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JUNE 2014

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Special Section

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BEST PRACTICES**

**PREVENTIVE
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Technical

[Ask the Expert: Adjusting Tapered Roller Bearings]

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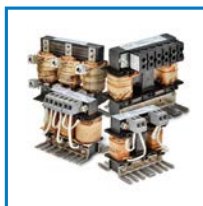
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Vol. 8, No. 4. POWER TRANSMISSION ENGINEERING (ISSN 2331-2483) is published monthly except in January, May, July and November by Randall Publications LLC, 1840 Jarvis Ave., Elk Grove Village, IL 60007, (847) 437-6604. Cover price \$7.00. U.S. Application to Mail at Periodicals Postage Prices is Pending at Palatine, IL and at additional mailing offices. Send address changes to POWER TRANSMISSION ENGINEERING, 1840 Jarvis Ave., Elk Grove Village, IL 60007.

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VOL. 8, NO. 4

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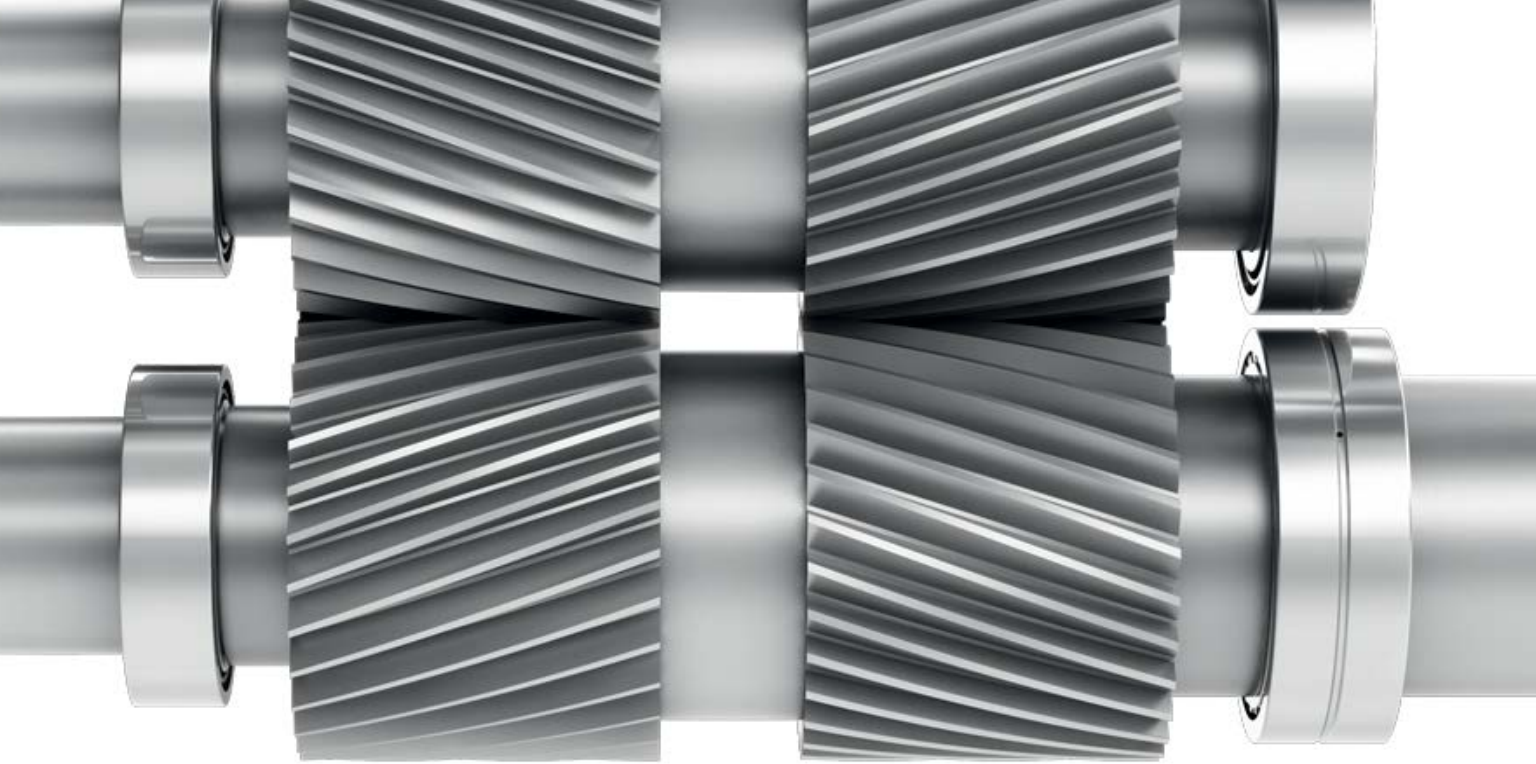


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PTE Videos

Watch a video that examines the SKF TKSA 11, a shaft alignment tool that uses inductive proximity sensors instead of lasers for measuring. It's operated with an App for iOS mobile devices that allows high quality displays to be used and offers productivity increases (www.powertransmission.com).

Coupling Technology

In the latest R+W blog, Andy Lechner discusses mounting a sprocket or pulley to a torque limiter. See this and other PT component news items at *Power Transmission Engineering's* various social media networks (LinkedIn, Twitter, etc.).



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

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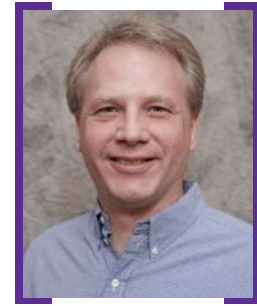
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Who Do You Trust?



At the recently held annual meeting of the Bearing Specialists Association, there was a lot of talk about online sales channels and how Internet retailers are changing the way industrial products are researched, sourced and purchased.

Two of the three guest speakers at the event focused heavily on the threat that these online channels pose to traditional distributors like the companies that make up BSA's core membership. The speakers explored ways that distributors can reinforce their value proposition by emphasizing the services and expertise they provide.

"You can't out-*Amazon Amazon*," said Dr. Barry Lawrence, who is director of the Global Supply Chain Lab at Texas A&M University. Once a product becomes commoditized, it's difficult for traditional distribution channels to compete, he explained.

Amazon.com is perceived as the lunchroom bully of the sales world. They have the clout and resources to take your lunch money if they want to. And recently, they've been paying more and more attention to things like gears, bearings, motors and other industrial products. In 2010, Amazon Industrial & Scientific division joined the PTDA. Today, Amazon lists almost half a million products under the "Power Transmission" category alone.

My question is: Can you trust it?

My brief and unscientific survey of the power transmission category revealed that if you want to buy a Timken tapered roller bearing—or an SKF, FAG or Koyo—you can find it on *Amazon.com*. Likewise you can buy name brand gears, belts, chains, sprockets, etc. In most cases, you'll be shown a variety of choices for each product, with different prices being offered by different sellers.

For example, on the first page of listings on *Amazon.com* for tapered roller bearings I found a Timken 13889 tapered roller bearing. It's a 1.5" ID, single-cone, standard accuracy bearing that was being offered in prices ranging from \$25-\$44. The same bearing from the Motion Industries website costs \$49.

Discounted prices are attractive to anyone. A backyard mechanic working on his weekend project wouldn't think twice. But most of you design, build or maintain equipment that requires a much more responsible approach. A factory's production might depend upon it. Your job might depend upon it. People's lives might depend upon it.

And on Amazon, it's often hard to tell exactly whom you're buying from. Amazon is a distributor itself, so they stock and warehouse a lot of components, but they don't say where they got them, and as far as I can tell, Amazon is not an authorized

distributor for any major power transmission brand. They say they have policies in place to prevent counterfeit goods from getting in their pipeline, but various online discussion forums and recent news headlines indicate the system may not be perfect. They also allow third-party sellers to participate in their marketplace. I'm just a lowly editor, not a purchasing professional or an engineer, but I find it hard to trust.

My guess is that you or your companies have well-established channels for sourcing power transmission products, whether you deal directly with the manufacturers or work with established distributors. Doing otherwise might introduce risks that far outweigh any potential cost savings or convenience.

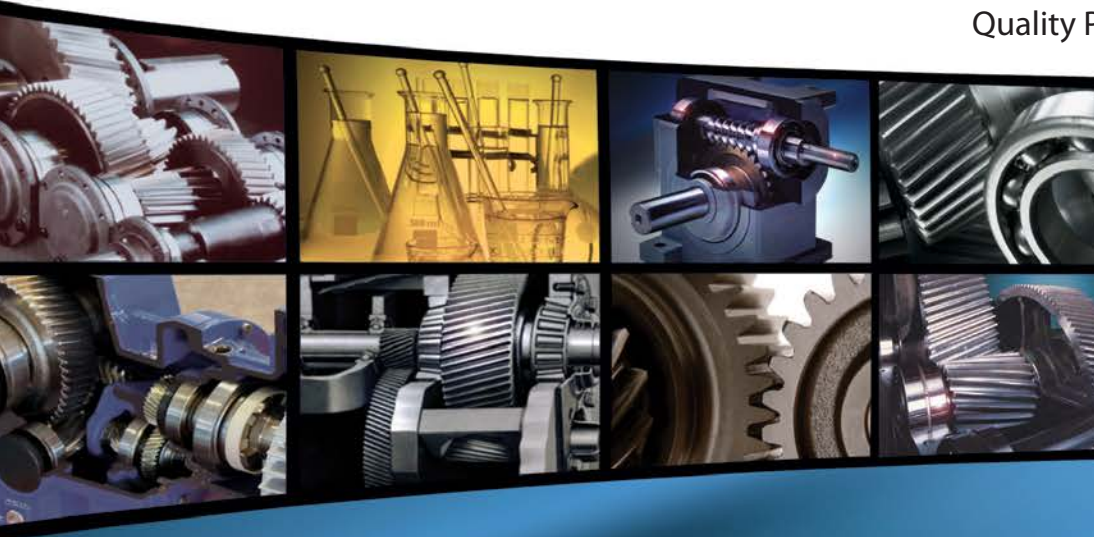
But my guess is also that those lower prices are a temptation for some of you, which is why the online sales channels remain a hot topic at meetings like the BSA's.

The distributors recognize that the game is changing. They know that the online sales channels aren't going away. Some of them with deeper pockets and greater resources—like Motion Industries—provide an online channel that's every bit as convenient as *Amazon.com*. Other distributors with fewer resources may not be able to compete as effectively online, but they're not panicking either. Most distributors know that they provide significant value beyond holding inventory and shipping goods. Their knowledge and understanding can go a long way toward helping you make the right choices when buying products.

And the game will continue to change. How it does so will depend largely on you, the buyers of mechanical power transmission products. So I'm very interested in what *you* have to say, in *your* experiences and *your* company's philosophy and practices. Drop me a line at wrs@powertransmission.com and keep the discussion going.

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OFFERS MOTOR TESTING TECHNOLOGY

The electronic devices used to test and analyze electric motors and other equipment have become much more powerful than in the past. Yet, in many instances these sophisticated devices have also introduced a high degree of complexity for users, requiring that highly trained and experienced personnel perform the testing.

Many of today's devices are feature rich and capable of measuring and analyzing many factors, including surge comparisons, resistance, impedance and more. Unfortunately, not all of these potent systems are very user friendly, and some require a substantial investment.

"Today, you can spend up to \$100,000 on a winding analyzer," says Mark Peden, president of Alliance Pump and Mechanical Service (Independence, Missouri), "but at the same time you could find a very robust model at a much lower price."

Peden, whose company services utilities including water and wastewater treatment plants, as well as municipal, commercial and industrial pumping equipment, elected to do the latter, investing in a powerful portable winding analyzer and motor tester. Not only was the price in the lower range, but also the system is user-friendly and is easy enough to use that highly trained specialists are not required to operate it.

Living up to customer guarantees

"We're a motor shop, which means we clean motors and install or service windings," Peden explains. "We use an

electronic analyzer to test the integrity of the motor windings, to ensure that they are going to provide our customers with dependable performance."

The motors Alliance Pump and Mechanical service have sometimes been subjected to harsh conditions, including excessive heat, debris, or occasional lightning strikes, all of which mean that windings have to be replaced. When a damaged or simply worn out pump and motor assembly arrives at the shop, Alliance technicians disassemble and thoroughly inspect the motor. The windings are then cleaned, baked and surge tested to make sure they are good.

"We have to be certain that the windings are good or six months later a motor could fail, and due to the comprehensive warranty we provide, we'd end up eating the cost of repairing the unit," Peden explains.

Peden says it takes a good analyzer to do a thorough test on the windings to make sure that the integrity of the motor windings is good. "I looked at several different models, and decided that the iTIG II looked like a pretty user-friendly unit that performed all of the tests and reports that we needed."

The iTIG II is a winding analyzer and motor tester from Electrom Instruments (Longmont, Colorado) that comes with varying options and output ranges from 4kV to 12kV. By adding power packs one can go to even higher voltages.

Peden adds that using this winding analyzer and motor tester is like an insurance policy.

"Once we've run the analyzer and everything passes there is no doubt that the motor is good. And it also assures the customer that we did comprehensive testing, and that



everything checked out," Peden says. "After the testing the device gives us a printable report that we provide to our customer as documentation of what we found. It's part of the procedure we follow in motor repair."

Power plant applications

Clark Myers, an electrician at Twin Oaks Power, L.P. (Bremond, Texas) a division of Optim Energy LLC, has been using Electrom winding analyzers for several years at the coal-fired power generation plant. The Electrom testers use high-frequency 60 Hz surge pulses eliminating ionization dissipation and thus better simulating what motors are subject to during operation.

"This is really the only testing and analyzing device we use for checking motors," Myers says. "We also use it on the back of switchgear to ensure proper protection of the motor and the line. Typically this testing is done during a scheduled outage."

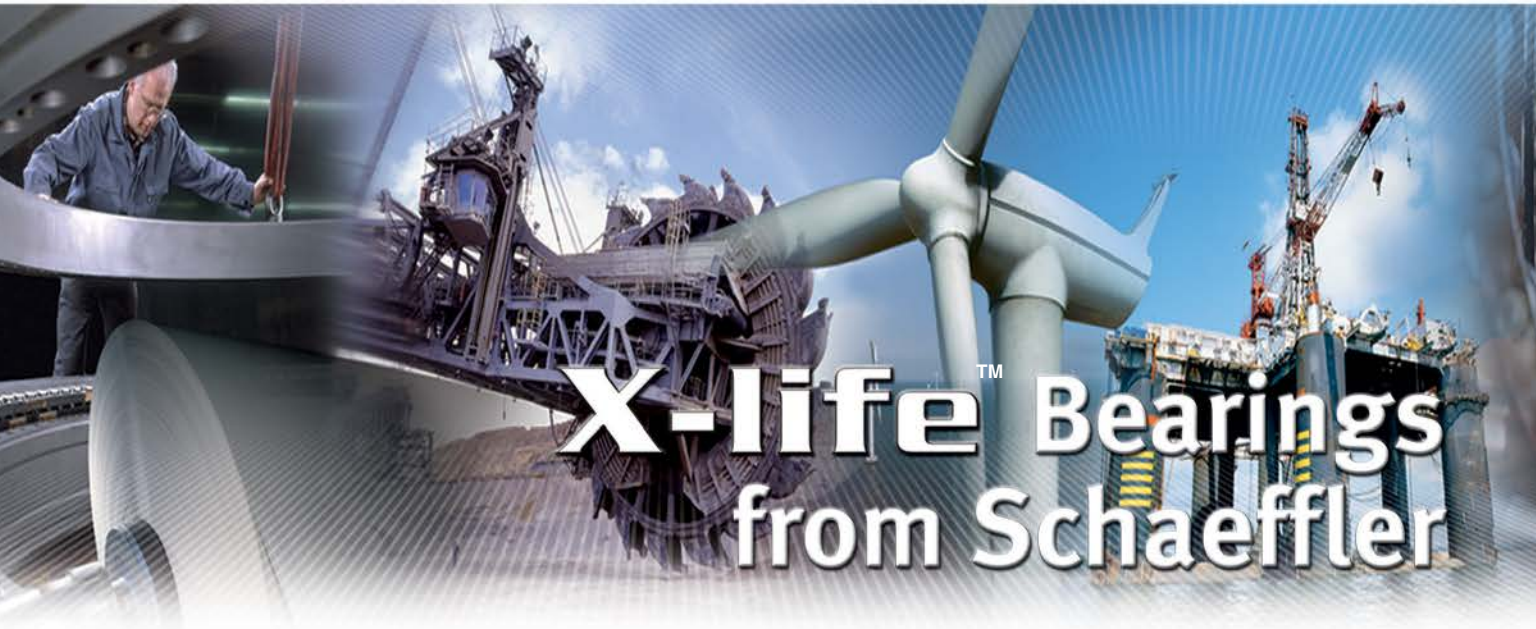
Myers, a 35-year veteran of power plant construction and operation, adds that the iTIG is quite user friendly, and does not require engineering expertise or extensive training to operate it successfully. "I'm not what you would call an expert as far as instrumentation is concerned," he says. "This particular instrument is pretty straightforward. Basically, the company just showed us how to use the device, and ever since it has been pretty much second nature."

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that they are both easy to operate and interpret, but also contain powerful features. The iTIG II that Alliance Pump and Mechanical purchased gives users the ability to perform a variety of tests from the most simple low resistance tests to Megohm (also called insulation resistance), Hipot and advanced Surge testing.

One of the key advantages of all iTIG models is that they use a 60Hz surge pulse frequency, the same frequency as most motors operate at. This high pulse rate provides a sufficient frequency to overcome ionization dissipation and can thus isolate insulation weaknesses with more sensitivity, predicting future faults before low frequency testers, and also better simulates motor operating conditions.

One of the most significant ease-of-use features is that the iTIG II enables users to enter the surge test voltage, push a button, and let the machine run

the test independently. Surge waveform ranges are automatically set for all models, which eliminates the need to specify configurations, push multiple buttons, or turn dials.

All tests can be done with one instrument; they are available in manual to fully automatic models. No additional items are required other than accessories, which can be added on at any time. Tests that can be performed on this system include Surge Comparison, DC Hipot, Step Voltage, Insulation Resistance (Meg test), Dielectric Absorption (DAR), Polarization Index (PI), Low resistance (Ohms), Impedance (Z), Phase Angle, Inductance (L), and Capacitance (C). Models have different features included and all can be upgraded to any higher-level model.

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Bosch Rexroth's GoTo Focused Delivery Program, originally launched in the United States in 2009, is now expanding throughout North America into a single program, with identical product offerings and lead times for customers in the United States, Canada, and Mexico. New manufacturing and logistics infrastructure at various locations in North America have made the expansion possible and reflects the increasing customer need for faster access to Rexroth technologies throughout the NAFTA region.

The GoTo Program, which started in the United States with just over 1,000 part numbers in April 2009, now offers more than triple the original offering and creates an identical program for all customers in the NAFTA region. Nearly 400 new products have been added for the Spring 2014 update. Rexroth also continues to shorten lead times within

the program; 97 percent of the products in the program ship in fewer than 10 days. Key new additions to the program include a wide selection of internal gear pumps, many directional and proportional valves, and a strong foundation of BODAS mobile electronics for flex-



ible, real-time control of electrohydraulic components. Overall, more than 250 new hydraulics products have been added to GoTo. The extensive electric drives and controls offering has expanded with new IndraDrive and safety



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controls products; and assembly conveyor products in the GoTo program now include popular TSplus Stop Gates for the first time. Rexroth is also adding more sizes of tightening systems products to the GoTo program; and the linear motion product offering has been upgraded with the latest generation of roller rail runner blocks for higher load capacities.

Users of Rexroth's popular GoTo Products apps for iPhone, iPad and

Android devices can retrieve all of the updates instantly by using the apps' sync-on-demand feature. The app will be enhanced for Canadian and Mexican customers with the release of version 4.0 in the coming months, including sales channel look-up and local pricing.

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EXPANDS DCX MOTOR SERIES

Like all motors in the DCX series, these brushed DC motors feature high power density and low vibration. In addition to the technical highlights,



the program's appeal lies in the configuration options. Motors, gearheads and encoders may be selected and ordered online. After only 11 working days, even complex drive systems are ready to be shipped. Detailed product data can be viewed online immediately, and 3-D data for the configuration is available for downloading.

