NEMA standard does correctly point out that "insulating the motor bearings will not prevent the damage of other shaft connected equipment." When the path to the bearings is simply blocked by insulation, the damaging current seeks another path to ground. That other path can go through a pump, gearbox, tachometer, encoder, etc., which consequently can end up with bearing damage of its own. The economical solution, of course, would be a maintenance-free, long-life shaft grounding ring that protects attached equipment as well as the motor's bearings.

Best Practices for Mitigating Bearing Damage

When designing a true inverter-ready motor, a manufacturer should strive to protect the motor's bearings as well as its windings. Stronger NEMA standards would be an incentive for built-in bearing protection that extends motor life. The following measures have proven effective under actual operating conditions and should be considered for inclusion in any NEMA standards updates:

For motors above 100 hp, where both circulating currents and common mode voltages could cause bearing damage, combining an insulated bearing on one end with a shaft grounding ring on the opposite end provides the best protection from electrical bearing damage (Fig. 4).

For motors up to 100 hp, where common mode voltages and circulating currents could cause bearing damage, adding a shaft grounding ring to the motor, either inside the motor or externally, provides effective protection against bearing currents for motor bearings as well as attached equipment (Fig. 5).

The Need for Long-Term Shaft Grounding Solutions

Other devices that are meant to provide a path to ground fall short of the Aegis ring. None of them works as well as the Aegis ring at high rpms. And although the primary reason is that they wear out faster, there are other reasons for their reduced effectiveness—reasons that limit the effectiveness of all "single-point contact brushes."

Metal spring-pressure grounding brushes, for example, are easily contaminated by corrosion or clogged by debris, requiring regular maintenance/replacement.

Carbon-block (graphite) brushes have an additional drawback. They are susceptible to "hotspotting," in which an arc briefly fuses the brush to the motor

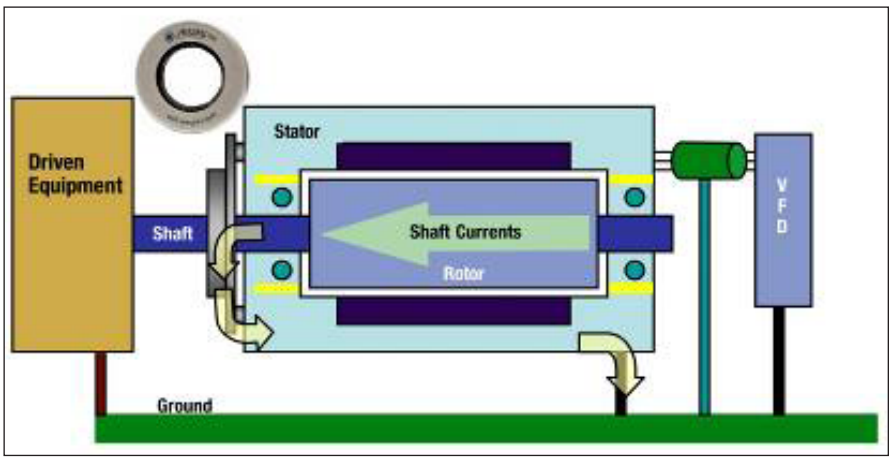


Figure 5—Adding a shaft grounding ring to the motor, either inside the motor or externally, provides effective protection against bearing currents for motor bearings as well as attached equipment.

shaft. And other "contact" brush designs quickly wear out, with the result that shaft currents return to discharging in the bearings.

The above configurations have one thing in common—they rely on direct contact to transfer current. The Aegis ring, however, is unique in that it works both with contact and also without direct fiber contacting the motor shaft. Its contact/non-contact Electron Transport Technology discharges shaft voltages even if its fibers are not touching the motor shaft. And because it works without contact, the Aegis ring will not wear out and requires no maintenance, regardless of rpm. Its patented technology makes it the most effective device for redirecting currents from shaft to ground (Fig. 6). Easily installed at the factory or retrofitted later (Fig. 7), it makes VFD-controlled systems sustainable by protecting motor bearings from catastrophic failure.