The center of the Maxon motor is the unique ironless winding, Maxon System. This motor concept has unique advantages, including low electromagnetic interference and a complete lack of magnetic cogging torque. The efficiency is unrivaled by other motor systems.

The Maxon X drives family is being expanded to include two additional motor sizes: 16 and 32. The new 16 DCX 16 S is available with precious metal and graphite brushes and can be combined with the new GPX 16 planetary gearhead in the customary modular system. Combinations with ENX encoders round off the modular system for demanding control tasks. The new DCX 32 L is also available with graphite brushes and can be combined with the GPX 32. This 32 diameter DC motor is a powerhouse with excellent parameters that can easily hold up to the competition. The high thermal resistance helps it achieve higher continuous power.

Three more versions are also being added to the GPX gearhead family. The GPX 16 and GPX 32 gearheads are available with diameters matching those of the motors, in 1-stage and 2-stage versions. The planetary gearheads have



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scaled gear stages. That means the geometry has been optimized for the load in each stage. With the compact design and the welded connections at the motors, the length may be kept to an absolute minimum. The GP 16 A planetary gearhead, manufactured by Maxon, has been part of the company's product program for many years, with great success. On the GPX 16, it was possible to install larger ball bearings. This increases the maximum permissible radial load by several factors. The maximum permitted input speed was also significantly increased to 14,000 rpm. The GPX 32 planetary gearhead features higher input speeds of up to 7,000 rpm and higher continuous torques of up to 2.9 Nm. The previous values were 6,000 rpm and 2.25 Nm. The 22 planetary gearhead is now also available as a low-backlash version, the GPX 22 LZ. In total, there are now four different gearhead versions available: standard, ceramic, reduced noise level and reduced backlash.

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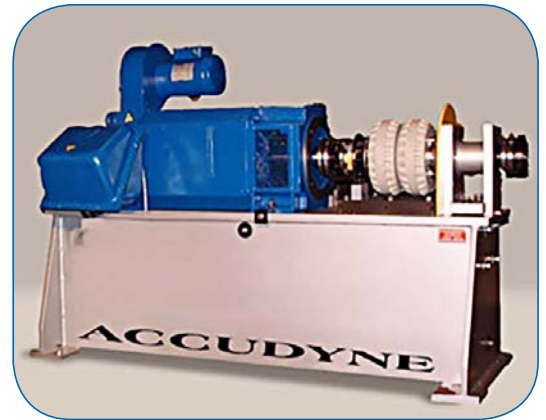
Sakor Technologies, Inc. recently announced the availability of its complete AccuDyne AC Dynamometer system for wind power testing applications. The system can be used by multiple engineering groups to test and verify designs, as well as for quality control testing after manufacturing.

Ideal for testing both active and passive wind power driveline components, the AccuDyne dynamometer system can be used to test turbines and their associated blade pitch control motors, generators and wind-sensing devices and motors, and transmissions. The system can also be used for testing water coolant pumps and other ancillary components.

In addition to independent component testing, the system can also be used to test groups of components si-

multaneously to see how they work together. For those conducting research and development, the AccuDyne can be used to simulate the generator itself during early design stages, before a physical generator or gear box unit exists.

With the AccuDyne, wind power test centers need only one dynamometer to test a wide range of model sizes and verify design specifications for mul-



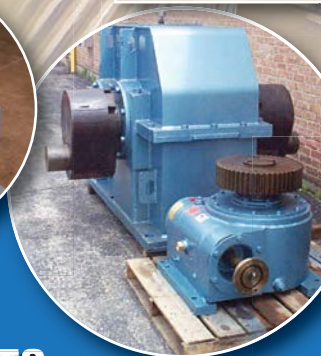
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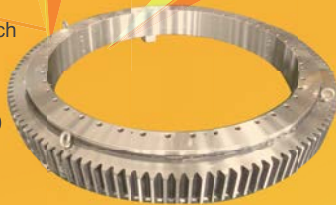
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- ▲ Independent research & development the high load, high life-time shield machine spindle slewing bearing. The special structure (such as overall structure Aluminum bronze cage with the performance oil film guided wedge angle, the logarithmic curve rollers) decide the equality load to each roller that improve the load and life time of the slewing bearing.
- ▲ The spindle Slewing bearings are extensively applied on China's largest rectangular shield pipe jacking, attributed to a substantial cost reduction in manufacturing shield machines.



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multiple product categories and driveline mechanisms. The system is also perfect for research and development groups working on new turbine and generator designs.

The AccuDyne comes packaged with the DynoLab EM test cell control system, making it a complete turnkey system to measure all mechanical and electrical wind power system components and simulate real world conditions in a fully automated test system.

Available in sizes ranging from 3 kW to 10 MW, AccuDyne dynamometers are appropriate for all wind power rotational testing needs. Modern vector drive technology allows the AccuDyne system to provide true 4-quadrant capability, with completely seamless crossover between motoring and loading modes. It also offers the most precise speed and torque control available, especially in low speed applications where full torque can be applied all the way to stall (zero speed).

The DynoLAB EM system offers many advanced features, including the ability to simulate inertia to test a wide range of large and small loads, torque pulse simulation for simulating components that exhibit cogging (such as PM generators), and noise, vibration, and harshness (NVH) testing.

For more information:

Sakor Technologies, Inc.
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SKF

BLACK OXIDE BEARINGS PROMOTE RELIABILITY

SKF black oxide bearings add a surface layer of protection to promote higher reliability and performance for wind turbines. The coating can be specified for all types of critical bearings in wind turbine systems to help promote higher reliability against widely varying temperatures, speeds, and loads and to resist contaminants, moisture, and chemicals that otherwise could limit bearing lifecycles and increase costs of turbine operation and maintenance. The coated bearings can be introduced into new installations or serve as replacement upgrades.

Black oxide bearings ultimately can increase turbine uptime by enhancing resistance to corrosion and smearing; improving performance in low-lubrication conditions; limiting risk of fretting, micropitting, and cracking; reducing potential damage from aggressive oil additives; and reducing the effects of friction and wear.

The black oxidation surface treatment is applied to a bearing's rings and/or rollers. The process - involving a chemical reaction at the surface layer of the bearing steel - is performed in an alkaline aqueous salt solution at defined temperatures. Up to 15 different immersion steps create a thin, dark

black surface layer delivering a significant performance upgrade for the broad range of bearing types and sizes in wind turbines (up to 2.2 m in diameter and up to 1,000 kg per individual bearing component).

Suitable bearing types for the coating include tapered roller bearings, cylindrical roller bearings, spherical roller bearings, and CARB toroidal roll-

er bearings, among others playing vital roles in wind turbine systems.

For more information:

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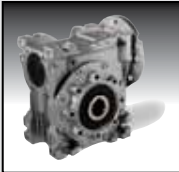
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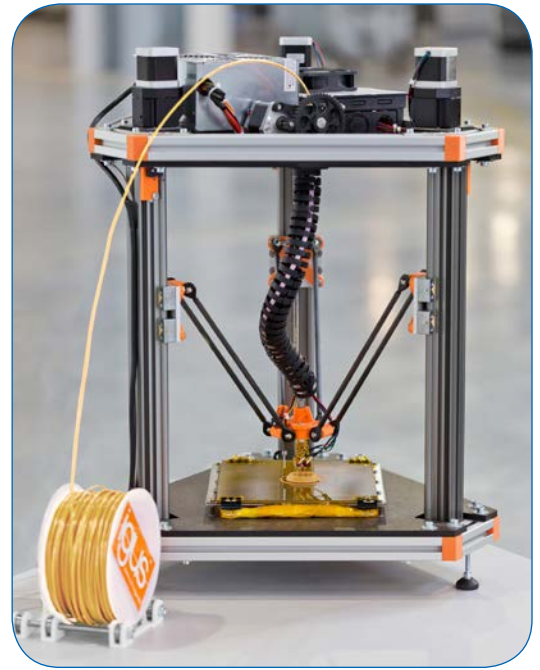
Igus

INTRODUCES PLASTIC FILAMENT FOR 3-D PRINTING

Plastics expert igus has introduced the world's first plastic filament for 3-D printers enhanced with tribological, or low friction, properties. The material, 50 times more resistant to wear and abrasion than conventional 3-D printer materials, is ideally suited for creating custom bearings.

Igus has been researching filaments for 3-D printers in order to provide customers with more flexibility in their design ideas. Now, for example, customers can design custom parts or manufacture prototypes, while still being able to rely on the dependable, tested service life of igus plastic materials.

This exciting new product, which has already completed countless tests in the Igus test lab, is the first filament for 3-D printers specifically developed for motion control applications. Currently, Igus carries 45 different high performance plastics as optional materials available for Iglide products, with a further 100 custom materials suited to specific, demanding customer needs. Moving forward, the new filament



will give customers more flexibility for the design of their application's bearings, even prototypes can be produced quickly and cost-effectively. Igus also offers access to 3-D models of Igus products in STL format, which can easily be downloaded and used directly as input data for 3-D printing.

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square-wave signal with frequency of 100 kHz. Signal quality exceeds industry standards for voltage amplitude and signal rise-time while driving as much as 350 meters (~1150 ft) of cable when terminated into a 40 ma resistive load. Signal integrity is maintained with temperatures ranging from -40 to 85 degrees Celsius. Lower frequencies would allow for even longer cables.

For more information:

Leine & Linde (Heidenhain)
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NSK

LAUNCHES BEARING SOLUTIONS APP

NSK has launched a Solutions App that works alongside the company's Added Value Program AIP to improve efficiency, reduce breakdowns and improve profitability for industrial users. The NSK Solutions App guides users through a series of application scenarios to illustrate how substantial savings can be made by applying the right Solution in challenging industrial situations.

Effectively a window into the AIP program, the App is designed to help identify the root causes of problems and provide a guide to real-world applications where savings have been made. A range of potential solutions can be explored that have been achieved by using the structured AIP approach in combination with NSK's high quality products.

Progress through the App begins by choosing industry sectors; they range from food & beverage to steel production, machine tools and quarrying & mining (more to come). Users can then decide to investigate solutions based around specific applications, or select the prevailing conditions that relate to their own production site. Within each sector there are a range of different application scenarios to choose from al-

lowing users to match their own equipment or conditions with examples provided by the App.

The App then provides detailed Success Stories on different industrial applications. Each application describes the issue that has been solved and provides details of the product that solved the problem; it also provides a figure for the financial savings achieved. The savings take into account a combination of factors such as replacement costs, maintenance costs, consumables and downtime.

AIP is designed to deliver real benefits in operating costs, efficiency and profitability across all industry sectors. These benefits are achieved by delivering tangible savings to assets, such as equipment and machinery, and also by improving the working

knowledge of maintenance and engineering personnel.

The NSK bearing solutions App is a free download available from iTunes for Apple devices and Google Play for Android and Windows based mobile devices, there is also a desktop PC version which is available to download from the NSK website below.

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Lubrication and Seals

Product Showcase

Klüber Lubrication

INTRODUCES BEARING GREASES

Klüber Lubrication, a worldwide manufacturer of specialty lubricants, has introduced Isoflex Topas NB 52 and Isoflex Topas NB 152, two rolling and plain bearing greases based on a synthetic hydrocarbon oil and a barium complex soap. The products help optimize operational reliability, cut servicing costs, conserve energy and extend maintenance intervals. The special barium-soap thickener used in the Isoflex Topas NB 52 and 152 greases offers good load-carrying capacity, as well as resistance to water and ambient media. Both products protect against corrosion, as well as oxidation and ageing.

Isoflex Topas NB 52 is suitable for temperatures ranging from -60°F to 250°F and short peak temperatures up to 300°F depending on the application. Isoflex Topas NB 152 can be used in a wide service temperature range of -40°F to 300°F. Isoflex Topas NB 52 is a versatile grease for many applications, including:

- rolling and plain bearings subject to high speeds and loads, as well as low temperatures – ideal for road, side-guide, and up-stop wheels
- tooth flanks in precision gears, such as bevel gears in milling machines and electromechanical actuators for valves

The following news items offer the latest on lubrication and seal technology in the power transmission market. From bearing greases to high-performance seals, these products will help extend the service life and manufacturing capabilities for a wide range of industrial sectors. Companies featured include Klüber Lubrication, SKF, Garlock, Schaeffler, Shell Lubricants, Trelleborg and Moventax. For additional information on lubrication and seal technology check out the Power Transmission Engineering Buyer's Guide at www.powertransmission.com.

- electric contacts and components to reduce insertion forces

Isoflex Topas NB 152 is compatible with many plastics and is used primarily for medium speed rolling and plain bearings, fan bearings and pump bearings. The grease is also suitable for plastic/plastic or steel/plastic friction points. "Using Isoflex Topas NB 52 and Isoflex Topas NB 152 greases leads to

more consistent torque over a wide temperature range as well as longer component life when exposed to water or aqueous media," said Stephen Mazzola, director of engineering & technical services for Klüber Lubrication North America L.P.

For more information:

Klüber Lubrication
Phone: (603) 647-4104
www.klueber.com



SKF

INTRODUCES AXIAL EXCLUDER SEAL

The new SKF axial excluder seal introduces an ideal high-performance alternative to conventional rubber seals for protecting wind turbine main shaft bearings from contaminants. Ultimately, the seal represents an advanced first line of defense against any debris or contaminants the wind may carry and can help wind farm operators significantly reduce the risks of contaminant-related bearing failures

and the high costs of associated unplanned downtime, repair, and lost productivity.

Unlike conventional rubber seals typically prone to excessive wear and subsequent failure, the SKF axial excluder seal (designated HRC1) is manufactured from a proprietary SKF polyurethane material exhibiting excellent resistance to wear, abrasion, UV radiation, and ozone.

Key design features include a robust sealing lip to help reduce bending and minimize contact area, friction, and wear; optimized flexibility and engineering geometry allowing axial displacement of ± 2 mm; and integrated grooves to keep the sealing edge properly lubricated. In addition, the seal features a stainless steel clamping band with a fast-lock mechanism to facilitate easy up-tower installation

Garlock Products

RECEIVE UPGRADED INGRESS PROTECTION RATINGS

The Garlock family of companies announces that several products in the Klozure line of bearing isolators have received upgraded ingress protection (IP) ratings from the National Electrical Manufacturers Association's NEMA MG-1 2009 Part 5 specification. The Guardian, Micro-Tec II, SGI and EnDuro have been upgraded from IP55 and IP56 sealing ratings to IP65 and IP66 sealing ratings, confirming their suitability for use in applications where no liquid or dust ingress is permitted.

"The newly upgraded ratings for the Klozure bearing isolators are important for our customers," says James Wong, associate product manager for bearing isolators at Garlock. "The IP65 and IP66 ratings allow our customers to protect their equipment against dust



and liquid contaminants, and will help reduce unexpected downtime and equipment damage."

IP ratings signify contaminant protection levels. While IP5x products can effectively protect equipment against dust, sealing products with an IP6x rating ensure zero dust intrusion making the equipment dust tight. IP65-rated seals protect against dust and forced water intrusion, whereas IP66-rated seals protect against dust, increasingly powerful water jets and heavy seas.

Klozure bearing isolators are designed to protect machinery in the world's manufacturing industries from dust, liquid and abrasive particle contamination while helping to ensure uninterrupted production with reduced maintenance. Testing services for the IP65 and IP66 ratings were performed by a third party evaluation group.

For more information:

Garlock
Phone: (800) 448-6688
www.garlock.com

and fixation on the shaft, whether for new installations or retrofits.

Early field trials confirmed the HRC1 seal's performance levels and robustness. Seals installed on 40 separate 2.5 MW turbines operated continuously under real-world conditions and, after three months, an initial inspection revealed only normally expected run-in wear - with no dramatic changes six months later.

HRC1 axial displacement seals are available in standard solid and split versions for shaft sizes from 1m to 3m. Custom solutions can be developed.

For more information:

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Schaeffler

OFFERS MULTI-POINT LUBRICATOR FOR ROLLING BEARINGS

This year, Schaeffler unveiled its unique multi-point lubricator for rolling bearings. The system can be adjusted to provide four different lubrication volumes to cater for bearings with varying lubrication requirements.

FAG Concept8 is an innovative, cost effective lubrication system for rolling bearings that ensures a constant, optimum supply of grease to the bearings without the need for manual intervention, particularly if machines are located in difficult-to-access areas or are deemed as critical to the production process.

FAG Concept8 provides up to eight separate lubrication points for dispensing precisely metered quantities of lubricant to rolling bearings. The system can dispense lubricant to rolling bearings in a wide range of industrial applications, including pumps, fans, compressors, gearboxes, electric motors, machine tools, wind turbines, as well as production lines in food and beverage processing plants.

FAG Concept8 is fitted with four pairs of lubrication points (eight in total), which are controlled by four individual dispensing pumps. Unlike other multi-point lubricators on the market, FAG Concept8 enables users to individually control each pump in order to optimize cycle times and volumes of dispensed lubricant (lubricant can also be dispensed in a 'pulsed operation'). This means the system can be adjusted to meet up to four different bearing sizes, each with varying lubrication requirements - an industry first. Rather than having to purchase multiple single point lubricators to cope with different bearing lubrication requirements, users can now buy one FAG Concept8.

FAG Concept8 is also equipped with heated outlets, which ensure reliable dispensing intervals, even at low tem-



peratures when the grease is more viscous. In addition, as the lubricant is stored in a transparent replaceable cartridge, users can easily check the lubricant level, enabling easier fill-level control. The system is easy-to-use with an integrated LCD user display that provides clear navigation menus and two keypad control buttons for set up and adjustment.

FAG Concept8 operates on Schaeffler's Arcanol range of lubricants. This range includes 17 different greases, each one developed by Schaeffler application engineers and produced by leading international lubricant manufacturers. These greases therefore provide specific lubrication properties for almost every type of industrial application.

For more information:

Schaeffler
Phone: (800) 243-7512
www.schaeffler.us

Shell Lubricants:

CHINA MARKET GETS NEW TECHNOLOGY CENTER

Shell recently opened a new technology center in Shanghai, China dedicated to research and development into lubricants and oils. The center (Shell (Shanghai) Technology Limited) will focus on lubricant product development and application for China and the wider Asia region covering countries such as India, Indonesia, South Korea, Thailand and Vietnam. Matthias Bichsel, Shell's projects and technology director, said, "The Shanghai facility will proudly bring Shell's technology leadership even closer to customers and partners in the region. Shell has long been at the forefront of lubricant science and technology. We recognize that better oils and greases can lead to energy savings and improved machine performance." The center will become a part of Shell's network of lubricants laboratories, working closely with the other two centers, in Hamburg, Germany and Houston, USA. These are part of a wider 10-center strong global network of Shell R&D centers. "The new center reflects the direction of the Shell Lubricants business today and the central role that China plays in its long-term growth strategy," said Mark Gainsborough, executive vice-president Shell Lubricants. "We are well-positioned to meet the anticipated growth in demand in the region. Locating in Shanghai will help us work more closely with our customers and shape mutually beneficial collaborations."

For more information:

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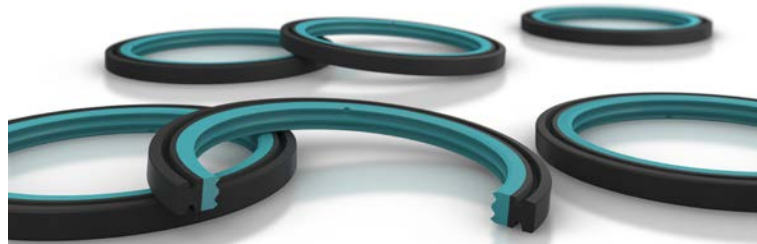
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Trelleborg

FOCUSES ON PRODUCTS AND SERVICES

In 2014, Trelleborg Sealing Solutions presented its "Trelleborg Solution," advanced delivery services and customized packaging as well as its array of innovative products including Turcon, Glyd Ring II, Zurcon Glyd Ring D and high performance rotary seals. With a focus on increasing the Total Value of Ownership (TVO) for customers and



supplying not just the highest quality of products, but also services, the "Trelleborg Solution" from Trelleborg

Sealing Solutions helps accelerate customers' business processes and delivers seal application and design for even more efficient manufacturing. When coupled with its advanced delivery services, Trelleborg Sealing Solutions can help empower fluid power component manufacturers through vendor-managed inventory and supply chain solutions, such as value-added packaging and handling services. These give customers the ability to customize packaging and labeling for a more simplified stocking and handling operation. Peter Hahn, president, Trelleborg Sealing Solutions Marketing Americas, says: "Our value proposition to our customers is a significant cost savings proposal through a radically different concept in helping our customers to not only *rethink their profitability* but actually deliver the solutions to help achieve it. As a forward-thinking company, we not only intend to bring business accelerators to the forefront for our customers but also to help them to implement and achieve increased business value."

Product highlights include: Turcon Glyd Ring II, a double-acting, rod or bore, bi-directional seal for reciprocating and static applications offering lowered friction and yielding a longer service life, Zurcon Glyd Ring D seal that is produced from a completely new Zurcon material and engineered to extend seal life in high-pressure hydraulic sealing applications. It is well suited for machines, equipment and motors filled with hydraulic cylinders and rotary seals that extend product life while improving safety and performance in extreme environments in power transmission and motion control applications.

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Moventas

DEVELOPS GEARBOX LUBRICATION FOR WIND TURBINES

Moventas has developed a special gearbox lubrication upgrade for customers operating WinWind made WWD3 turbines, to extend their lifetime. The first one of these projects will be carried out for Innopower in Kemi, Northern Finland.

Moventas carries out a lubrication upgrade for ten turbines in the Ajos wind park in Kemi as part of a larger service project. The lubrication upgrade that prolongs turbine lifetime consists of upgrading the entire gearbox lubrication system, installing extra pumps for the main bearings and adding temperature sensors, changing the coolers and updating the lubrication management logic. With the upgrade, lubrication will also be added in situations where it has previously been insufficient.

"We have high expectations for this upgrade. Key main components should last until the end of turbine lifetime. Professional maintenance and condition management enables minimizing potential risks. High-quality components, reliable solutions and professional partners are the secret to wind power's success," comments Production Manager Raine Laaksonen from Innopower.

Installing the upgrade only takes a few days, but considerably prolongs turbine lifetime, as functioning lubrication efficiently prevents main component failures. The installations take a maximum of five days per turbine, depending on the delivery scope. The service project of all ten turbines both on and offshore along with calibration and testing will be completed in August, says Moventas' Nordic Service Sales Manager Teemu Hyytiäinen. "We have a long-standing, good cooperation with our partner network for the benefit of customers who own WinWind turbines in Finland as well as the rest of Northern Europe, where these customers' wind parks are located."

Lubrication upgrades tailor-made for different gearbox types are just one example of the upgrade services that Moventas offers for prolonging gearbox lifetime. These include e.g. bearing solution modernizations, ring wheel material and heat treatment changes, housing enforcements and accessorizing. Depending on the ser-

vice, it can be carried out either in a Moventas workshop in Finland, Germany, U.K., Australia or the United States or up-tower in a wind park.

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Best Practices for Bearing Protection

Adam Willwerth

For either brand-new motors or those already in service, “best practices” means that informed technicians can make use of the latest diagnostic techniques (vibration analysis, thermography, shaft-voltage testing, etc.) to prevent electrical bearing damage—either at the very beginning or very quickly thereafter. If done correctly, the work need only be done once.

The Problem: Electrical Bearing Damage

Variable frequency drives (VFDs — or inverters) can save 30% or more in energy costs. Because of this, they have been identified as a key technology for those wishing to make their processing plants, automated assembly lines, HVAC systems, and other equipment more energy-efficient (“green”). Unfortunately, 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 a VFD yields and severely diminish the reliability of an entire system.

The Causes

Bearing failure rates vary widely, but evidence suggests that a significant portion of these failures occur only three to 12 months after system start-up. Because many of today’s motors have sealed bearings to keep out dirt and other contaminants, electrical damage has become the most common cause of bearing failure in AC motors with VFDs.

The high switching frequencies of today’s VFDs produce parasitic capacitance between a motor’s stator and rotor. By now it is widely understood that, once the resulting shaft voltages overcome the dielectric properties of bearing grease,

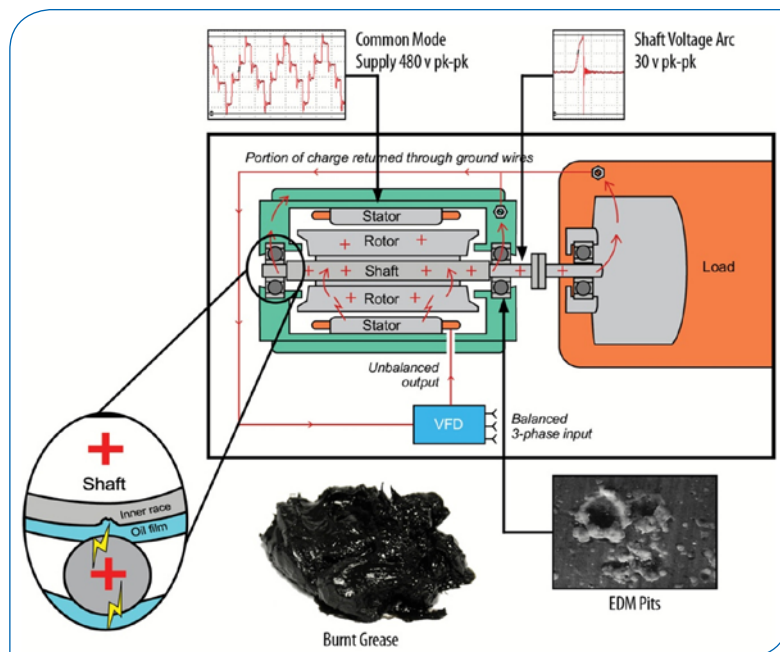


Figure 1 Voltages arcing through the bearings of VFD-driven motors create thousands of pits, which cause increased friction and noise and the potential for costly unplanned downtime as bearing grease deteriorates.

they discharge along the path of least resistance — typically through the bearings (Fig. 1).

These discharges are so frequent that they create millions of tiny fusion craters. Before long, the entire bearing race wall can become marked with countless pits, known as “frosting.” A phenomenon known as “fluting” may occur as well, shaping the frosting into washboard-like ridges across the bearing race (Fig. 2). This causes noise, vibration, increased friction — and catastrophic bearing failure.

Types of Damage

As the bearings degrade, the tiny metal particles blasted from the fusion craters intensify friction and abrasion, heat up the bearings, and burn the contaminated grease. Too often, the end result is bearing failure and costly, unplanned downtime.

Understanding the Damage

Cutting and carefully inspecting the bearings of motors needing repair will often provide information that can be used to prevent a recurrence of the problem. Following established safety precautions, technicians should:



Figure 2 In a process called fluting, pits form washboard-like ridges on a bearing race wall — ridges that cause still more noise and vibration and accelerate bearing failure.

For Related Articles Search

bearing protection

at www.powertransmission.com

- Inspect the bearing cavity, retaining a sample of the grease in case further analysis is warranted to detect contaminants, signs of excessive heat, etc.
- Cut the outer race in half.
- Clean the bearing's components with a solvent.
- With a microscope, inspect the race walls for electrical pitting/frosting/fluting.

Protecting Motors for the Long Term

If inspection of the old bearing indicates electrical damage, the most reliable and cost-effective way to protect replacement bearings is to install a modern shaft grounding ring. Unlike older single-point contact brushes, these rings completely surround a motor's shaft with contact points. Conductive microfibers should line the ring's entire inner circumference, boosting the electron transfer rate (Fig. 3). A properly installed ring provides a very low impedance path from shaft to frame, safely bleeding off damaging voltages to ground and bypassing the motor's bearings entirely. And because the microfibers work with little or no contact, they do not clog up and wear out like conventional grounding brushes.

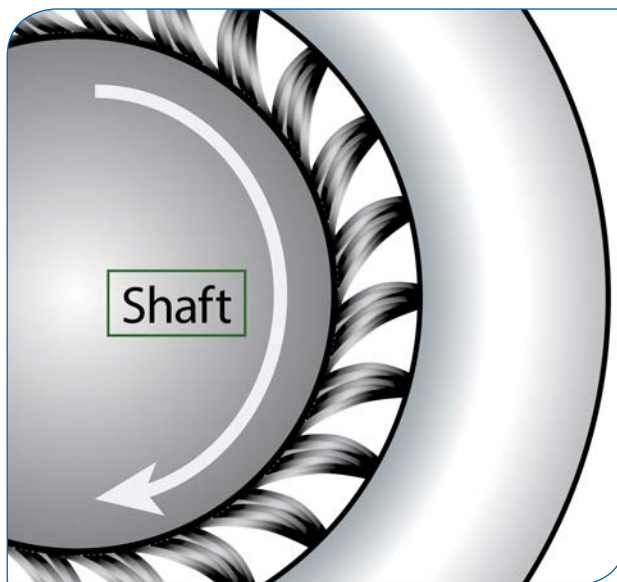


Figure 3 The best grounding rings are lined with flexible, conductive microfibers that completely surround the motor shaft.

A growing number of forward-looking motor manufacturers have recently added a factory-installed shaft grounding ring as a standard or optional feature on certain models, but they are still exceptions to the rule. Many industrial supply houses and distributors of motors and bearings sell grounding rings that can be installed on new, refurbished, or in-service motors.



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Tips & Tricks for Ring Installation

To maximize a grounding ring's effectiveness, all electrical paths must be conductive; paint on the motor's faceplate must be removed. Likewise, the motor's shaft must be clean down to bare metal. Even after scrubbing with emery cloth, wiping the shaft with a non-petroleum-based solvent will remove unseen residues. After cleaning, the conductivity of the shaft should be checked with an ohm meter. If the reading at the section that will contact the ring's microfibers is higher than two ohms, the shaft should be cleaned again.

A grounding ring should never operate over a shaft keyway, which has sharp edges and could reduce conductivity. On some motors the dimensions of the spacer and mounting screws can sometimes be adjusted/changed to avoid a keyway. If this is not feasible, the portion of the keyway that will contact the ring's microfibers should be filled with epoxy putty.

Conductivity should be further enhanced by lightly — but evenly — coating with colloidal silver any portion of the shaft that will contact the ring's microfibers. This will also help retard corrosion (Fig. 4).



Figure 4 Prior to installation of a grounding ring, the motor shaft must be cleaned down to bare metal, free of any nonconductive material. Conductivity can be further enhanced by coating the part of the shaft that will contact the ring with colloidal silver.

Thread-locking gels and liquids other than conductive epoxy are not recommended for the screws that mount the ring to the motor, as they might compromise the conductive path to ground.

The ring should be centered on the motor shaft so that its microfibers contact the shaft evenly.



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When mounting the ring externally to an end bracket, split rings designed to slip around an in-service motor's shaft instead of over its end simplify installation.

After installation, testing with an ohm meter is again recommended. The best method is to place one probe on the ring and one on the motor frame. (The motor and drive must be grounded to common-earth ground in accordance with applicable standards.)

Variations on a Theme

For environments where the motor will be exposed to excessive amounts of dirt, dust, or other debris, it may be necessary to protect the ring's fibers with an O-ring or V-slinger. Bearing isolators with built-in circumferential grounding rings are also available. For severe-duty environments such as many mining applications, however, mounting the shaft grounding ring inside the motor provides the best protection from contamination (Fig. 5). Using conductive epoxy or screws, the ring can be mounted directly to a bearing retainer. An additional machined spacer will keep the ring away from the bearing grease cavity. Metal-to-metal contact is still essential, so the bearing retainer must be free of any coatings or other nonconductive material where it will touch the ring.

For horizontally or vertically mounted motors with horsepower of 100 (75 kW) or less and single-row radial ball bearings on both ends, a shaft grounding ring can be installed on either end. For horizontally mounted motors with horsepower greater than 100 and single-row radial ball bearings

on both ends, the bearing housing at the non-drive end must be electrically isolated to disrupt circulating currents. Options for achieving such isolation include insulated sleeves, nonconductive coatings, ceramic bearings, or hybrid bearings. The grounding ring should be installed at the drive end.

For any motor in which the bearings at both ends are already insulated, the drive end is preferred for installation of a grounding ring to protect bearings in attached equipment, such as a gearbox, pump, fan, or encoder.

For any motor with cylindrical roller, Babbitt, or sleeve bearings, the end with such bearings should be electrically

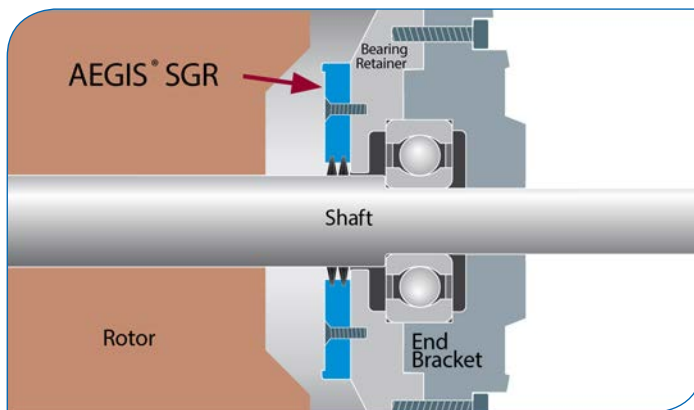


Figure 5 Internal installation of the grounding ring provides extra protection from dust, dirt, and other contaminants in severe duty applications.

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isolated and the grounding ring should be installed at the opposite end.

Protection Should Start at Installation

Measuring shaft voltage on a VFD-driven motor provides valuable information for determining whether there is a risk of electrical bearing damage. The best time to take such measurements is during the start-up of a new or recently repaired motor. Every motor has its own unique parameters. Combined with vibration analysis, thermography, or other diagnostic services, results (including saved oscilloscope-screen images) can be presented in a report to the supervisor/customer. Results should then be used in developing preventive and predictive maintenance programs.

Shaft voltages are easily measured (using appropriate safety procedures) by touching an oscilloscope probe to the shaft while the motor is running. The best probe will have a tip of high-density, conductive microfibers to

ensure continuous contact with the rotating shaft. A portable oscilloscope with a bandwidth of at least 100 MHz should deliver accurate waveform measurements; probe/oscilloscope kits are available.

Confirming that Motors are Protected

Just as shaft voltage measurements can show that a motor's bearings are in danger of electrical damage, they can also confirm that a shaft grounding ring is working. If a proven ring has been properly installed, typical discharge voltage peaks should be less than 10 volts.

Getting the Most from Your Motors

In summary, end users of VFD-driven motors have every right to expect uptime and reliability. After all, VFD-induced electrical bearing damage can now be prevented, not just repaired. Routine inspection, testing, and analysis can provide advance warning and

insight into the problem, and when bearings fail, proper repair practices can fix the problem—permanently. Motor shaft grounding rings such as AEGIS bearing protection rings can be installed during motor repairs or on new motors before they are put into service.

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Adam Willwerth, sales and marketing manager for Electro Static Technology, has extensive experience in industrial product development. He is named on four patent applications pertaining to conductive microfiber shaft grounding technology, and has presented seminars on the subject of bearing current mitigation at professional conferences in the U.S. and Europe. For a 36-page handbook on the practices summarized in the above article, contact www.est-aegis.com/bearing.

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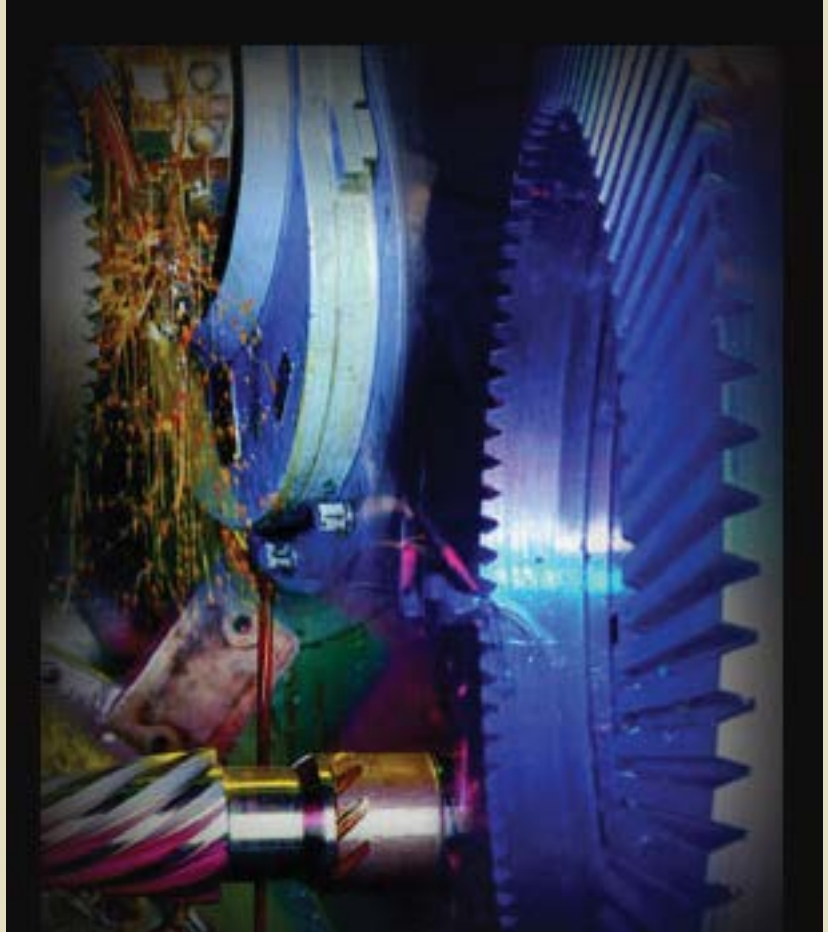
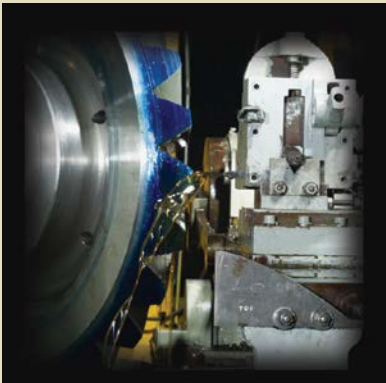
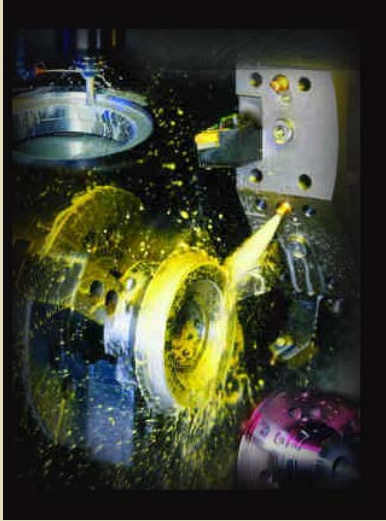
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Under Pressure

Wichita Clutch helps drive storm simulator at the University of Florida

Approximately \$10 billion in damage occurs in the United States annually due to natural events, the majority from Category 3, 4 and 5 hurricanes. In 1992 Hurricane Andrew caused more than \$25 billion in just Dade County Florida. In 2005, Hurricane Katrina caused more than \$100 billion in total economic loss. In 2009, Henry Upjohn, CEO of Special-Lite, Inc., a manufacturer of heavy duty entrance door systems, was approached by a business acquaintance that works with the insurance industry, and routinely tours post-storm environments. This professional explained that he regularly finds instances where roll-up and sectional garage doors, built to known standards and storm ratings, were consistently failing at levels below their rating. There was a need to develop better diagnostic tools to understand how building components and claddings respond to extreme wind effects.

During that initial meeting, it was suggested that Upjohn should meet Dr. Forrest Masters, Ph.D., P.E., associate professor of civil and coastal engineering at the University of Florida (UF). The UF wind engineering program is one of the largest of its kind in the



Damaged sectional roll up door following test (all photos courtesy of Altra).

United States. The group is well known for full-scale research, i.e. performing experiments in hurricanes or replicating their effects at a sufficient scale and realism, to evaluate the performance of complete building systems.