Key to the Aegis ring's success are the proprietary conductive microfibers that completely surround the motor shaft. Secured in the ring's patented FiberLock channel, these fibers can flex without breaking, and the deep protective channel keeps them away from dust, liquids and other debris. Testing shows surface wear of less than 0.001" per 10,000 hours of continuous operation and no fiber breakage after 2 million direction reversals.

The cost of the Aegis ring and installation is very low when compared to the cost of the overall system, usually less than 1 percent of the equipment cost. And, by preventing electrical damage to bearings, the ring protects the whole VFD system from costly downtime and unplanned maintenance.

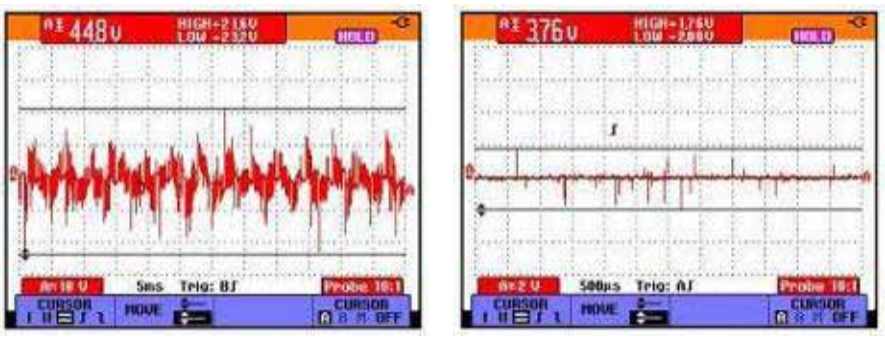


Figure 6—Measured with an oscilloscope, motor shaft currents before (left) and after (right) installation of the Aegis SGR bearing protection ring on a motor in an HVAC unit.

Conclusion

Virtually all VFD-driven motors are vulnerable to bearing damage, but for too long the importance of shaft grounding to protect motor bearings has been ignored or underestimated. To make the savings generated by VFDs sustainable, an effective long-term method of shaft grounding is essential.

Current NEMA standards dealing with the problem of shaft voltages are incomplete or not specific enough to help. While they point out the problem of VFD-caused bearing damage, they often understate the potential for such damage. They do not acknowledge the combination of capacitively induced shaft voltages and high-frequency circulating currents from VFDs. Furthermore, they fail to take into account recent advances in technology such as microfiber shaft grounding rings.

For motors without adequate bearing protection, the term "inverter-duty" is misleading—it ignores a major potential cause of premature bearing and motor failure—electrical discharge machining. And while some leading motor manufacturers are now installing the Aegis SGR Bearing Protection Ring in selected models, most motors labeled "inverter-duty" or "inverter-ready" are still not adequately protected. It is thus incumbent upon savvy specifiers to make sure that any motor to be used with a VFD is truly inverter-ready-equipped at the factory or retrofitted—not just with extra winding insulation but also with a shaft grounding ring and, in certain cases, an insulated bearing.

For more information

Electro Static Technology
Phone: (207) 998–5140
Fax: (207) 998–5143
www.est-aegis.com.

Figure 7—The Aegis SGR bearing protection ring is available for any size NEMA or IEC motor. It can be factory-installed inside new motors, as with the Baldor Super-E NEMA premium motor (left) or quickly and easily retrofitted—even in the field—using conductive epoxy (right). A new Split uKIT simplifies and speeds mounting of the ring on motors with shaft shoulders, slingers or other end-bell protrusions.

Adam Willwerth *is the sales and marketing manager for Electro Static Technology. He has extensive experience in industrial product development and commercialization, and is attached to four patent applications pertaining to conductive microfiber shaft grounding ring technology. Willwerth has presented seminars on the subject of bearing current mitigation at professional conferences in the U.S. and Europe, and holds a Master of Business Administration degree from Southern New Hampshire University and a Bachelor of Science degree in management from the University of Maryland.*

Kan

APPOINTED CHAIR OF CMTA


Pamela Kan

Bishop-Wisecarver Corporation president Pamela Kan was appointed chair of the California Manufacturers and Technology Association (CMTA) Board of Directors at the trade organization's annual meeting. The CMTA is a nonprofit that works to improve the business climate for California's 3,000-plus manufacturing, processing and tech companies—like Bishop-Wisecarver, which manufactures linear and rotary guided motion technologies. Kan became a member in 2004 and stepped up to the governing board in 2008. She joined Bishop-Wisecarver in 1991 as a corporate programs director, was appointed president in 2000, and acquired controlling shares of the company in 2009.