Upjohn and Dr. Masters met soon after, and decided to build a testing apparatus capable of simulating wind and

wind pressure associated with some of the most severe weather known on the planet. Conventional solutions were not up to the task, so they formed a diverse engineering team encompassing civil, mechanical, manufacturing and industrial engineers to create a one-of-a-kind machine capable of simulating the damaging effects of hurricanes and other extreme wind events.

Conceptually, the system can be thought of as a means to replicate naturally-occurring wind and pressure caused by turbulence in the approach flow and flow distortion around a building. For example, if a pressure sensor recorded high-fidelity data on the wall of a commercial building in Homestead, Florida during Hurricane Andrew, the simulator can “replay” this pressure sequence in its entirety. Ideally, the measured and artificially-applied load would be virtually indistinguishable.

To meet the challenge, Upjohn developed original simulator concept design drawings, as well as personally supervised the simulator construction and assembly at the Powell Laboratory on the University of Florida’s campus. He and various members of his engineering



J. Alex Esposito, M.E., E.I.T, lab manager, Powell Family Structures and Material Lab at the simulator’s analog control panel designed by Henry Upjohn. Monitors and equipment for digital test data capture are seen in background.

and electrical fabrication team from the Special-Lite facility in Decatur, Michigan took many trips to Gainesville, Florida over the course of 18 months during the simulator construction.

Simulations Get Real

The new simulator, officially referred to as the Dynamic Wind Velocity and Pressure Simulator (DWVPS), is a unique machine that creates dynamic simulated Saffir-Simpson Scale Category 5 pressure events that produce rapidly fluctuating positive and negative pressures on a test specimen to determine at what level failure, if any, occurs. The simulator's primary function is evaluate the performance of large component and cladding systems with the goal of designing better, more robust products that will endure all classes of hurricane and tornado events.

Some of the examples for the use of the simulator relating to the construction industry include testing for both sectional and roll-up garage doors, entry doors, windows, curtain walls, siding, shingles and soffits. Other exterior components affected by extreme wind loads caused by hurricane and tornado events can also be tested. The system operates in two modes. The apparatus has a simulation range capability of 460 psf at 70,000 cfm leakage in the pressure chamber and 230+ mph in the high-speed test section. "We can replicate wind effects expected on buildings expected to occur during an entire hurricane passage," Dr. Masters said. "A strong Category 5 hurricane is not a problem. We haven't run a simulation yet, but I'm confident we can also simulate loads on a low-rise building in an EF4 tornado."

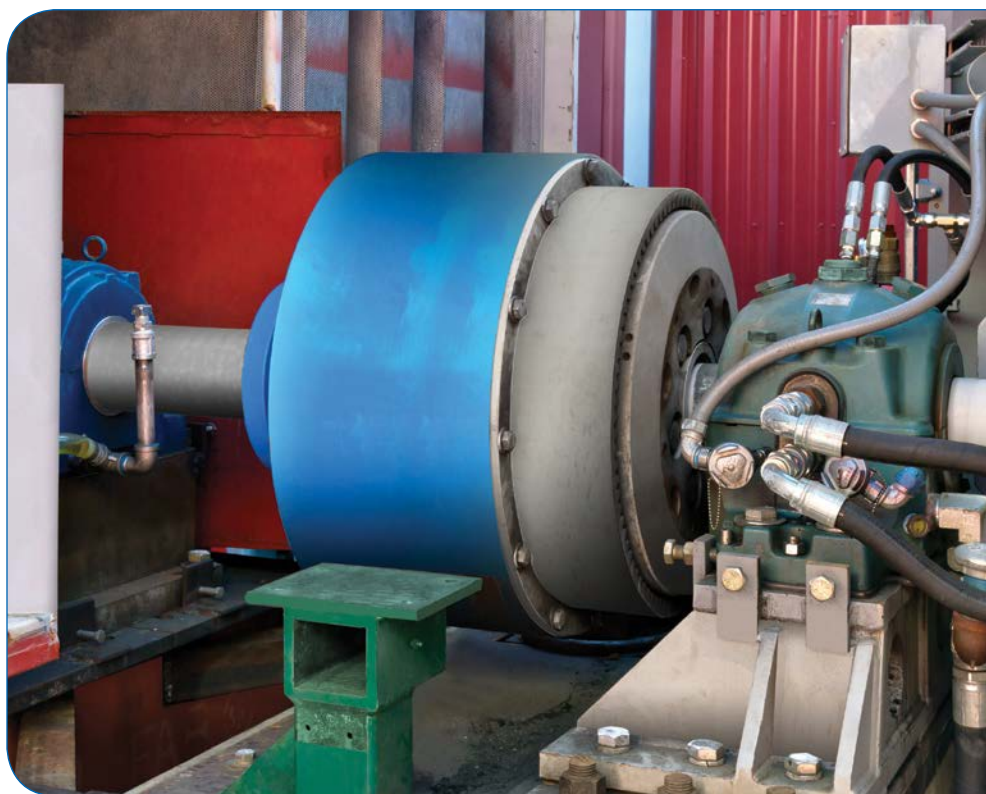
The DWVPS also features a velocity simulation area which subjects smaller specimen samples (typically shingles and siding) to high speed wind flow with rapid fluctuations.

Funding for the simulator was provided primarily by Special-Lite, with support from the Florida Catastrophic Storm Risk Management Center at FSU, the Florida Building Commission, Oak Ridge National Laboratory and the University of Florida. "The new simulator complements multiple modeling and testing apparatuses, ranging

from universal testing machines, to the boundary layer wind tunnel. Its specific purpose is to apply out-of-plane loading to large-scale building components and cladding to understand how they behave under dynamic wind loading. The findings (data) are used to verify computational modeling and rational engineering analysis," Dr. Masters said. Test data is captured on the DWVPS with load cells, strain gauges, photogrammetry and HD video. Deliverable data includes forces (reactions), strains, 3-D displacement, and video of the entire test to identify time and degree of damage. The principal

- Heavy-duty 60" duct work
- (4) 60" dampers to change function of air system (butterfly valves)
- 4-blade opposed louver to modulate air flow through the fan
- Post-tensioned, reinforced concrete pressure chamber and accompanying reaction frames
- Analog control to drive louver valve

The deep air box is a unique component of the simulator. It is capable of housing a 24' wide and 18' tall test specimen. 100 tons of concrete and 10 tons of rebar were used to build the air box with 16" thick side walls and a 22" thick backwall to withstand the forces



Wichita standard ventilated clutch installed with drive ring.

construction took approximately 18 months. There were other activities leading up to the main phase of the construction and also verification/commissioning. The first trials occurred in August 2012.

Complex Engineering and Construction

The simulator consists of the following primary components:

- 1800 hp Caterpillar diesel engine
- 100,000 cfm @ 80" diameter w.c., 1,750 rpm fan

upward of approximately 450 lbf/ft². The pressure exhaust bell and the vacuum inlet bells are cast permanently in the back wall of the air box. The test specimens are mounted to the front of the air box and can be tested in either pressure or vacuum modes.

Function through the simulator is controlled by dampers. The simulator has (4) 60" dampers, one on the inlet, one on the exhaust, one on the pressure side of the air box and the other on the vacuum side of the air box. Closing off the vacuum damper in the air box

and closing the exhaust damper creates a pressure build up in the air box. Closing the inlet damper and the pressure damper in the air box creates a vacuum in the air box.

The modulating louver valve is the key to recreating the rapid pressure fluctuations that occur in a real hurricane. The louver valve is operated by an analog control that allows the louver to open and close very quickly to disrupt flow through the simulator causing varying pressure in the air box and on the test specimen. Data (voltage) sent to the analog control will be actual pressure traces recorded from a model structure in a wind tunnel or a field measurement from a real building in a storm. The modulating louver valve can function anywhere between fully closed to fully open. This rapid movement in the louver will cause an interruption in the airflow, causing the test specimen attached to the air box to react accordingly.

The variable speed of the engine and fan required a novel approach to the fan's plain bearing temperature control. The control features a tempered heat transfer fluid (HTF) loop with 9 kW of heat as well as an outside charging loop of 35°F chilled HTF for each fan bearing. Control is executed as PID, 0-10 VDC driving three-phase, solid-state relays for heat and 4-20 ma driving 50:1 turndown controls for cooling. Prior to engine start up, the driveline oil temperature of 70 degrees F must be achieved. Safe guards are in place in case of accidental overheating or overcooling of the system. A clutch was required to provide a frictional interface which brings the fan up to the same rpm as the engine. The engine was coupled to a drive shaft. The clutch coupled the drive shaft and the fan shaft, as shown below.

Wichita Clutch Meets the Challenge

Jeff Baillairge, application sales engineer at Torque, Inc., a major Wichita Clutch distributor, was called in to help determine an ideal clutch solution for the project. "Accelerating a fan with a large inertia is always a challenge, as there is an abundance of heat that the clutch must deal with during

slipping. After studying the hp and torque curves of the Caterpillar 12-cylinder, 1,800 hp diesel engine, we recommended engaging the clutch at a very low idle rpm to limit initial heat buildup," Baillairge said.

The layout of the drivetrain changed several times during the project's design phase, resulting in different clutch models to be considered along the way. Initially, the clutch was to be mounted directly to the back of the Cat engine, but later changed to a shaft coupling clutch positioned farther down the drivetrain.

Baillairge worked closely with Al Smith, applications engineer at Wichita Clutch, to determine that a standard ventilated clutch with three

plates would be an excellent choice due to the large amount of frictional surface area available to deal with the extremely high heat of engagement. Also, the relatively small 21" diameter was able to rotate at the high 1,750 rpm of the engine.

The Wichita ATD-321-X standard ventilated clutch acts as a combination clutch and shaft coupling which is designed for reliable in-line power transmission. The simple air tube design, with small air volume, effectively speeds engagements and disengagements. It is unaffected by centrifugal force and has no self-energized effects like drum clutch designs. This clutch is suited for large inertia loads where smooth controlled starts are required.

The Wichita air-tube disc design combines all the best features of a disc type clutch with all the advantages of direct air engagement. Full-width molded composition teeth on friction discs minimize wear on the drive ring. It is the simplest and most trouble-free method of applying air pressure yet designed. "We designed and manufactured a modified Wichita standard ventilated clutch to meet the unique performance expectations. The clutch was dynamically-balanced and featured a torque rating of 350,000



Setting strain gauges on subject door prior to testing.

lb-in and 1,086 in² of lining area with special high-energy linings, a custom bored hub, high-speed hoses and a high-speed air tube and steel pressure plate," Smith said. "While competitor clutches could not handle either the excessive heat nor the high speed requirements, the Wichita standard ventilated dry friction clutch is designed to be punished and can stand up to the massive inertia of the 17,000 lb. blower fan assembly."

Upjohn explained the elaborate control system that feeds air to the clutch bladder. The air feed system is comprised of a manual three-way block and bleed valve, some check valves, a regulator, the air tank, three filters, a proportional valve, an emergency release valve and finally a rotary union. Several pressure switches determine that no pressure is on the clutch at engine startup. The manual lockout is off. The clutch pressure is not less than the predetermined minimum and full air pressure is available before the clutch engagement begins.

Electro Hydraulic Analog Servo Control was Critical

The design and development of the elaborate analog control system was quite complex. Henry Upjohn enlisted

the help of Dr. Bob Nicholson, an analog controls engineer out of Birmingham, Michigan, who has more than 40 years experience of developing high-speed control systems for hydraulic and pneumatic servo applications.

According to Upjohn, PLC's are an easy and very cost-efficient way of implementing industrial control. They also run on a program that is very easy to alter leading to lots of flexibility. The ladder logic programs that are run by PLC's run in sequence, from top to bottom. The time required to run the program is short, on a step-by-step (rung-by-rung) basis.

Some outputs do not work as intended if there are even small delays between calculations of the output valve. As an example, the calculations of two different RPM's whose difference is needed at a very high frequency on an almost continuous basis. In order to accomplish this, the calculation of each RPM and their difference is inserted into the PLC ladder, not once, but every 10 or 20 rungs to keep the output current. Several of these fast calculations may be required resulting in a greater time needed to run through the ladder (in this case, one to a few seconds).

Obviously, this technique only works for a few time-critical outputs. The outputs that are not required to be so fast are significantly delayed. In the vast ma-

majority of systems these delays have little or no meaningful effect. However, in this system, where there are a large number of safety systems that must react quickly to prevent damage, this delay is not tolerable. Thus, the entire safety control was accomplished with hard-wired, heavy-duty industrial control relays and industrial machine switches.

As a result, the "program" is very robust since rewiring is required to make a change. It is not easy to make a logic change, which is desirable in safety systems that must be shut down in certain specified orders, to prevent other damage such as melting the fan's bab-bitt bearings. Finally, each reduction to out-of-tolerance safety values happens just as fast as any other, usually as quick as a magnetic field in the relay can be collapsed.

The complexity of the simulator subsystems requires a 20 minute start-up sequence. "We like to run the engine at 1,200 rpm to warm everything up and then we take it down to 450 rpm to engage the clutch," Upjohn noted. "We go from totally disengaged to totally locked up in 17 seconds. And during that time, we're using the absolute maximum amount of torque that the engine can produce. So the engine isn't producing any extra torque and making it slip. We are actually loading the clutch as heavily as we can and not stalling the engine."



Engine/Blower drivetrain features left to right, engine, coupling, bearing assembly, shaft drive ring, Wichita clutch, bearing assembly and blower assembly.

Upjohn and Nicholson personally designed the elaborate control systems. All the control panels were assembled, per Upjohn's original drawings, at a facility in Michigan. The final wiring was completed by his team when the panels were installed on site. The analog control for the simulator uses absolute pressure transducers to measure the pressure in the airbox that has the device under test (DUT) fastened to it. The transducers are analog feeding an analog control receiving analog commands. Thus, several A/D and D/A converters, with their associated time delays, were eliminated. The transducers measure the pressures in two separate locations. These signals are then averaged.

The command is a recording of the pressure on a model in a wind tunnel. Alternatively, real pressure measurements on existing structures can be replayed. The recording is characterized as large pulses (up to 400 lbs/sq ft) at a low frequency (~.3Hz) decreasing continuously to ~10 lbs/sq ft at ~10Hz. 10Hz is faster than the control is expected to be able to maintain a 1:1 relationship between the input and output. For this reason, from ~3Hz up to ~20 Hz, the command will be increased proportionately, e.g. doubled at 6Hz.

Since its installation, the simulator has proven to be a real work horse, performing tests on discontinuous roof cover systems such as asphalt shingles and roofing tiles, and sectional doors. Special-Lite considers the machine to be a major step forward in the research and development of residential and commercial building systems intended for high-wide areas. The simulator will soon be made available for use by any company or institution for materials testing. **PTE**

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THE QUESTION

What Are the Best Methods to Adjust Tapered Roller Bearings?

Expert Response Provided by: Norm Parker, Technical Specialist – Driveline Bearings, GM Milford Proving Grounds

One of the most popular discussions around tapered roller bearings (TRBs) involves methods for adjusting or preloading. We are always looking for ways to increase preload accuracy, reduce manufacturing complexity and improve serviceability. We will review some common methods while highlighting a few benefits and drawbacks of each.

There are two different buckets we can throw preloading methods into; one we will call a “direct” method and the other, “indirect.” The end goal of preloading is to have a net axial load on the bearing while at rest. The “direct” method either directly measures the axial force on the bearing during preload or measures the axial displacement based on a known displacement vs. force chart to make a shim selection. The “indirect” method uses a measured relationship between the axial load placed on the bearing and the torque needed to rotate it. For this method the preload will be set by measuring the rotating torque of the bearings as an indirect way of measuring the axial preload.

Direct Method

Many people may more readily recognize the direct method as a solid

spacer and shim arrangement. In this method the housing and bearing dimensions are measured and a shim size is calculated to give a desired dimensional offset or interference. This is considered a direct method because the bearing is being displaced by a known value, which directly correlates to an axial preload with very little variation.

This method can be extremely accurate (but still only as accurate as the shim thickness increments and tolerances) or about as accurate as an indirect method. If we need high accuracy, each housing and bearing can be measured prior to installation and the appropriate shim will be selected to reach the desired interference for the bearing set. If less accuracy is needed, the direct measurements can be skipped and the assembly will rely solely on the tolerances of the mating components. This is usually only recommended where some end-play is desired and can be verified after assembly. Trying to preload solely based on tolerances will almost certainly result in some over-preloaded sets which will produce early failures.

Indirect Method

Many TRB applications are set up through the indirect method of measuring the assembled turning torque of the bearing set. Wheel bearings, pinions for axles and PTUs, final drives and others are set up using this method.



Figure 1 Solid spacer and shim pack.

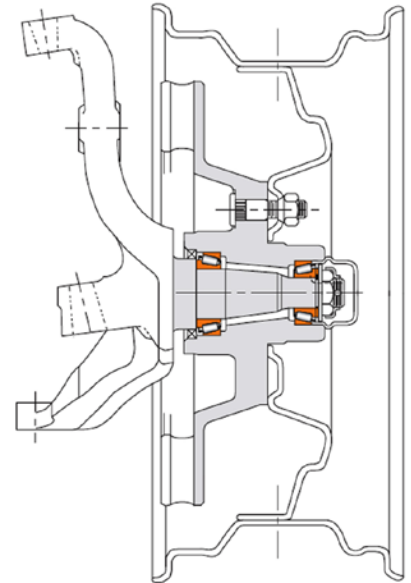


Figure 2 Wheel ends set up through tightening the bearing nut.

The indirect method is less accurate than the direct method because the torque vs. preload relationship is less accurate than axial displacement vs. preload relationship. You could easily expect a 20% scatter for preload ranges with this method. However, for high production and serviceability, this is often a manageable trade-off. The indirect method may or may not use some type of elastic or collapsible spacer between the bearings as a means of adding resistance to the preloading process in an effort to avoid over-preloading and sometimes increase the nut torque if a prevailing torque requirement is needed.

Just as with the direct method, we can add or remove accuracy to this system as needed. If higher precision is needed, the individual bearings can be measured for torque and then set up. This removes the bearing-to-

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Figure 3 Timken AP bearing arrangement.

bearing torque variation and makes for a very accurate system.

Purchased Assemblies

In a perfect world, we could utilize the many variations of paired assemblies that are already preloaded or matched sets that utilize ground shim arrangements that assemble to hit the perfect preload every time. Often, our unique assemblies can't accommodate these nice, premium products and we have to set the preload in the factory.

Conclusion

Clearly, there is no "best" method for preloading bearings. The method is usually selected based on what is possible with the bearing arrangement, the surrounding componentry, available resources, budget, manpower, factory capability and serviceability. We can adjust our needed accuracy by measuring each individual bearing or rely on statistical deviation.

Usually, the system architecture will push you into a method. If a bearing tightening nut is possible, this is usually desired because it is an adjustable, easy-to-use system. However, inside a manual transmission or power takeoff unit, there is no external access and the only option is to measure and shim.



Figure 4 Iljin Gen 2 hub unit.

In certain applications where failure is not permissible or the system is not available to reliably set the preload, we may be pushed into purchasing an assembled bearing arrangement. Today, automotive front wheel hubs are almost exclusively assembled, preloaded, bolt-on units. This can be a costly upgrade, but sometimes, considering the cost of failure, this may be the best option available. (See p. 38 for Parker's "Tapered Rolling Bearing Application Guide.") **PTE**

Norm Parker is the bearing technical specialist for the driveline division at General Motors LLC, located onsite at the Milford (MI) Proving Grounds. With his bachelor and master degrees in mechanical engineering from Oakland University (Rochester, Michigan), Parker has developed a keen, diversified interest in the academic, commercial and engineering aspects of the bearing industry.



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BEARINGS

Tapered Roller Bearing Application Guide

Norm Parker

This article summarizes some common hurdles, issues and questions encountered by the newer and casual users of tapered roller bearings.

There are few other bearings that can drive people into fits like tapered roller bearings. They are supplied as two separate pieces, the installation must be perfect, they usually need to be preloaded, they are temperamental and hard to service; but, when your application demands maximum precision and power density, there are few alternatives that can compete with the tapered roller bearing, aka TRB.