Kan's experience as a small business executive, as a woman in manufacturing and as a second-generation owner of her company, will make her a powerful advocate for other manufacturers in California, said CMTA president Jack M. Stewart. She grew up in the business, he noted. Kan's father, Bud Wisecarver, founded Bishop-Wisecarver.

"California manufacturers are indeed fortunate to have Pamela Kan serve as their chair of the California Manufacturers and Technology Association for the next two years," Stewart said. "She brings an extraordinary level of enthusiasm and personal commitment to the job. As a small business owner who has to compete in a cost-competitive global market, Pamela will provide a wealth of operational knowledge to CMTA through her experience as president of Bishop-Wisecarver Corporation."

"I think it will be a very interesting two years for our state in terms of manufacturing and the laws that govern it," Kan said. "I am excited to help give manufacturing a voice in Sacramento." She said her main focus, however, will be to promote science, technology, engineering and mathematics (STEM) education in California schools. "The CMTA is working on building an education platform and I am very eager to be a part of that work," Kan said. "Having an education system in our state that allows kids to graduate from high school with the foundation for a technical skills-based job is vitally important."

Kan has made it a priority for Bishop-Wisecarver to support education through sponsorships, mentorships and other community involvement. Her role at CMTA will give her a stronger, farther-reaching role in supporting STEM academics. "We once had one of the top educational systems in the country and the world and recent data now ranks our state 48 out of 50," she noted. "None of us should be satisfied with that performance for California and the future of our kids."

Hydraulic Institute

BROADENS ELIGIBILITY REQUIREMENTS

Hydraulic Institute (HI) members have approved a bylaw change which broadens eligibility for associate membership to include all corporations that manufacture products or develop software for ultimate use in or with pumps and pumping systems. The new bylaw permits corporations and firms engaged in the manufacture of such products as motors, variable speed or other drivers, seals and sealing systems, bearings, component parts, gears, couplings, gauges, instrumentation and controls, coatings, lubricants and lubricating systems or the design and development of pump-specific software, regardless of location where that manufacture occurs, to become associate members of HI, provided that the corporation or firm sells into the North American market.

Also eligible for associate membership are corporations or firms whose primary business is the integration, manufacture and assembly of pumps and pumping components into a system or modular solution. Eligibility is not dependent on the location of these activities, but rather on the provision that the corporation sell such products into the North American market.

By opening membership eligibility to new pump-specific manufacturing specialties, the institute gains additional expertise and manpower in the development of its highly regarded ANSI/HI pump standards. By joining HI, supplier and software companies become eligible for the many benefits available to HI associate members. For more information, visit *www.pumps.org*.

Dunkermotor

RECIEVES CUL CERTIFICATION

Dunkermotor, now part of Ametek Precision Motion Control, has received cUL certification for its brushless motors, intelligent servo motors and brush motors for use in applications that require compliance with Canadian safety requirements. This Underwriters Laboratories certification is in addition to existing UL certification in the U.S. and means that OEMs, distributors and users in Canada can be assured their choice of certified Dunkermotor components is compliant with the appropriate regulatory standards in North America. The new certification for Canada encompasses Dunkermotor's permanent magnet brush DC motors in 42, 51, 53, 63 and 80 mm frame sizes, as well as brushless DC (BLDC) motors in 42, 45, 65 and 75 mm frame sizes, including brushless motors with integral control intelligence (iBLDC).

"This new certification reinforces not only our commitment to our Canadian customers, but also our U.S. and other global customers who sell their products in the important Canadian market," said Wilfrid Vinson, president of Dunkermotoren USA, Inc. "We are proud to be among a select few motor manufacturers who can offer their global customers not

only UL and cUL certifications for the U.S. and Canada, but also CE and CCC certifications of our products, including brushed DC motors, in Europe and China."