Below is a basic 1-5 rating chart showing the benefits and drawbacks of the most popular bearing selections (there are many more). In terms of load and abuse-handling capability, the TRB earns its place as the king of bearings.

If you are a new designer or application engineer for TRBs, the “how-to” guides are abundant but tend to talk in generalities. Usable information can be difficult to find. This guide attempts to address some common trouble areas that are not always obvious to the casual user. This article will frequently refer to the bearing catalogs, so it will be useful to have one handy for reference.

Intro to TRBs

Becoming familiar with TRB nomenclature will become useful as you walk through the application process. For the purpose of this guide we will limit the discussion to radial, single-row tapered roller bearings with stamped cages, as opposed to the various paired arrangements and cages which are more common in heavy industry.

TRBs have separable cups and cones and are usually sold individually. It

would not be the first time that somebody started building prototypes to find they only ordered half of the bearing. Matched sets are available for higher precision, but are difficult to implement in high-production operations because the cup is often installed into the housing as a completely separate operation from the cone. Cups and cones from different suppliers should not be mixed. Even though the part numbers and appearance may be identical, the crowning of the contact surfaces between the cone, cup and rollers are designed to match and are not standardized.

The cone of the TRB will always come assembled with the rollers and is referred to as the cone assembly. The assembly consists of the cone, rollers and cage. For small to medium



Figure 2 Single-row TRB. (courtesy Schaeffler Group)



Figure 1 TDO-style dual-row TRB. (courtesy RKB)

	Tapered Roller Bearing *	Ball Bearing	Angular Contact Ball Bearing*	Cylindrical Roller Bearing	Needle Roller Bearing
Radial Load	1	3	3	1	1
Axial Load	1	4	2	5	0
Combined Radial/Axial Load	1	3	2	5	0
Power Density **	1	4	3	2	2
Vibration & Impact Capability	1	3	3	2	4
High Speed Capability	3	1	1	2	1
Low Torque	3	1	1	2	1
Rigidity	1	4	2	3	3
Misalignment Capability	3	2	2	4	5
Preload Capability	1	5	1	0	0
Overall Ease of Use	5	1	5	3	3

1 = Best, 5 = Worst, 0 = Not Capable, * Preloaded matched pair, ** Load rating/mass

sized applications, the cage will always be stamped strip-steel of various grades. For large bearings, where the size of the stamping becomes impractical, pin-type, machined steel or brass cages may be utilized. Wheel hub assembly tapered bearings often use polymer cages but are not yet available in single-row tapered bearings (but we have been assured for the last decade that they are “almost” ready).

TRBs can only take a thrust load in one direction and therefore need to be paired with a mating bearing for most applications. Occasionally a TRB is paired with an angular contact ball bearing for various reasons; but overwhelmingly, two tapers are paired together. The two are often different sizes, depending on the loading situation.

Sizing up Your System

Likely, one of the first things you will receive as the bearing application engineer is the duty cycle and a schematic of the system, and/or you will be asked to help develop one. Early in the design stage, it is not uncommon for this to change weekly or even daily, so set up a system that is easy to make iterations with. By the end of a design cycle you may easily have over 100 iterations of a design. You will thank yourself later for utilizing good organization early on.

It is fairly common practice for the bearing engineer to reduce the duty cycle down to a workable size of 10–15 steps through equivalent damage calculations, which are beyond the scope of this article. It is important to capture adequate parts of every section of the duty cycle to ensure you don’t average out a problem area. For instance, while you may only have 100k cycles and a very low speed and high torque, this section may cause trouble down the road if ignored. While you are working on the duty cycle, it is also very useful to have a separate reduction of only one step; that is one single equivalent load, speed and life requirement for the entire duty cycle, in addition to the 10–15 step reduction. This makes for an easy way to calculate an estimated load rating needed for the bearing. An example of this is shown later.

After you have the duty cycle ready and have enough information to calculate loading, it is time to get down to business. Early on, you should determine the critical characteristics of the design. Assuming top priority is always meeting the basic durability functions—Is stiffness a critical function? Is efficiency important? Will your lubrication become contaminated? Are there safety concerns with failure? Do you expect impact loading? All of these questions will guide you to what level of quality, safety factors and material type you may need.

If you have a bearing software suite, most of the work for determining bearing loads will be spent in modeling your system. Don’t be discouraged if you don’t have software, as many complicated systems are still calculated by hand. If you don’t have the (substantial) budget for modeling software and you frequently design similar systems with several iterations, it may be worth taking the time to make your own program. A simple program to calculate axle loads on each bearing can be made in *Excel VBA* forms in a few days with very limited programming knowledge (one way is to just open *Excel*, hit alt-F11 and you are off to the races). Many free sources are available online for training and reference. Otherwise, you can just plug-and-chug formulas into a spreadsheet.

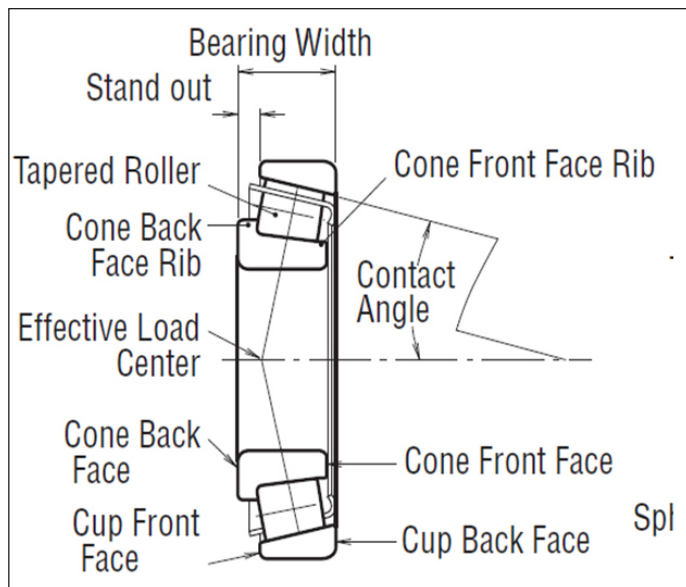


Figure 3 TRB features.

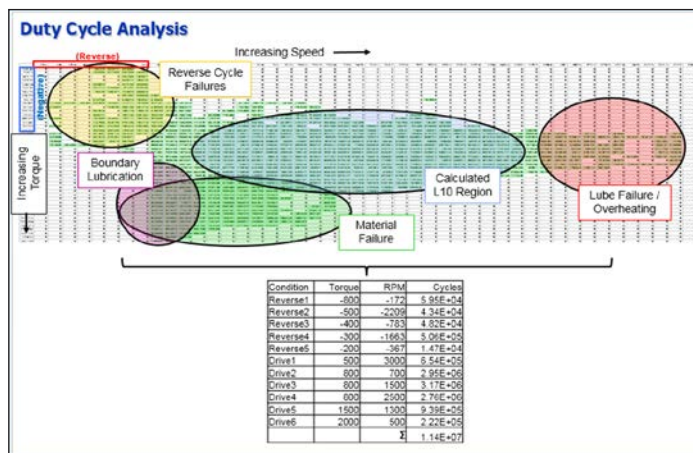


Figure 4 Reducing the duty cycle into workable pieces.

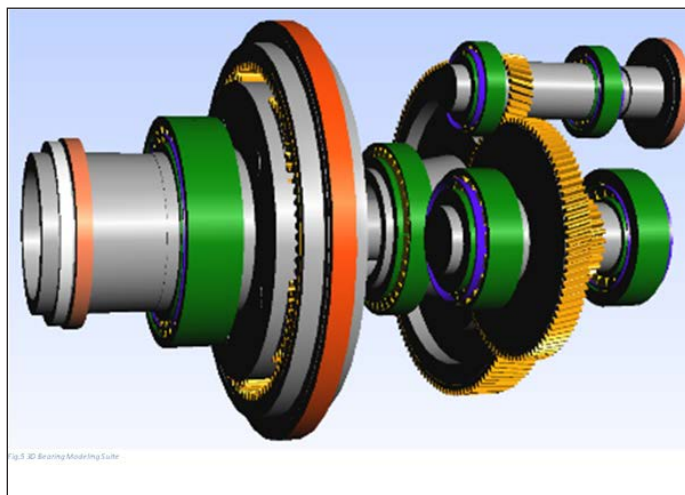


Figure 5 A 3-D bearing modeling suite.

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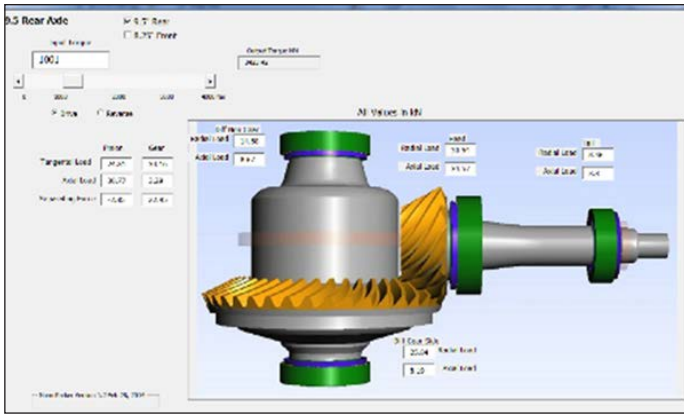


Figure 6 Excel VBA form.

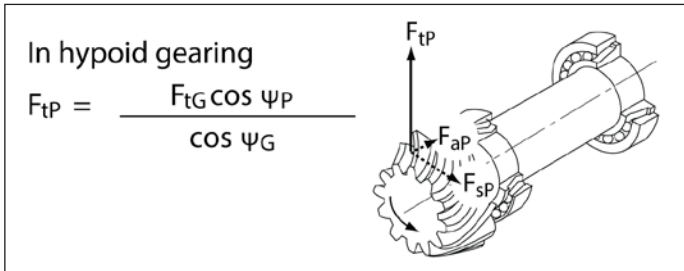


Figure 7 Timken hypoid calculations section.

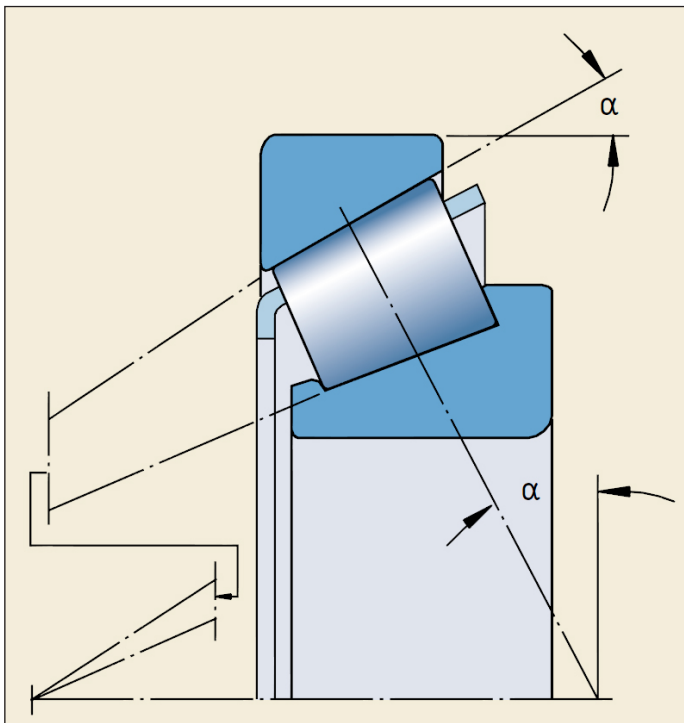


Figure 8 TRB contact angle. (courtesy SKF)

Most bearing catalogs have a nice section outlining how to calculate bearing loads for various systems. This is a tedious and time consuming process, but when executed properly, is accurate enough for most purposes.

For fatigue, or L_{10} calculations, we only need to be concerned with radial and axial loading. The direction of the radial load and the resultant between radial and axial loads will be used in other areas, but is not needed for L_{10} .

After your loading calculations are set up, the next step is to select representative bearings. This will be an iterative process, so your best guess is sufficient at this point.

As you browse your bearing catalog, you have likely noticed there are inch and metric series bearings. There is actually a third type hidden in the inch series section known as the “J” series. The “J” series is basically metric-sized and tolerance-bearing, with an inch style numbering system. Most major bearing companies produce all three series, though non-U.S. companies tend to produce more metric sizes while large domestic suppliers (particularly for axles) have a wider offering of inch and “J” series. *Just a note of caution here:* the inch and metric series bearing tolerances are in opposite directions. Metric and “J” series bearings always have a unilateral negative tolerance (e.g. 40 mm +0/-0.012), while inch series always have a unilateral positive tolerance (e.g. 40 mm +0.013/-0). It is not uncommon for both series to be in the same assembly; if this is overlooked for fitting, headaches will ensue.

Now we can get in the ballpark for the minimum dynamic load rating. If you binned down your duty cycle to one step, now is an excellent time to use it. We can easily calculate a minimum dynamic load rating based on that value (See Example 1).

Example, Part 1.

Using standard catalog formulas and equivalent damage methods for a pinion head bearing, you have calculated an equivalent load of 10 kN for a duration of 2.5×10^9 cycles at 1,000 rpm. What is the minimum dynamic load rating to meet this criteria?

Having a single step value of 10 kN allows us to take a good guess for a bearing we might need by using the basic L_{10} formula: $L_{10} = (C/P)^{10/3}$

Plugging in our values and solving for the dynamic load rating C, we have (L_{10} is measured in millions of cycles):

$$2500 = (C/10,000N)^{10/3}$$

$$\rightarrow C = 10,000N(2500hr)^{3/10} = 104,564N$$

Our minimum anticipated dynamic load rating will be roughly $C_r: 105\text{ kN}$

Contact Angle α

Now we have a dynamic load rating target, but we have no idea what contact angle α is needed. There are a few different strategies for selecting a good angle, but all are centered on finding the ratio between radial and axial loads. When we refer to the contact angle, we are always referring to the angle of the cup in relation to the shaft or centerline (Fig. 8).

Generally speaking, if the radial (F_r) and axial (F_a) loads are equal, a decent contact angle would be in the 20-25° range. The greater the radial / axial load ratio, the lower the contact

angle should be and vice-versa. Ranges are typically 10-12° on the low end and 25-40° on the high end. If we had no axial load, we could flatten the bearing out completely and change over to a cylindrical bearing ($\alpha=0^\circ$). If we had no radial load, we could change to a pure thrust bearing ($\alpha=90^\circ$).

If the ratio of radial to axial loading remains constant (e.g. gearbox), this is an easy step because there is only one ratio. After the radial and axial loads are calculated, they can be resolved on the X-Y plane to give the loading direction in relation to the bearing contact angle (Fig. 9).

$$\tan^{-1}(Fr/Fa) = \text{resultant loading angle}$$

It might be tempting to conclude that the complement of the resultant would be the perfect contact angle, as it represents the plane normal to the load. There are a few issues with this; first, TRBs are about twice as stiff in the radial direction as the axial, so we want to take advantage of that by putting more load in the radial direction. Secondly, the steeper the angle, the larger the induced axial load (explained in the following section), which places more load on the opposite bearing. Finally, if there is a reverse load, it will likely have a completely different resultant load and needs to be accommodated. For these reasons, it turns out that approximately half of the complementary angle is often a decent contact angle to start working with.

Induced Axial Load F_{ac}

Directly related to the contact angle is the concept of induced axial loading F_{ac} . This is purely a function of geometry of the bearings. In Figure 10, if we only apply a radial load to the larger bearing, an axial component is developed as a function of the force acting on an inclined plane. That force is transmitted, or induced, through the shaft, to the other bearing with a magnitude of:

$$F_{ac} = \frac{F_r}{2Y_1}$$

Where Y_1 is the axial load factor that can be found in the bearing catalog tables for each bearing or can be calculated as shown below:

$$Y_1 = 0.4 / \tan(\alpha)$$

A deeper dive into induced axial loading is beyond the scope of this article, but a rule of thumb is to consider that, for many TRBs, approximately one-half the radial load is induced as an axial load on the opposite bearing. If both bearings are identical and have equivalent loads, these forces will balance and have no effect on fatigue life. When the bearings are different in size and loading conditions, care must be taken to ensure the induced load

on the smaller bearing is not being overlooked as it can be substantial.

Materials

Bearing companies have been arguing for 100 years over which type of steel is best suited for different bearing applications. Outside of the U.S., the overwhelming majority of bearing steels are through-hardened. In the U.S., however; there is a substantial supply of case-carburized TRBs. Even in the U.S., the other bearing types (ball, needle, cylindrical, etc.) are usually through-hardened. What makes the U.S. unique is in part due to the early days of the industry where high-production bearing companies founded in the U.S. began using case-carburized low-carbon steel due to lack of supply for high quality through-hardened steel in contrast to Japan where through-hardened steel was more available.

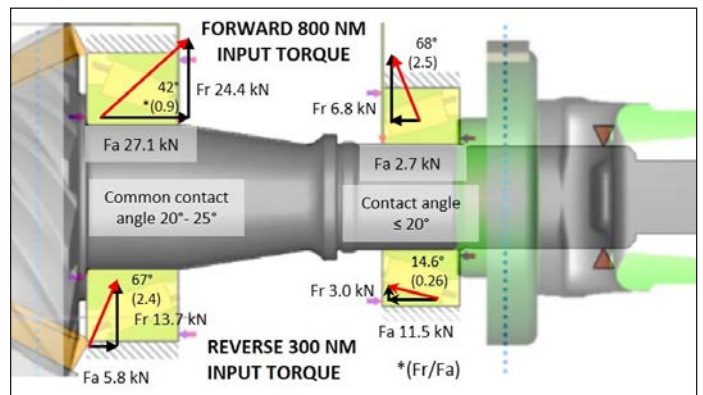


Figure 9 Pinion bearing load ratios.

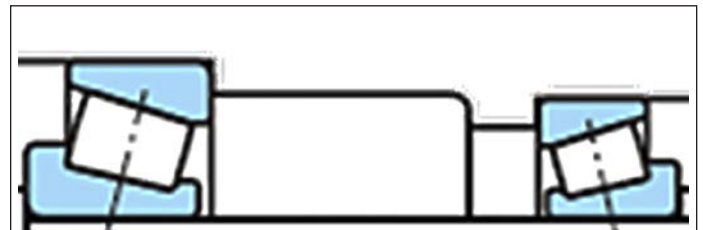


Figure 10 Induced axial load.

d	Boundary dimensions (mm)					r _{min.}	r _{1 min.}	Basic load ratings (kN)		Bearing No.		Constant e	Axial load factors	
	D	T	B	C	C _r			C _{0r}	Inner ring	Outer ring	Y ₁		Y ₀	
45.242	73.431	19.558	19.812	15.748	3.6	0.8	55.6	78.1	LM102949	LM102910	0.31	1.97	1.08	
	77.788	19.842	19.842	15.080	3.6	0.8	57.1	73.5	LM603049	LM603011	0.43	1.41	0.77	
	77.788	21.430	19.842	16.667	3.6	0.8	57.1	73.5	LM603049	LM603012	0.43	1.41	0.77	
	79.974	19.842	19.842	15.080	3.6	0.8	57.1	73.5	LM603049	LM603014	0.43	1.41	0.77	
45.618	85.000	23.812	25.400	19.050	3.6	2.4	77.2	100	25590	25526	0.33	1.79	0.99	
45.987	74.976	18.000	18.000	14.000	2.4	1.6	52.6	74.6	LM503349R	LM503310	0.40	1.49	0.82	
46.038	79.375	17.462	17.462	13.495	2.8	1.6	47.1	59.1	18690	18620	0.37	1.60	0.88	
	85.000	20.638	21.692	17.462	3.6	1.2	71.8	81.7	359A	354A	0.31	1.96	1.08	
	85.000	20.638	21.692	17.462	2.4	1.2	71.8	81.7	359S	354A	0.31	1.96	1.08	
	85.000	25.400	25.608	20.638	3.6	1.2	80.0	106	2984	2924	0.35	1.73	0.95	
47.625	88.900	20.638	22.225	16.513	3.6	1.2	74.3	87.3	369A	362A	0.32	1.88	1.03	
	88.900	25.400	25.400	19.050	3.6	3.2	87.1	112	M804049	M804010	0.55	1.10	0.60	
	95.250	30.162	29.370	23.020	3.6	3.2	104	140	HM804846	HM804810	0.55	1.10	0.60	
	96.838	21.000	21.946	15.875	0.8	0.8	80.4	101	386A	382A	0.35	1.69	0.93	
	101.600	34.925	36.068	26.988	3.6	3.2	131	159	528	522	0.29	2.10	1.16	
	104.775	30.162	29.317	24.605	4.8	3.2	109	144	463	453X	0.34	1.79	0.98	
	104.775	30.162	29.317	24.605	0.8	3.2	109	144	467	453X	0.34	1.79	0.98	

Figure 11 Standards Catalog (excerpt).