The newly certified motors, currently available in powers up to 530 watts (0.71 hp), are part of a complete family of modular components such as planetary and worm gearboxes, encoders, and brakes which offer virtually infinitely variable configurations to meet most OEM and specialty equipment builder application requirements. For more information, visit www.dunkermotoren.com.

Lenze

EXPANDS SALES AND MARKETING POSITIONS

Lenze Americas, a global manufacturer of electrical and mechanical drives, motion control and automation technology, has announced two strategic promotions that will align the company's sales and marketing resources, drive revenue growth through stronger sales planning and execution, and expand and enhance management of its large national and global accounts.

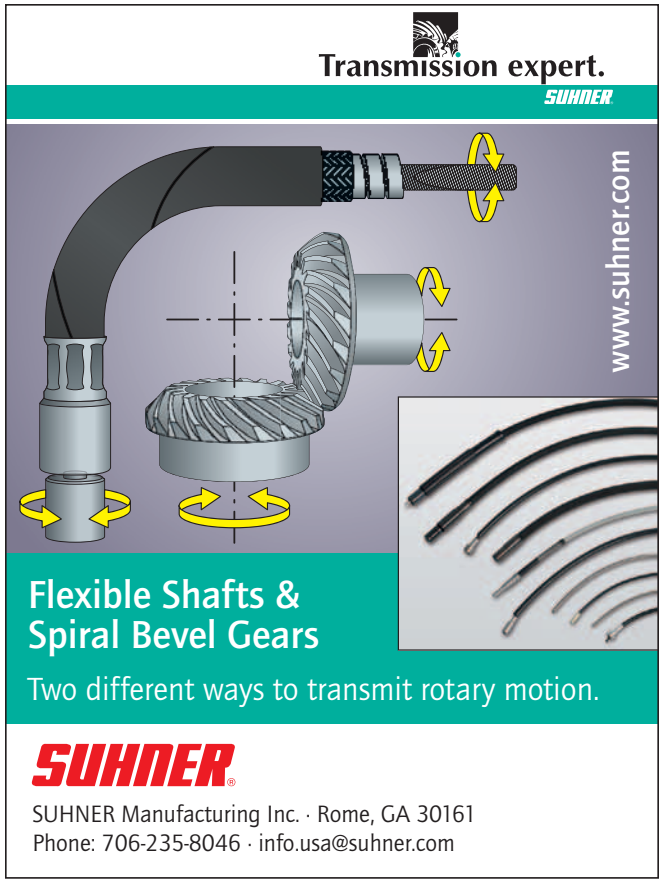
Eric Klein

Eric Klein's director of sales role has expanded. In his new capacity Klein's responsibilities include oversight of all Lenze field-based customer resources including the field sales, field service and customer program management groups. His successful sales team comprises a direct sales force, manufacturers' representatives and distribution channels. Klein joined Lenze in 2006 as distributor sales manager and most recently held the position of Northeast regional sales manager. A graduate of Cornell University with a BS in engineering, Klein previously worked for Toshiba and Reliance Electric.

"Klein is known for continuously improving sales strategies and maintaining a seamless line from Lenze customers to the factory. He brings to the position industry expertise in automation and motion control products, and plays a pivotal role in developing and strengthening customer relationships," states Chuck Edwards, president, Lenze Americas.

Additionally, Deb Kling has been promoted to the position of commercial marketing director for Lenze Americas. Kling supervises Lenze marketing and customer service managers, in addition to overseeing agency relationships. Creating individual marketing and sales strategies for business opportunities, Kling drives distribution programs from a national level, complemented and supported by field sales initiatives. In her new role, Kling assumes expanded responsibilities for headquarters-based resources involved in marketing and

Deb Kling



distribution programs, strategic marketing, customer service, and sales and applications support. In 2005, Kling began her tenure with Lenze as marketing manager, progressively assuming expanded responsibilities. Kling earned her BS in mechanical engineering from the University of Illinois and an MBA from Northern Illinois University.

"Kling's product knowledge, strategic marketing background and enthusiasm for the motion control industry, coupled with her field sales and distribution management experience, make her uniquely qualified to be a leader in these areas," remarks Edwards.

SDP/SI

APPOINTS EMT ENGINEERING FOR SALES REPRESENTATION

Stock Drive Products/Sterling Instrument-SDP/SI has announced the appointment of EMT Engineering Sales, Inc. as their exclusive sales representative in Canada, Illinois, Wisconsin, Minnesota, Iowa, North Dakota, and South Dakota. In making the announcement SDP/SI national sales manager

James Mastrorilli said, "This appointment will vastly increase our ability to provide superior service for the SDP/SI customers in these areas. EMT has a large and capable force of 14 representatives in Canada and the US Upper Midwest which will be able to provide additional service to our customers in both markets." EMT Engineering Sales has 27 years of experience in the sales and marketing of electromechanical components to the commercial and defense OEM marketplace. Their organization is structured to provide the companies they represent complete territory management. This effort encompasses both the sales and marketing requirements necessary to excel in today's rapidly changing environment. Companies represented include: Honeywell, EAO. Emcor Products Enclosures, Fisher Connectors, Jonathan Ball Bearing Slides and Madison Cable, to name just a few.

Eriez

NEW PENNSYLVANIA FACILITY UP AND RUNNING

Mike Mankosa, Eriez vice president ofoperations, recently announced the company's newest facility, located in Erie, Pennsylvania, is up and running at full production. The Wager Road plant houses the Eriez 5-Star Service Center and handles manufacturing of Eriez' largest equipment including Metal Recovery Systems, Column Flotation Cells and Hydroflow Fluid Filtration and Recycling Equipment.

Eriez purchased the 114,000-square-foot building, located approximately 15 miles from its Asbury Road world headquarters facility, in late 2011. The staff at the Wager Road facility is made up of a combination of new hires and existing employees who moved from the Asbury Road headquarters to the new building.

"2012 is an exciting time filled with milestones and new beginnings for Eriez," says Tim Shuttleworth, Eriez president and CEO. "In this, our 70th anniversary year, we are experiencing phenomenal growth around the world and right here at home. In addition to our new building in Erie, the company's operations in Canada, China and India have recently been moved from existing facilities to larger buildings in the area to meet our growing order demand overseas."

Shuttleworth explains, "Our new Wager Road facility is an important component to our continued success as this additional space helps us accommodate our staggering domestic manufacturing volume so we can continue to meet customers'

deadlines and exceed expectations. In many ways, our recent expansions have been 70 years in the making. We are proud of how far our company has come since 1942, and we look forward to a bright future of unlimited potential."

Force Control

PRESENTS TRAVELING ROAD SHOW

Force Control Industries, Inc., the manufacturer of oil shear clutches and brakes, brings their traveling Road Show to the western part of the United States and western Canada through October 2012. This unique vehicle provides the opportunity for hands-on demonstrations to maintenance, engineering, purchasing and plant management teams. This first-

hand experience allows company officials to better understand oil shear technology and how it can increase production while significantly reducing costs. The route includes Denver, Salt Lake City, Boise, Spokane, Calgary, Edmonton, Vancouver, Seattle, Portland, and San Francisco area. For more information, visit *www.forcecontrol.com*.

Altra

ACQUIRES LAMIFLEX

Altra Holdings Inc. announced that its subsidiary, Altra Industrial Motion Netherlands BV, has acquired privately held Lamiflex do Brasil Equipamentos Industriais Ltda. ("Lamiflex"). Lamiflex, headquartered in Sao Paulo, is the premier Brazilian manufacturer of high-speed disc couplings, providing engineered solutions to a variety of industries, including oil and gas, power generation, metals and mining. "Expanding our reach in emerging geographies is a key component of Altra's strategic plan, and the acquisition of Lamiflex provides us with an important growth platform in Brazil," said Carl Christenson, Altra's president and CEO. "Lamiflex is a well-known supplier of high-quality coupling products to the Brazilian marketplace. The acquisition will provide Lamiflex with the resources required to continue its growth initiatives while, over time, serving as a launching platform for several other Altra businesses." For more information, visit *www.altramotion.com*.