A common rule of thumb (though not written in stone) is if the application is going to experience sustained loads above 50% of the static load capacity with substantial shock loading, case-carburized steel is a good consideration. It is generally accepted that case-carburized bearings will outperform through-hardened bearings in high-performance applications, providing both are standard, non-premium products made with the same steel quality. Several enhancements can be made to either bearing to skew the results to the casual user.

The driving difference between the two materials lies in the residual stresses of the finished bearing. Fatigue theory has shown that materials with a greater net compressive residual surface stress will outperform those with low compressive or tensile surface stress.

Typically, case-carburized bearings have a high net-compressive surface stress, while the through-hardened bearing will have little if any compressive stress. In fact, if you cut through a bearing cone pressed onto a shaft, a case-carburized bearing will often clamp onto the grinding wheel or saw while a through-hardened bearing will pop open. If a substantial press fit is needed for a through-hardened bearing cone, there is a good chance the bearing cone is in tension after installation. This does not mean the bearing cannot perform well, in fact they frequently do. It simply means that if heavy loading and shock loads are present, a similar quality, case-carburized bearing would likely perform better. On the other hand, there is some argument that if the loads are low to moderate, a through-hardened bearing may perform better because the steel near the surface is often cleaner, resulting in longer fatigue life. People can (and do) go on for days about the potential benefits and drawbacks of each.

Another consideration is carbon-nitride treated bearings (CN). These come in two varieties; one is strictly a CN surface treatment, resulting in a harder surface which helps handle hard particle contamination. The other version is an actual CN case that is imparted into a medium carbon steel which has shown similar performance to a case-carburized bearing. Both applications of CN do have real and measurable benefits, though it is a premium product addition.

Now we have enough information to make a good guess at a bearing for our example application:

$$\longrightarrow C = 10,000N(2500hr)^{3/4} = 104,564N$$

Example, Part 2.

The shaft engineer informs you that his target diameter is between 47 mm – 49 mm. Your contact angle calculations indicate you will need a fairly steep angle bearing with Y_1 around 1. Additionally, the application team indicated that there will be heavy loads at times with occasional shock loading. As always, the smallest bearing that will meet the target is ideal.

The shaft size requirement already puts us into the inch series bearings if we want to stay with standard sizes. We are likely going to consider case-carburized bearings due to potential shock loading. The smallest bearing that would meet this requirement of 104 kN with Y_1 of 1.1 is the HM804846/10 with a dynamic load rating of 104 kN.

Installation Topics

A couple of significant items that we will not cover in this article are fitting and preload. Proper execution of your selected bearings can often be the most difficult part of the process. Do your homework and do not take these topics lightly.

Conclusion

Of course there are more sophisticated methods of calculating bearing life; however, if you utilize the information shown here along with the online calculators available, you can come close to the life calculated by sophisticated software packages. The real benefit of software comes through the time savings. At least 10× the amount of analysis can be performed with software as opposed to a spreadsheet with the additional benefit of shaft deflections, stress analysis, stiffness calculations, etc. That being said, I would never hire a new bearing engineer and have them skip the deep-seated knowledge gained by going through this process by hand. (See also Parker's Ask the Expert response on tapered rolling bearings in this issue.) **PTE**

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Koyo: <http://eb-cat.ds-navi.co.jp/enu/jtekt/tech/eb/eb1.asp>


NSK: www.jp.nsk.com/app02/BearingGuide/html/bearing.html?PageCode=1005&LangID=1&ActCode=1

Schaeffler: www.schaeffler.us/content.schaeffler.us/us/products_services/inafagproducts/calculating/Calculation_and_testing.jsp

SKF: www.skf.com/us/knowledge-centre/engineering-tools/index.html

Timken: www.timken.com/en-us/knowledge/engineers/Pages/default.aspx

Norm Parker is the bearing technical specialist for the driveline division at General Motors LLC. Located onsite at the Milford (MI) Proving Grounds, he is regularly tasked with testing theoretical models in the real world, in real time. With his bachelor and master degrees in mechanical engineering from Oakland University (Rochester, Michigan), Parker has developed a keen interest in the academic, commercial and engineering aspects of the bearing industry. Prior to joining GM, he rose through the ranks of traditional bearing companies; by so doing he acquired invaluable experience in working with some of the largest customers — with the toughest applications and demands — on the planet. Parker plans to continue expanding his expertise and providing substantial personal contributions to bearing technology through metallurgy, design and processing.





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Study of Multiple-Point Oil-Jet Lubrication of High-Speed Ball Bearings

Mingxing Wu, Wei Wu, Shihua Yuan and Jibin Hu

The air-oil, two-phase flow inside the multiple-point, oil-jet lubrication ball bearing was studied based on CFD (computational fluid dynamics) theory and technique, and compared with single-point, oil-jet lubrication. The results indicate that the air-oil distribution inside the bearing with multiple-point, oil-jet lubrication is more uniform than single-point injection.

Introduction

The running state of rolling bearings affects an entire system's performance. To ensure smooth operation, an effective lubrication is important. For high-speed ball bearings, oil-jet lubrication can prove quite beneficial (Ref. 1). The lubrication performance of the rolling bearing has been comprehensively investigated via the single-phase method (Ref. 2), but in fact the air oil, two-phase flow will be formed inside a bearing with oil-jet lubrication (Ref. 3). Many studies of the two-phase flow formed by bearing lubrication have been investigated, but these were all dedicated to bearing chambers of aircraft engines with single-point, oil-jet lubrication (Ref. 4).

In this work, the two-phase flow inside the high-speed ball bearing with multiple-point oil-jet lubrication was simulated using CFD software and compared with single-point, oil-jet lubrication. The results can be used to optimize the accurate lubrication design of the bearing.

CFD Model

Figure 1 shows the structure chart of an oil-jet lubrication ball bearing. The three-dimensional model of flow field inside the dual-nozzle bearing was built based on the structure shown in Figure 2, and the computational mesh has 118,709 cells. The sliding mesh plane was used at the edge of the flow field inside the bearing to complete the data transfer in the entire computation domain.

The nozzle inlet was set as "mass flow inlet," and the outlet boundary was set as "pressure outlet" (atmospheric pressure). Different walls were also added to the rotation boundary conditions and no slip conditions. The standard wall

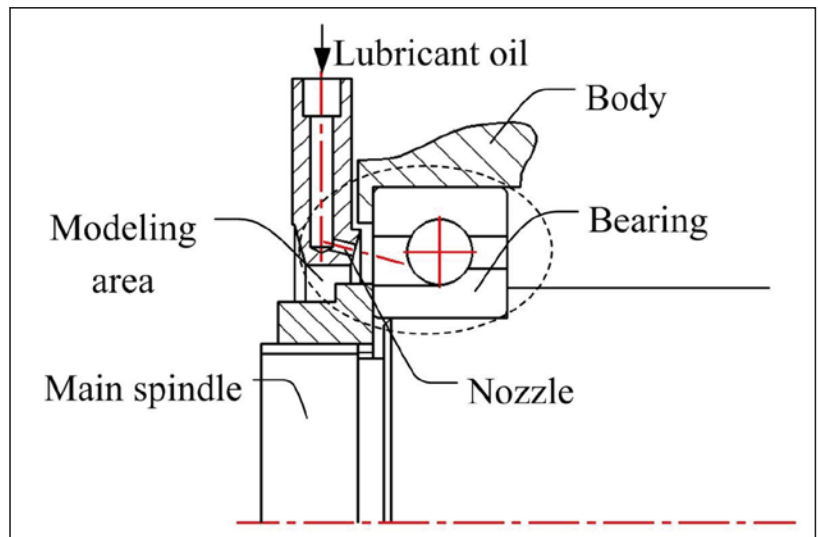


Figure 1 The schematic of oil-jet lubrication.

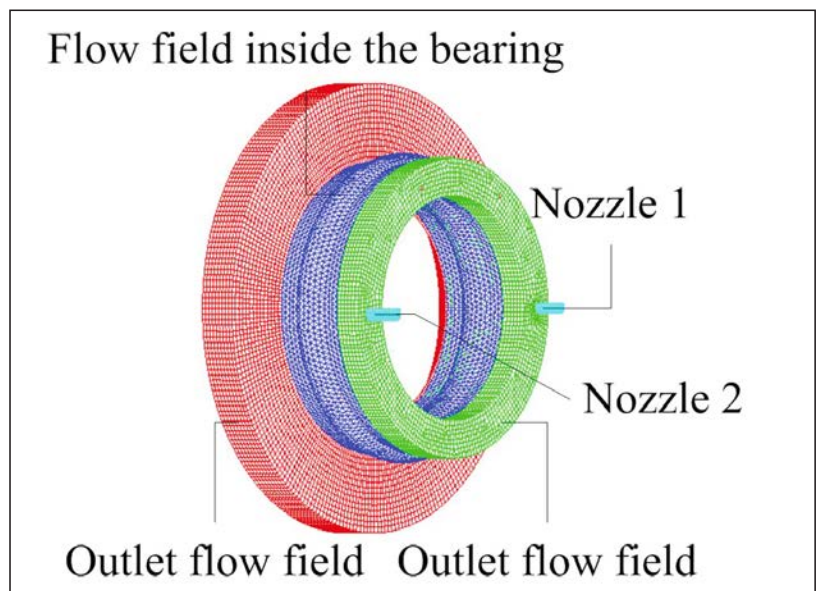


Figure 2 Calculating grid for the whole domain.

function was adopted for the near-wall region. The adopted iterative algorithm was SIMPLEX.

Simulation Results and Analysis

Model validation. Figure 3 shows the experimental apparatus for oil-jet lubrication; the speeds can reach up to 15,000 r/min. Three thermal resistances were uniformly placed on the outer ring of the bearing — T_1 , T_2 and T_3 — along its rotational direction.

Figure 4 shows the distribution of average oil volume fraction on the rollers' surface along the circumferential azimuth. The azimuth at Nozzle 1 is 0 degrees and increases along the rotation direction of the bearing. It can be found that the air-oil distribution inside the bearing is not uniform and decreases along the rotation direction. The air-oil distribution is more uniform with dual-nozzle, which also makes the temperature distribution along the circumferential direction of the bearing more uniform. However, the temperature difference is less (Table 1); the temperature at the position with more oil volume fraction is lower. The bearing temperature distribution is affected by the non-uniform air-oil distribution, which validates the correction of the simulation model indirectly.

Non-uniform, air-oil distribution. Figure 5 shows the simulated air-oil distribution of different nozzles. The speed of the inner ring is 10,000 r/min and the oil flow rate is 3.0 L/min. It can be found that the air-oil distribution inside the bearing is not uniform. At the same oil flow rate, the more the number of nozzles, the more uniform is the oil-air distribution.

Single-Nozzle, Dual-Nozzle, Tri-Nozzle

The influence of nozzle number. Figure 6 shows the variation of the average oil volume fraction inside the bearing with the nozzle number. It can be found that the average oil volume fraction increases with the increased number of nozzles. The increasing trend of average oil volume fraction slows when the number of nozzles increases to a certain value, which indicates that the impact of the number of nozzles on the oil volume fraction is limited.

Conclusions

- The two-phase flow model was used to study the flow character inside the high-speed ball bearing with multiple-point, oil-jet lubrication.
- The model was verified as correct by the test.
- The air-oil distribution inside the bearing is not uniform, and decreases along the rotation direction.
- At the same oil flow, the more nozzles, the more uniform the oil-air distribution.

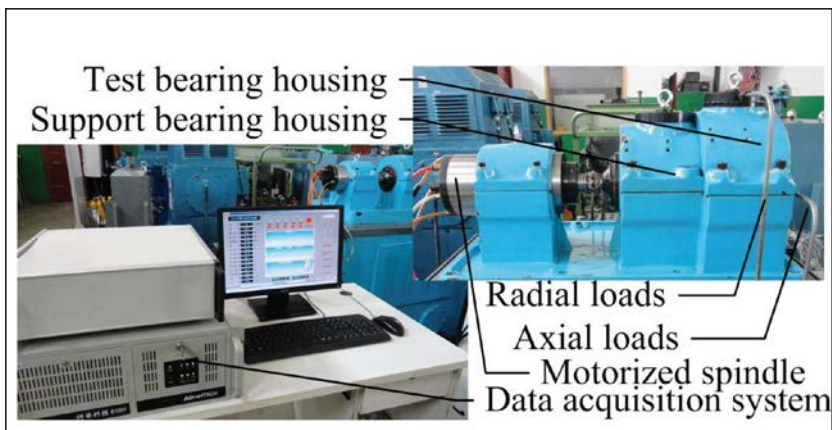


Figure 3 The test rig of bearing lubrication.

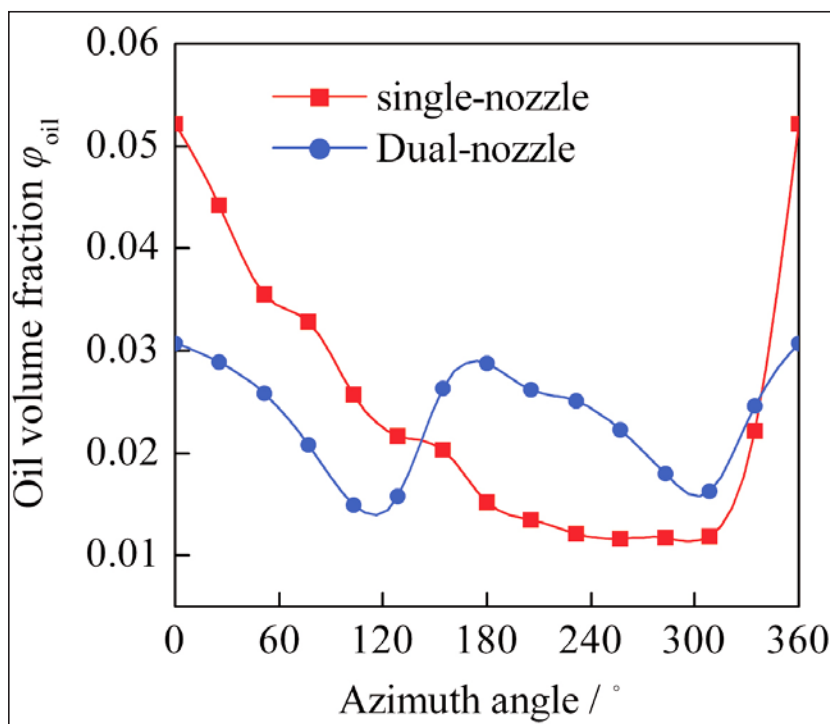


Figure 4 The oil volume fraction distribution.



Flow rate (L/min)	Temperature of outer ring (°C)					
	Single-nozzle			Dual-nozzle		
	T_1	T_2	T_3	T_1	T_2	T_3
4	51.5	54.2	57.1	77.5	77.1	79.5
6	52.4	55.8	56.9	75.1	74.5	76.2
8	53.5	56.5	58	77.1	75.5	78.2

- The oil volume fraction increases with the increase of nozzles.
- The increasing trend of oil volume fraction slows when the number of nozzles increases to a certain value, thus indicating that the impact of nozzle number on the oil volume fraction is limited. **PTE**

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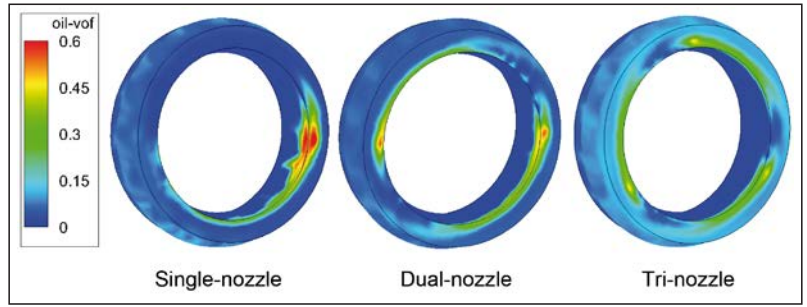


Figure 5 (a) The non-uniform air-oil distribution inside the bearing.

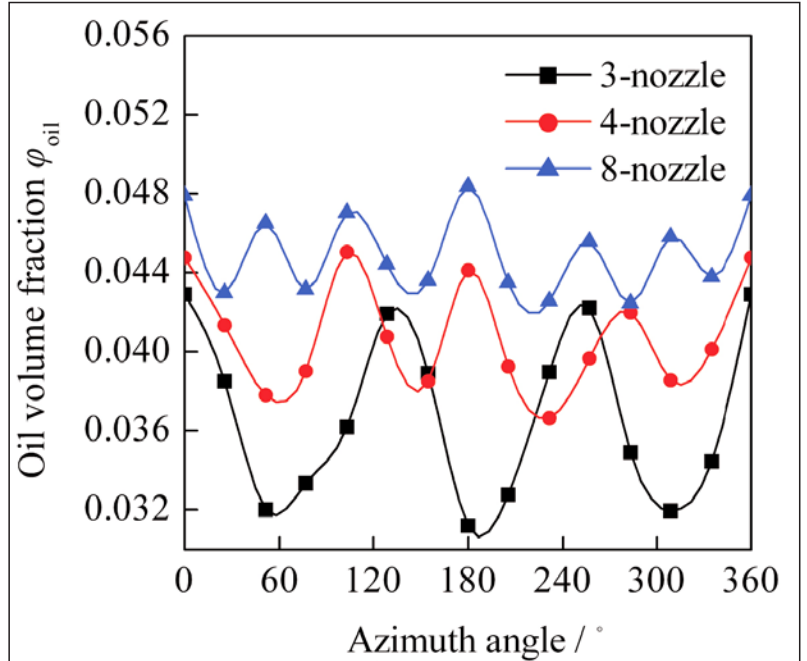


Figure 5 (b) The oil volume fraction distribution inside the bearing.

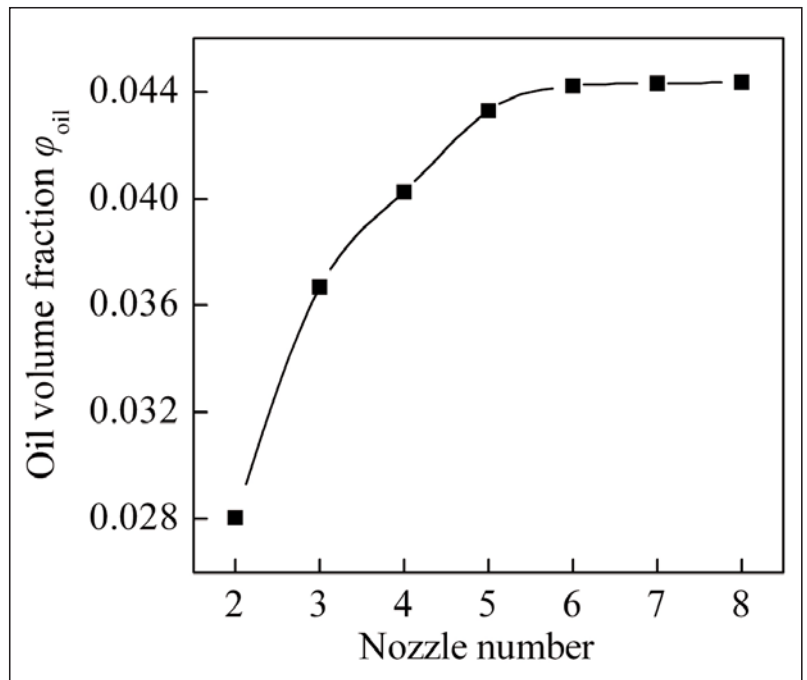


Figure 6 The variation of oil volume fraction with nozzle number.