calendar

August 27–30—Power Transmission Principles

Indianapolis. IDC University's Power Transmission Principles course (PTP) 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 10–15—IMTS 2012

McCormick Place, Chicago. The 29th edition of the manufacturing technology show boasts more than 1,100 exhibiting companies that will occupy 1.1 million net square feet of exhibit space. The show attracts 82,000 buyers and sellers from more than 116 countries. Leading manufacturers will display their equipment in pavilions including metal cutting, tooling and workholding systems, metal forming and fabricating/laser processes, gear generation, industrial automation and many more. The IMTS 2012 Conference brings industry together to discuss technologies, business development and optimization, plus workforce efficiency and productivity. Special emphasis will be placed on maintaining focus on short- and long-term goals during a tough economic environment. For more information, visit *www.imts.com*.

September 11–13—International Conference on Manufacturing Research 2012

Aston University. For over two decades, the International Conference on Manufacturing Research has been the main manufacturing research conference in the U.K., successfully bringing researchers, academics and industrialists together to share their knowledge and experiences. Initiated as a National Conference by the Consortium of U.K. University Manufacturing Engineering (COMEH), it became an International Conference in 2003. COMEH is an independent body established in 1978. Its main aim is to promote manufacturing

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engineering education, training and research. Keynote speakers for the event include Hamid Mughal, executive vice president, manufacturing, Rolls Royce Plc.; professor Sir Mike Gregory, Institute for Manufacturing, Cambridge University; John Ladbrook, European simulation specialist, Ford Motor Company and Professor Jay Lee, director of the Center for Intelligent Maintenance Systems, University of Cincinnati. For more information, visit *www1.aston.ac.uk/icmr2012*.

September 17–20—Hydraulic Principles and Applications

Indianapolis. IDC University's Hydraulics Training is a comprehensive course covering the principles, functions and applications of low pressure/low force and high pressure/high force hydraulics. Students will receive instruction on: the inner workings of hydraulic equipment (specifically how the components fit together and their functions); how to identify the basics of pumps, cylinders, valves, motors and related systems; and how to identify applications in the field. This course serves as an introduction to basic hydraulic principles and applications. Coursework combines classroom learning with hands-on training to achieve hydraulic product and system awareness and understanding. Students will be taught basic hydraulic principles related to pressure, force, area, flow and horsepower. In addition, students will learn of the options for hydraulic functions and fluid connectors. Coursework will include hands-on training and case studies. For more information, visit *www.idc-usa.com*.

September 18–19—Human Error Prevention Seminar

Fogelman Executive Conference Center, Memphis, Tennessee. The principles and practices of human error prevention are universally applicable, regardless of the type of industrial, commercial or governmental enterprise, and regardless of the type of function performed within the enterprise. This seminar is truly unique and up to date with the latest developments in human error prevention. Ben Marguglio's new taxonomy of human error causal factors and his human error-related models demonstrate his leadership in this subject. Examples and case studies amply reinforce the human error prevention principles and practices. This seminar covers: classifications of human error; quality and safety culture and the quality- and safety-conscious work environment; leadership responsibilities; the total quality and safety function and much more. For more information, contact Ben Marguglio at (845) 265-0123 or e-mail *ben@hightechnologyseminars.com*.

September 24–25—Bearing Specialists Association (BSA) 2012 Fall Meeting

Hilton Suites Chicago. Co-located with the American Bearing Manufacturers Association (ABMA) Fall Meeting. Each association will be pursuing its own business agenda, but there will be a joint reception and dinner to facilitate industry networking. BSA's Information Technology and Supply Chain Committee Meeting on September 24th, from 9:00 a.m.–11:30 a.m., will feature a presentation by Susan Streich, national sales manager of IDEA e-solutions, on their data synchronization solutions for business. All Fall Meeting attendees are invited to participate at this meeting. Traditionally, the Fall Meeting provides an unprecedented opportunity to network with industry peers and experience the work of the committees with no obligation to join. Expanded networking opportunities this year include a joint BSA/ABMA reception and dinner; ABMA's Anti-Counterfeiting Committee Meeting on Sunday; the Education Committee Meeting on Monday; and breakfast and General Session on Tuesday morning. For registration information, visit *www.bsahome.org*.