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Brushless PM-Motors Speed Ahead

Dan Jones

There are more brushless PM motors being made every day. These brushless PM motors are smaller in size — i.e., less than 50 watts in power output found in hard-disk drives, CD and DVD players and many portable medical devices. Servo systems with brushless PM motors ranging from 50 watts to 50 kilowatts are now challenging the larger electric motor applications. A few manufacturers have pushed brushless PM motors above 200 Kw.

History

The development of this motor type was initially driven by the U.S. government and the military. Brushed DC motors suffered from extreme wear at altitudes above 30,000 feet during World War Two. As the U.S. was launched into the Space Age in 1958, there was a critical need for an electric motor that ran on DC batteries and eliminated carbon brushes. From 1963 through 1968, the brushless PM motor developed rapidly, driven by space aircraft needs. Concurrently, two other technology developments enhanced the brushless PM motor's major improvements: the development of electronic drives with reliable electronic commutation, followed by the creation of the first rare earth magnet — Samarium cobalt — spurred the use of these brushless PM motors in the Apollo Lunar Module. By 1965 space-qualified motors from 1 watt to 370 watts were in use.

In 1968 Siemens used a brushless PM motor with an electronic drive system to be used in battery powered tape recorders. They sold the brushless system to U.S. Tape Recorders for the incredible unheard of price of \$25. The Japanese motor suppliers joined the Europeans (plus some emerging U.S. motor manufacturers). By 1982 the direct drive brushless PM motor had replaced a belt driven AC induction motor in IBM's first major electric hard disk drive machine. It stored an incredibly high 50 megawatts (at that time). A few years before a number of machine tools began using much larger brushless PM motors with transistor drives. The last 30 years has seen the brushless PM motor evolve into a major player in thousands of applications.

Measuring Up

The brushless PM motor measures up to other motor types quite well. It is a synchronous motor with linear-torque-speed-current performance (Fig. 1) voltage drive's torque vs. speed profile. Its peak torque capability exceeds any other motor type. Raising the input voltage proportionately increases motor speed. The rotor inertia is low in conventional inner rotor brushless motor types, thereby accelerating and decelerating application loads faster than other motor types. It possesses a higher torque and power density capability. It also possesses a higher intrinsic power efficiency. If it wasn't for its higher unit cost and the need for electronic commutation it would be in many more applications today. While the brushless PM motor will instantly draw more current, it rapidly settles down to its rated levels. Motor life is long usually limited by bearing problems. Induction motors must limit their peak or inrush current by using a soft starting circuit

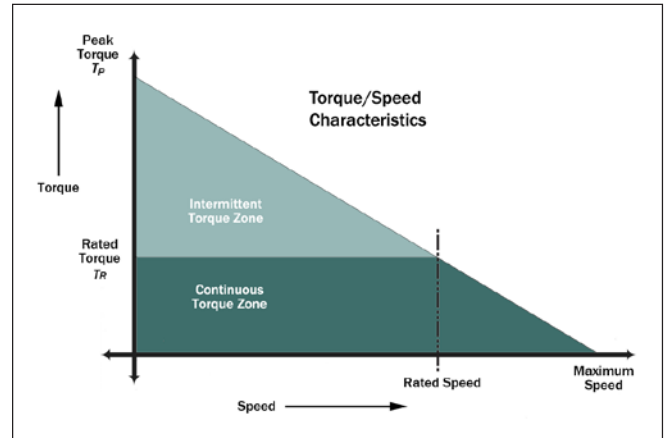


Figure 1 Typical BLPM motor torque-speed curve with rated and peak torque zones.

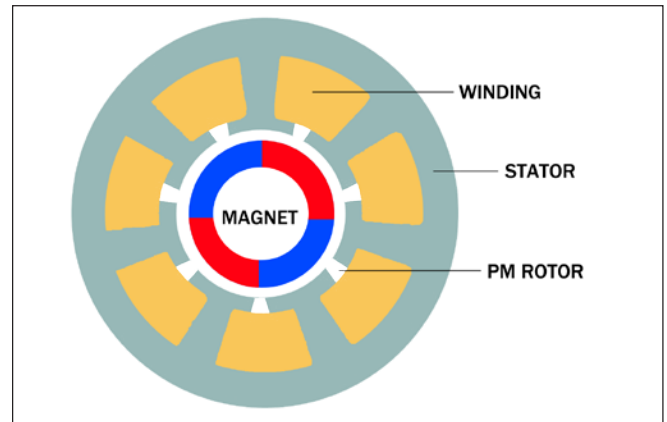


Figure 2 Traditional inner rotor slotted BLPM motor.

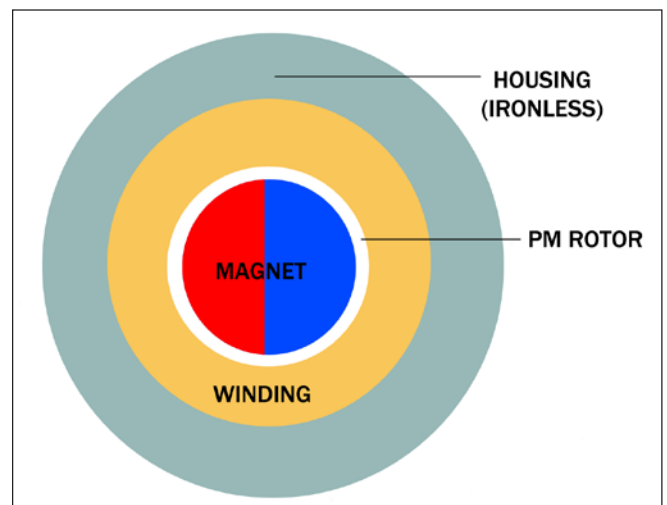


Figure 3 Slotless or ironless BLPM motor.

that slows, and limits current build up. The brush dc motor will experience higher current arcing with repeated application starts and stops. The brushless PM motor makes an excellent long-life-position servo with proper feedback devices.

Motor Shapes Match Customer Needs

Brushless PM motors have morphed into a myriad of configurations; they are also known by many names: brushless dc motors; brushless PMAC motors; brushless PM motors; permanent magnet synchronous motors (PMSM); and electronically controlled (or commutated) motors.

The initial motor configuration developed was the radial surface magnet PM motor type (Fig. 2) — still the most popular type used today. The availability of the strong, rare earth magnets (samarium cobalt and later, neodymium-iron-boron) led to the development of the ironless or slotless/brushless PM motors (Fig. 3). This motor type eliminated the stator magnetic steel tooth structure and utilized the rare earth's higher air gap flux to produce lower sufficient torque. Eddy current and hysteresis losses within the ironless motor were virtually eliminated. Applications requiring smooth torque and speed in many medical and instrumentation applications use the ironless type.

A more recent development was the buried magnet — or internal permanent magnet (IPM) — motor (Fig. 4). It was developed to provide more shaft torque in the same package size as its surface magnet counterpart. Two torques (a permanent magnet torque and a reluctance torque) are created and are added vectorially to achieve the higher torques. This motor type has been utilized as a next-generation replacement in most recent brushless PM servo motor products.

Another motor with magnets located radially on the rotor surface is the large pancake-shaped, direct drive rotary (DDR) brushless PM motor (Fig. 5). They use the principle of large outside motor diameters to significantly increase the motor's torque capability. Most DDR motors have large rotor IDs to reduce the motor's overall weight. They can grow as large as 39" OD and develop peak torques approaching 12,000 Nm (8,850 lb-ft). Applications range from large machine tool table drives to telescope positioners where position accuracy is critical. The DDR motor can be supplied as a housed or frameless motor.

The frameless DDR motor can be assembled directly on the machine application's major shaft, thereby eliminating any coupling losses. Ignoring some new IPM designs, the DDR motor has load or rated speeds below 1,000 rpm. Some larger DDR motors operate at speeds below 100 rpm.

The axial flux, brushless PM motor has located its magnets on the motor face; it has a number of shapes with the more popular single- and dual-stator windings facing the rotating magnet structure. This configuration is being used in automotive and other traction applications. It typically provides both a high-peak torque and a high-speed capability.

The various brushless PM motor configurations described are currently used in today's applications. Other new motor types just moving into production include the transverse flux and hybrid motor types that use permanent magnets in combination with other motor technologies.

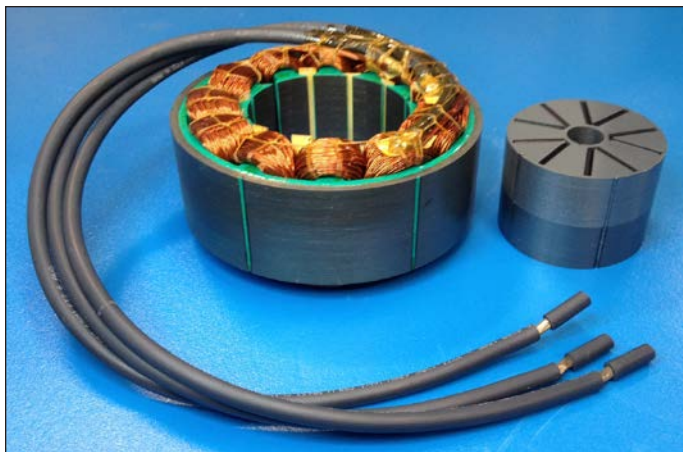


Figure 4 Buried magnet or internal PM (IPM) BLPM motor. (courtesy Applimotion)



Figure 5 Direct Drive Rotary (DDR) BLPM Motor (frameless type). (courtesy Applimotion)

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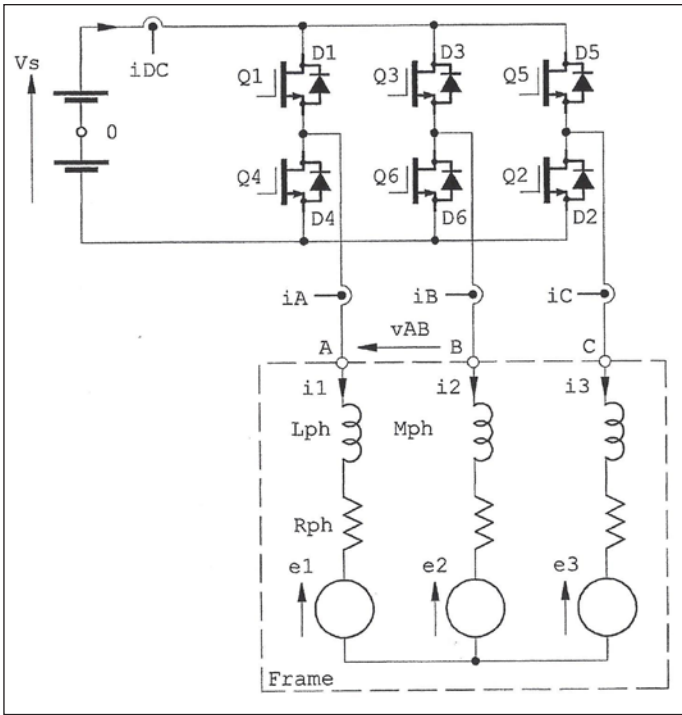


Figure 6 Three-phase BLPM motor and driver in 6-step H ridge configuration (Courtesy of SPEED, CD-adapco).

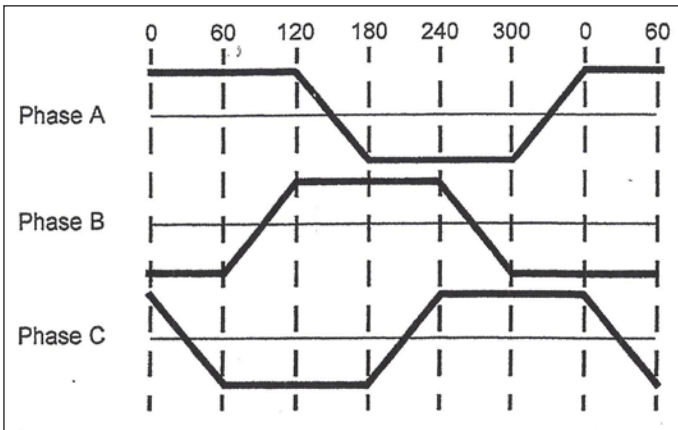


Figure 7 BLPM motor trapezoidal back EMF. (Used in fans, blowers, pumps, toys, lawn mowers, etc.)

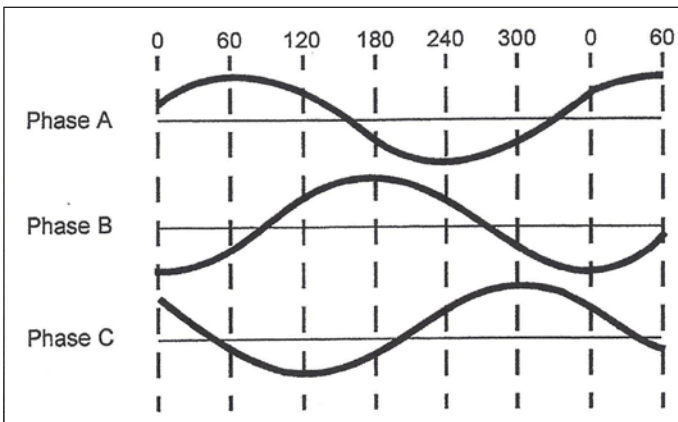


Figure 8 BLPM motor sine wave back EMF. (Used in machine tools, grinders, and many other position servo motor applications.)

Electronic Control

The brushless PM motor requires some means of switching or commutating the motor's stator windings at the correct position to ensure continuous motion. Hall devices or commutating encoders are typical devices used to locate the rotor position to ensure smooth commutation. For variable speed applications the motor's internal back emf signals can be utilized. With the exception of smaller motor types, an overwhelming number of larger brushless PM motors are 3-phase wye or delta-connected inverter drives. For four-quadrant operation, six power FETs or IGBTs in an inverter configuration are used to ensure servo-like operation (Fig. 6).

There are two major drive strategies used to control a brushless PM motor: they are designated square wave current, and trapezoidal torque vs. sine wave current and sine wave torque profiles. The square wave current drives are used in ticket printers, fans and blowers. The sine wave current drives are utilized in more demanding machine tool grinding and machines where torque ripple is minimized.

But the brushless PM motor's back emf wave forms must be designed in a trapezoidal (Fig. 7) or sine wave (Fig. 8) configuration. The brushless PM motor's back emf must be shaped by various motor design choices to achieve the trapezoidal wave form or the sinusoidal wave form and then matched to the inverter drive's appropriate wave forms to achieve the application's required performance.

Double-Digit Growth

Two major-market needs continue to propel brushless PM motor growth in both current and new applications:

- The first is the continued evolution of power and control electronics in the form of ICs and power modules. Drive and control costs for brushless PM motors under one Kilowatt (1.37 hp) have dropped dramatically over the past decade. The brushless PM motor and associated drive are moving into the cost-sensitive heating, ventilation and air conditioning (HVAC) market.
- The second need is the establishment of new power efficiency requirements by the U.S. government that fosters the use of brushless PM motors. The only dark cloud looming over brushless PM motor growth is the availability of rare earth magnets for the higher-performance brushless PM motors at "reasonable" prices. **PTE**

Dan Jones has since 1962 worked as chief and staff engineer with numerous companies. Whether as direct employee or consultant — he has applied his technical skills and experience working with and writing about DC, step, AC, brush and brushless motors; electronic drives, and on control systems in applications for the military, industrial and commercial markets. Jones is a former president of the Association of International Motion Engineers (AIME), and has served on the board of directors of the Small Motor Manufacturers Association (SMMA). Jones is president of Incremotion Associates, a firm combining the capabilities of engineering and marketing with a direct focus upon the motion control and power conversion industries.



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Global Industrial Outlook: Frogs' Legs, Bratwurst and the Bear

By Brian Langenberg, CFA

First-quarter results are in (bad weather) and summer will prove more interesting than either the market or the fall elections until after Labor Day. But much is happening! Three areas for discussion in this installment:

- **Current outlook**
- **Big deal with implications**
- **Geopolitics: How Russia, Ukraine, China affect you**

Current Outlook

Broadly speaking, we are seeing "more of the same" with stability in energy, growth in aerospace, North American truck (PACCAR, Cummins), and global

automotive. Mining is (*yes, still*) awful—but stabilizing.

Weather conditions in North America disrupted construction equipment, but every company saw a bounce-back starting in April that appears genuine.

While weather caused a slew of revenue and EPS misses vs. expectations, management commentary was broadly constructive to positive.

Oil & Gas: In April's issue we told you overall capital spending will remain stable this year, with particular strength in downstream (refining), midstream (pipeline infrastructure), while upstream would decline per-

haps (1-3%) overall. Within the North American market we see midstream-related activity remaining strong—if slowing— after this year, but overall in solid demand.

Mining: Continuing to see signs of a thaw and stabilization beyond 2014. Not this year. Capital spending in the mining sector will fall another 25-35% this year and can fall further in 2015. Near-term, high-utilization will drive continued stability in consumables and service. U.S. coal producers still having a difficult time, but rising metallurgical and thermal coal demand wins in the end.

		SURPRISE		
COMPANY	TICKER	REV	EPS	PUNCH LINE
OIL & GAS				
Emerson	EMR	(2)	(9)	Strength in O&G, Chemicals. Power generation (CAT) improving.
Flowsolve	FLS	(6)	+4	Weak quarter for orders, underlying strength in end markets.
MACHINERY				
PACCAR	PCAR	+11	+1	Rising outlook for North American Class 8 truck.
Cummins	CM'	5	+8	N. American Truck drove EPS beat and raise. Medium, light duty also.
Caterpillar	CAT	+0	+15	Strong construction, Mining bottoming, improved Power Generation.
United Rentals	URI	(0)	+27	Volume, price, time utilization all improving.
Oshkosh Corporation	OSK	(1)	(5)	Strong ex defense. Improving municipal balance sheets also.
Terex Corporation	TEX	(3)	(14)	Weather, crane weakness.
Deere & Co.	DE	(4)	+6	Ag sales off (12%); lower US farm cash receipts.
Manitowoc Company	MTW	(7)	(15)	Weather socked 10 crane sales, delayed projects and shipments.
POWER GENERATION				
Wartsila	WRTB.IX	+6	+6	Good activity.
Alstom	ALO.FP	+2	(19)	Disappointing results. In play (GE, SIE).
General Electric	GE	(1)	+3	Strength in gas turbine, wind, Oil & Gas, Commercial Aviation.
Siemens AG	SIE	(3)	(14)	Restructuring to focus on power. Alstom bid could create disruption.
EURO MACHINERY				
Atlas Copco	ATCO.B.IX	(2)	(6)	Compressor stable, Mining & Rock remain ugly.
SKF	SKFB.SS	(2)	(6)	Strength in Europe, LatAm, MEA. Weather impacted N. Am.
Sandvik	SDVKF	(4)	(13)	Miss.
Alfa Laval	ALFA.IX	(7)	(32)	Marine & Diesel improving off low base.
AEROSPACE				
Boeing	BA	(0)	(18)	Strong commercial outlook.
Airbus	EAD.FP	(4)	(8)	Defense restructuring continues; strong commercial outlook.
Bombardier	BBD.B	(4)	(29)	Delays in C Series. Rail outlook solid.
TXT	TXT	(6)	(12)	Small/Medium business jets remain soft.

Aside from indisputable facts and figures, the opinions and conclusions are the author's and do not necessarily reflect the position of Randall Publications LLC.

Power generation: There is a *reason* General Electric is seeking to buy the coal turbine assets of Alstom. Band-Aid shipments (wind turbines) are up, along with gas, which is trending upward.

Transportation infrastructure: No change. U.S. infrastructure spending will remain flat until *late* 2016 at the earliest, as it would require bipartisan support and willingness to spend on *infrastructure*.

Water & Environmental: Municipal budgets and tax receipts are modestly improving, though home price recovery has slowed. Indirectly, a 10-15% increase in home prices over the next 2-3 years would drive a dramatic increase in construction equipment demand.