October 15–19—AME Chicago 2012

Sheraton Chicago Hotel and Towers. The Association for Manufacturing Excellence (AME) has a long track record for finding and convincing some of the best manufacturing practitioners from around the world to share their lean practice experiences. More than 60 leading presenters will be on hand to discuss customer focus, process sustainment, continuous improvement, material flow and other lean practices and strategies. Manufacturing tours highlighting some of the best lean and six sigma operations in and around the Chicago area include Caterpillar, Bimba Manufacturing, Whiting Corporation, S&C Electric Company and Winzeler Gear. Workshop topics include maintenance management, lean behaviors, training within industry, lean business simulation and lean tools for the office. Six keynote speakers will be featured at the conference. For registration information, visit *www.ameconference.org*.

November 12–15—Bulk Material Handling

Indianapolis. IDC University's Bulk Material Handling course is a four-day intensive study into the various types of conveyors and bucket elevators. This course introduces students to the bulk material handling industry and the details behind the design and application of screw conveyors, bucket elevators, drag conveyors and belt conveyors. Throughout the course, students will learn about various bulk materials and how to classify them by CEMA standards. Resources available for designing and selling screw conveyors, bucket elevators, drag conveyors and belt conveyors will be covered. For more information, visit *www.idc-usa.com*.

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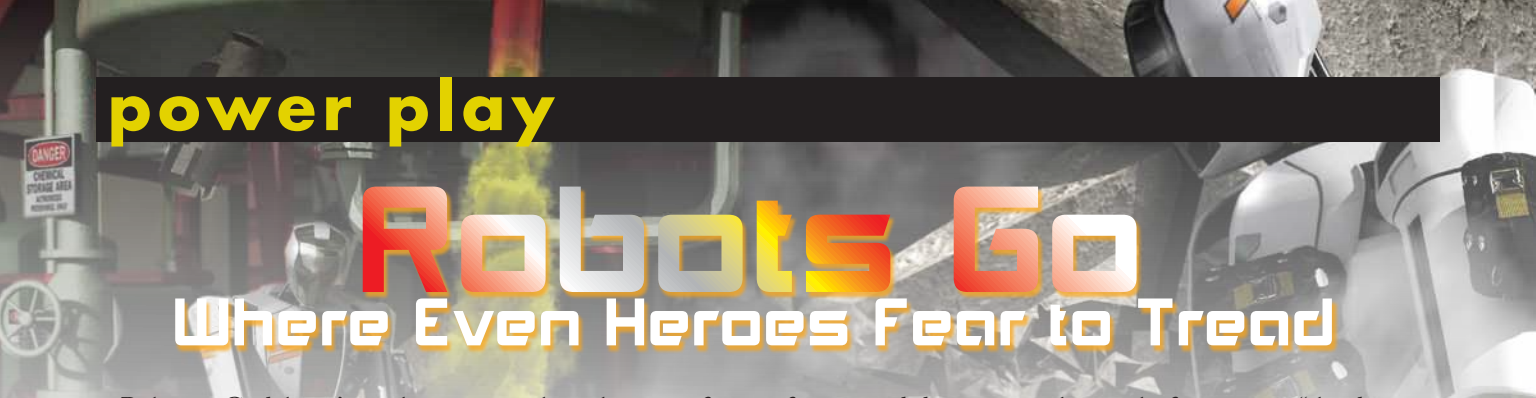

Photo courtesy of DARPA

Robots—God love 'em—have a very long history of instilling we humans with emotions encompassing wonder, dread and downright horror. Greek mythology has its Talos (Talon)—a giant automaton tasked with patrolling the shores of Crete to discourage foreign invaders. Robots of a sort also pop up in the Old Testament—AKA the "Golem."

Some contemporary robotic wonder-horror-dread examples: The wonder—the Da Vinci Surgical System; the horror—*2001, A Space Odyssey*'s HAL 9000 (Heuristically programmed Algorithmic computer), quoted here regarding a questionable ship malfunction: "It can only be attributable to human error"; and, the dread—a box of wires taking your place on the production line.

But this Power Play exists in praise of our metallic mates—specifically, the DARPA (Defense Advanced Research Projects Agency) Robotics Challenge (DRC), a U.S. Department of Defense (DOD)-sponsored competition beginning in October and wrapping up sometime around the end of 2014. Comprised of three competitions—a mix of virtual and live—the contest is a significant element of the DOD's "strategic plan" that "calls for the Joint Force to conduct humanitarian, disaster relief and related operations."

You can see where this is going, but to be precise: "The plan identifies requirements to extend aid to victims of natural or man-made disasters and conduct evacuation operations. Some disasters, however, due to grave risks to the health and wellbeing of rescue and aid workers, prove too great in scale or scope for timely and effective human response. The DRC "will attempt to address this capability gap by promoting innovation in robotic technology for disaster-response operations."

First-responder robots—in our lifetime!

One can think back to any number of disasters in which life-saving robots replacing humans would have been a miraculous endeavor; for most Americans, 9/11 comes immediately to mind; the 2011 Fukushima (Japan) nuclear accident is a more recent example. According to the DARPA website, "The goal of the DRC is to develop ground robots capable of executing complex tasks in dangerous, degraded, human-engineered environments. Competitors…are to focus on (creating) robots (that can use) equipment commonly available—from hand tools to vehicles—with an emphasis on adaptability to tools with diverse specifications."

Breaking it down, it is DARPA's intent via the challenge "to advance (robotics') current state of the art in the enabling technologies of supervised autonomy in perception and decision-making; mounted and dismounted mobility; dexterity; strength; and platform endurance."

The competition will concentrate on "robotics hardware and software development tasks," and will be open to all comers, foreign and domestic, with a goal of increasing "the diversity of innovative solutions…including universities, small, medium and large businesses, and even individuals and groups with ideas on how to advance the field of robotics." Yet another hope for the DRC is "to make software and hardware development for ground-robot systems more accessible to interested contributors, thereby lowering the cost of acquisition while increasing capabilities."

In what shape, size or form the "contestants" might show up could be a real eye opener for those of us more familiar with the canned Hollywood versions we've come to know. In an April 9 story in the *New York Times* on the challenge by John Markoff, there is mention that "while such (abovementioned) tasks may well inspire humanoid designs, roboticists say they may also lead to the robotic equivalent of the Minotaur—a hybrid creature that might have multiple arms and not just legs but treads." The piece goes on to quote Aaron Edsinger, co-founder of San Francisco-based Meka Robotics, that the robots would be a menagerie of "analogs to animals such as spiders, monkeys, bears, kangaroos and goats" that serve as "useful inspiration when considering parts of the challenge."

> Carrying out time-sensitive, tricky tasks—such as pump repair or replacement—conducted in extremely dangerous, life-threatening environments is a part of what the DARPA robotics challenge is all about.

Edsinger goes on to comment that the real challenge for the robots is not in the completion of each individual activity; rather, it will be in the successful integration (of the tasks) into a single, focused mission. "I feel we already have systems that can achieve each individual task in the challenge."

According to a DARPA press release, there are "eight likely tasks the robot will need to perform, among them driving a vehicle to a simulated disaster site; moving across rubble; removing rubble from an entryway; climbing a ladder; using a tool to break through a concrete wall; finding and closing a valve on a leaking pipe; and replacing a pump."

Also mentioned in the *Times* article regarding Fukushima is that "Despite Japan's significant investment in robotics, Hirochika Inoue—the father of humanoid robot development in Japan—(and who in fact suggested such a contest last year)—noted that the country did not have any robots capable of completely replacing humans at the time of the Fukushima disaster."

"Many people wanted to do it by robots," (Hirochika) said in an e-mail, "but we had not prepared." (For more information: *www.darpa.mil.*)

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