Machinery: *North American Truck demand is accelerating* as evidenced by strong results and guidance from Cummins, PACCAR and others. *Construction equipment* demand will remain solid, owing to weak comparisons and low channel inventories, despite the 1Q weather impact which resulted in numerous delayed projects. Things are less rosy on the farm; Deere reported a (12%) decline in Ag equipment during its fiscal 2nd quarter and U.S. farm cash receipts are down.

Consumer (auto, appliances): Global automotive demand remains quite good, and within the U.S. market the average fleet age is over 10 years—supporting a strong multi-year demand outlook that will improve over the next 2-3 years with gradually improving home prices (i.e. consumer equity). Housing demand is being impacted, on the margin, by slightly higher interest rates, but more importantly, weather delays that we consider transitory.

Aerospace/Defense: We flesh out a long view, shortly, that is not broadly accepted or recognized by most, but which seems increasingly obvious to our more astute contacts. The near-term punch lines are as follows: Commercial aerospace is and will remain strong in original equipment, MRO and aftermarket spares, though growth rate will moderate. On the defense side one should expect a slower rate of decline in the near-term within the U.S. Growth is coming—if not after the 2016 election cycle—for a host of reasons,

all of which relate to a) global reality and b) recent underinvestment.

Big Deal with Implications

Pay close attention if you do business directly, or indirectly, with General Electric (Power & Water), Siemens (Energy, Rail), Bombardier (Transportation), or Alstom.

Sometimes size matters—and in the global power generation arena a few major Western players compete in global power generation—primarily

meaning coal, gas and nuclear. Large global growth projects also pressure these manufacturers for price and terms, and a product hole can become problematic.

As we write this column the final outcome of negotiations involving GE, Siemens, Alstom and the French government are unclear, but one of two outcomes appears likely: the steam turbine assets of Alstom will end up with either General Electric or with Siemens.



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If General Electric wins the business, existing suppliers on the gas/turbine or oil-and-gas side should get opportunities at more content in steam turbines. We see little disruption by combining the two businesses, as GE gets a broader portfolio but in turn may curtail R&D spend on its current coal plant technology. Conversely, a Siemens/Alstom combination would lead to inevitable supplier consolidation, given the significant product and geographic overlap. This is a greater challenge for those with a strong European presence.

Rail could also be impacted in an Alstom/Siemens combination that merges their passenger rail assets. Suppliers to both will need to navigate supplier rationalization moves as neither will want to fire their own people and cost cuts must be found. Alstom suppliers should note that 60-70% of Bombardier Transportation revenue is in Europe and dealing with a larger, stronger consolidated competitor could prove challenging.

Geopolitics: How Russia, Ukraine and China Affect You

The best wars are those that do not get fought—either because people are nice (on occasion), are reasonably satisfied (this varies) or are smart enough *not* to start something (often requiring credible visual aids and political/national backbone).

For example, the USS Wisconsin (BB-64), decommissioned in 1991, was a fantastic visual aid. It was big (887' long, 106' beam, 58,000 tons) and credible (capable of sending 9 tons of high explosive behavior modification up to 23 nautical miles every 30 seconds). And the missiles, of course.

She isn't coming back—but we need more ships (about 300 now vs. 571 at the 1980s peak), and bigger (Littoral Combat Ships, a.k.a. utility infielders do not scare anybody).

DEFENSE SPEND / GDP	U.S.	U.K.	GERMANY	FRANCE	JAPAN
1970	8.0%	5.8%	3.3%	4.1%	0.8%
1980	5.5%	5.1%	3.3%	4.0%	0.9%
1990	5.3%	4.1%	2.8%	3.6%	1.0%
2000	3.1%	2.5%	1.5%	2.5%	1.0%
2010	5.4%	2.7%	1.4%	2.0%	1.0%
2012	4.4%	2.5%	1.4%	2.3%	1.0%
Versus 1980:	80%	49%	42°A	58%	111%

Without these visual aids and political/national will people can misbehave. Recent examples include:

On May 25th a Vietnamese fishing boat was sunk by a Chinese fishing vessel near a Chinese deep-water oil rig. Lest you think it was an accident, not even twenty years ago, unmarked Chinese naval vessels were conducting raids on merchant ships at sea, sometimes with deadly consequences.

Ukraine, Crimea, Europe—Putin will get most of what he wants—Crimea, influence over the Ukraine, intimidation of most neighbors—Europe is throwing Ukraine under the bus.

In a nutshell: the U.S. electorate is not focused on global engagement, Europe is picking economic interests over extended confrontation, and China is the fastest growing Asian military presence.

Paradigm shift is not far off and you should not ignore the following opportunities in your longer-range growth strategies in both the U.S. and Europe:

The U.S. spends at 4.4% of GDP but the navy in particular is short on real combat ships. Period. Look for opportunities. Electro-magnetic gun—the United States Navy recently tested an EMG, firing a projectile 100 miles at Mach 7. By way of comparison, the USS Wisconsin could shoot its guns 23 miles. It will be tested at sea in 2016 and did we mention that gun systems have gears? Go make them!

Europe realizes it no longer has its (U.S.) sugar daddy on defense—U.S. lack of engagement coupled with Putin's territory grab has brought a message home to a continent highly reliant

on Russian gas, and militarily unable to defend itself. Europe is now quietly forming plans for a defense organization outside of NATO because of the realization they must fend for themselves. Three countries matter in terms of defense spending—UK, Germany and France—collectively, over \$7 trillion in GDP and spending at 40-60% of already underfunded cold war levels. They will never hit the 4-6% range required to support power projection because it is not needed, but 1.4-2.5% doesn't cut it if you want tough guys to take you seriously. Poland is the bulwark but these three need to pay for it. A 1% increase in defense GDP translates into \$70 billion per annum, of which 1/3 would be equipment. Find ways to get at European defense business.

Japan prefers to make their own stuff but get in on weapon systems and platforms they are likely to buy. They are going to a) increase overall spending and b) emphasize sea power projection.

The other angle is playing the energy security side. Europe has discovered that if you seek to close coal plants and nuclear plants and opt to buy Russian gas, you leave yourself exposed. Likely outcome is, sooner or later, U.S. exports of natural gas and thermal coal to Europe. Find ways to get in front of the infrastructure build out. As noted, U.S. midstream companies (pipelines) are investing to get the gas moved to population and the coasts. Terminals and ships need building.

Focus Company:

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sales	9,633	7,806	7,022	7,932	8,871	11,571	11,257	13,901	11,666	8,726	9,179	8,787
EBIT (Adj.)	(772)	164	305	543	711	1,007	1,248	1,468	1,052	850	959	930
Invested Capital			1,436	1,351	1,458	1,287	1,469	2,204	3,118	2,070	2,264	2,774
Tangible Capital			(1,373)	(1,445)	(1,529)	(1,965)	(1,899)	(1,177)	(550)	(1,138)	(957)	(130)
After-tax ROIC			15%	28%	34%	55%	59%	47%	24%	29%	30%	23%

Alstom (ALO.FP)

Alstom currently operates in two areas—power—including thermal (coal, gas, nuclear), renewable (mostly hydro) and transmission grid—represents about 75% of sales and the balance is rail. We will focus on thermal ex nuclear, which is the piece everybody wants.

Alstom is considered a “national champion” by the government of France, but in fact is in financial straights for the second time in just over ten years. While returns on invested capital within the thermal segment remain outstanding—2013 was a weak year with “only” a 23% return on invested capital. Shown below is a 12-year history.

The key takeaway here is thermal segment revenue (including nuclear) is only 63% of peak, which means 60% growth potential just to hit 2010 revenue. A combination of growing global power need, reality that turbines and solar won't carry the load and aging plants in the U.S. and Europe augur well for growth—particularly if Gen-

eral Electric gets the business because they can both grow their service model in Europe but also participate more effectively in the U.S.

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



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Bodine Electric

HIGHLIGHTS MANUFACTURING AT DISTRIBUTOR TRAINING CONFERENCE

Representatives of Bodine's distributor network from across the USA and England recently attended the Bodine Electric Company 2014 Distributor Training Conference in Dubuque, Iowa and at their main plant in Peosta, IA. Developed to help distributors increase their understanding of Bodine gearmotors, motors, and controls, the training conference reflected Bodine Electric's ongoing commitment to providing the best possible support and training for their channel partners and global distributors.



The two-day event featured educational sessions on product design, how to select the right gearmotor for an application, and industry specific sales strategies. The conference focused on fundamentals of construction and operation of brush-type permanent magnet DC, brushless DC, and AC Induction drive systems. Hands-on workshops explored basic motor maintenance, wiring, and load-current measurement. Other workshops covered gearhead construction, motor control systems, and application success stories. Capping the event was a tour of the company's manufacturing facility in Peosta, IA.

We know that in today's marketplace well-trained and knowledgeable distributors are what keep Bodine Electric ahead of the game," said Peter Kos, Bodine Electric Company's distribution channel manager.

QA1

HIRES INDUSTRIAL SALES MANAGER

QA1 is excited to announce the recent addition of **Mike McVeigh**, who joins the QA1 team as the industrial sales manager. Within this role, McVeigh will develop and execute sales plans to increase market share, develop and maintain relationships with key distributors and OEMs, identify and pursue opportunities that support QA1's complete port-



folio offering and work on new product ideas and marketing strategies.

"We couldn't be more excited to have Mike join our team," said QA1 President Melissa Scoles. "He brings a wealth of experience that will help QA1 grow in the industrial market with both our product offering and exposure."

McVeigh has over 25 years of sales and marketing management experience in motion control and bearings. He is excited to help QA1 grow their customer focused sales force thru ongoing training, mentoring and positive motivation.

"QA1 has a great industrial offering, and I'm excited to help take this team forward," said Mike. "QA1 has been a leader in the industrial world for a long time, and I'm glad I can lend my expertise to help them grow."

When he's not in the office, he loves to travel and has been all over the world. He's even taken a high speed ferry from the U.K. to Ireland.

PTDA

WELCOMES EIGHT NEW MEMBERS

The Power Transmission Distributors Association (PTDA) has welcomed eight new members to date in 2014. Distributor members include DIRISA (San Pedro Sula, Honduras), a distributor of bearings, motors, mechanical PT and material handling products.

Edwards Industrial Sales Inc. (Kalamazoo, Michigan), a distributor of mechanical PT products, bearings, and hydraulic and pneumatic prod-



ucts, as well as other material handling components, motors, electronic drives and linear motion products. Chris Hawk, marketing, states, "Edwards Industrial Sales joined PTDA to access resources, to connect and network with peers in the industry and to take advantage of opportunities in a very competitive market."

Standard Bearings (Des Moines, Iowa) distributes bearings and mechanical PT products. Tri-Power MPT, Inc. (Akron, Ohio), is a distributor of sensors, power transmission and motion control products. "We are very excited to re-join PTDA and look forward to seeing old friends and making new ones. PTDA provides many opportunities to network with the industry's premier manufacturers. Our membership is well worth the investment," notes President Richard Wiley.

Manufacturer members include Cone Drive (Traverse City, Michigan) a gear manufacturer as well as Rossi North America (Suwanee, Ga.), a manufacturer of gearing and AC motors.

Associate members include Interlynx Systems, LLC (Bryan, Ohio), a lead management system provider to the power transmission distribution industry. WarehouseTWO (Palo Alto, California) provides inventory-sharing solutions. Principal Mark Tomalonis notes, "WarehouseTWO, LLC is the leading inventory-sharing solution used by industrial manufacturers and their wholesaler-distributors in North Ameri-

ca. Our system's rich functionality and method of excluding counterfeit products make it ideal for the power transmission industry. Many power transmission distributors use our service to fill backorders faster, increase revenue and expose selected inventories to a much larger audience—all within authorized wholesale networks." For more information, visit www.ptda.org.

Heidenhain

HIRES SYSTEM PRODUCT SPECIALIST

Heidenhain Corporation announces the new hire of **Mark Skaer** as systems product specialist, ETEL. Of particular interest to the semiconductor and high tech equipment industries, ETEL's motion stages are known worldwide as high quality systems, and are available in North America through parent company Heidenhain. Skaer is now positioned to assist area customers and prospects of ETEL motion stage systems with specifications, application and troubleshooting information as needed. He also serves as a liaison to ETEL's corporate worldwide headquarters in Switzerland. Holding a bachelor's degree in electrical engineering from Milwaukee School of Engineering and a master's degree in electrical engineering from Michigan Technological University, Skaer was first employed as an interface analyst at an EMR software company before coming to Heidenhain.



Sercos

ELECTS BOARD OF DIRECTORS

Sercos International e.V., supplier of the Sercos automation bus, elected its new board of directors during the member's meeting at Hannover Fair 2014. **Dr. Thomas Bürger** of Bosch Rexroth AG is the new chairman, supported by Klaus Weyer of Schneider Electric Automation GmbH and Prof. Alexander Verl of Fraunhofer Institute. Matheus Bulho from Rockwell Automation was newly elected to the board, replacing the departing Ralf Prechtel (LTi Drives), who was honorably discharged together with the previous chairman, Dr. Bernd-Josef Schäfer (Bosch Rexroth AG). Christoph Melzer (Automata GmbH) and Hans-Juergen Hilscher (Hilscher Gesellschaft für Systemautomation GmbH) were both confirmed in their functions as cash auditors. During the meeting, the members were comprehensively informed of the technological development of Sercos based on current market trends and also took a look at the strategic orienta-



tion of the user organization. "Strong growth in the spectrum of manufacturers and providers accelerates the implementation of innovative automation concepts and is, at the same time, proof of the high level of acceptance of Sercos in machine and systems engineering," explained Peter Lutz, managing director of Sercos International. "We also see this growth in Asia, specifically in China."

GAM

RECOGNIZED FOR STEM EDUCATION INITIATIVE

GAM, a manufacturer of precision gear reducers and servo couplings used in automation technology, was recognized by the Northwest Educational Council for Student Success (NECSS) after partnering with Thomas Middle School to help educate students who are interested in STEM (Science, Technology, Engineering, and Math) fields. The NECSS is a secondary and post-secondary regional educational collaborative that focuses on student success and opportunities, teacher qualifications and professional development, and enriching collaboration between all district partners and the local communities. NECSS partners include school district 211, 214, 220, EFE 070 and Harper College. Gary Michalek, CEO of GAM, accepted the award at the NECSS Business Partner Recognition Breakfast for the partnership with Thomas Middle School. "If we want to maintain our leadership role in the U.S. for manufacturing, we need to inspire and expose our young people as early as possible to the wonderful opportunities that exist in today's manufacturing environment and the future it holds," said Michalek.



Twice a year, students from Thomas Middle School visit GAM as a part of their Careers Connection class. The Careers Connection class is a three part program designed to help prepare students for the work force by introducing career options as well as identifying their interests and strengths. Students take surveys, participate in discussion groups, and then have an on-site job shadow experience. When students visit GAM for their job shadow, they are engaged in an interactive learning experience as they are tasked to help design and manufacture an actual product.

CTI Symposium

Raises the Bar on Transmission Technology

The 8th International CTI Symposium on Automotive Transmissions, HEV and EV Drives took place in Rochester, Michigan from May 12-15. The event kicked off with its popular introductory seminar “Basics and Practice of Automotive Transmissions,” hosted by the Institute of Automotive Engineering (IAE), Technical University of Braunschweig Professor Dr. Ferit Küçükay likened transmission technology today to a giant box of Legos where engineers take pieces from conventional, hybrid and electric drives and mix and match until new transmission concepts have been developed.

The first day of the symposium featured discussions from key members of companies such as Getrag, SAE International and Argonne National Laboratory, as well as a panel discussion on “The 54.5 MPG Challenge,” that was moderated by Larry Nitz, executive director of global transmissions and electrification at GM. The second day of the symposium featured presentations from HIS, Getrag, Jatco, AVL North America and the importance of the vehicle transmission from Strategic Vision, USA.

The Transmission Expo featured a wide variety of technology updates and product innovations from companies like Dupont, Great Taiwan Gear, Jatco, Borg Warner, Dana, Getrag, Saint Gobain, Schaeffler, SKF and Victrex Polymer Solutions. Some highlights from the show floor:

Great Taiwan Gear has installed 9-axis CNC controlled power honing equipment to produce AGMA Quality 12 (DIN 6) gears. The low noise and greater durability of power honed gears are of particular benefit in electric and hybrid vehicle applications.

Fallbrook’s NuVinci continuously variable planetary (CVP) technology improves the performance and efficiency of machines that use a transmission, including bicycles, elec-

tric vehicles, automobiles, off-highway vehicles, stationary equipment, wind turbines, and others. The NuVinci technology offers companies the flexibility to design and produce next-generation products that are better-tailored to their unique business, market, and competitive requirements.

Jatco CVT8 expands its suitability to the 2.0-3.5 liter classes and achieves an increased ratio coverage while being compact in size. Improvements allow for greater efficiency and a significant reduction in friction, improving fuel economy by up to 10%.

Means’ Selectable One Way clutch provides an efficient mechanical clutch solution with negligible drag torque, for transmission, and driveline designs.

TeamTechnik has developed a highly flexible, modular EOL transmission test platform that delivers NVH test technology of the highest quality. Modular machine design is the foundation for this innovative test stand concept that can be adapted to all transmission types.

DuPont Vespel parts can help vehicle manufacturers meet emissions regulations, fuel efficiency and performance standards with high performance thrust washers, bushings and seal rings. Vespel parts help reduce frictional and parasitic losses while maintaining the durability of advanced transmissions.

Beginning in Berlin in 2001, exporting the conference to the United States eight years ago, and this year already in China for the third time, the CTI team has scored big with topics related to transmission systems. Last year, 230 globally recognized gear drive experts discussed the latest developments in the world of transmissions with a total of approximately 1,800 participants from 25 countries. Up-to-the-moment topics, workshops, discussions, extensive exhibitions, and



extras such as presentation of the CTI Young Drive Experts Award and a total of 25 road tests – e.g., the Mercedes E-Class 9G-Tronic, the 2014 Jeep Grand Cherokee with TorqueFlite 8-speed automatic transmission, the Ford Focus Electric, the Nissan Altima with Jatco CVT8, and the Subaru Outback 2.0D Comfort Navi CVT – have ensured a multifaceted program.



Experts from BMW, Daimler, Geely, Honda, Volkswagen, Getrag, Jatco, and ZF have informed audiences on the latest transmission concepts for use in compact to super sports cars, exchanged views on the electrification of the drive train, and covered aspects of functional safety. For specialists, there have been interesting lecture series on transmissions and drive systems for hybrid vehicles, 48V, transmission components, and NVH, though expertise on efficiency analysis and optimization was also conveyed in a practice-oriented way. Representatives from government agencies, automobile associations, and renowned institutions have reported on strategies to meet more stringent environmental requirements.

Over 160 exhibitors have presented their products and services in America, China, and Germany and enjoyed the high quality of the conferences. The growing number of participants, especially at the Berlin flagship conference, has also been noted positively: “The CTI Symposium has grown each year, and was particularly strong last year,” said Yuki-nao Takeya (Keihin Seimitsu Kogyo). Koji Okumura (Kyowa Synchro Technology Europe SAS) was also delighted: “It was a very good opportunity to present our newly developed synchronization system.” Nick Bade from the clutch lining manufacturer Tribco concluded: “It was an efficient opportunity to make valuable customer contacts.” **PTE**

For more information:

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July 7–11 – Additive Manufacturing and 3-D Printing International Conference.

The Nottingham Belfry Hotel, England. The conference includes a dedicated exhibition open only to event delegates. The exhibition is the perfect opportunity to talk in detail with metallic and polymeric additive machine manufacturing companies, material suppliers and service organizations. The exhibition will take place in a parallel room to the conference and is the hub of delegate and vendor networking. Presentations made at the conference (subject to speaker permission) will be made available on a USB card supported by a printed booklet containing key conference information, speaker biographies and abstracts. A complimentary copy will be issued to each delegate on registration. Further copies will be available for purchase at the conference and after the event. For more information, visit www.am-conference.com.

July 14–17 – EMTE-EASTPO. Shanghai, China. This exhibition offers a high quality showcase of innovative technology and practical solutions for Asia's manufacturing industry. Jointly organized by CECIMO, EASTPO and the MP Organization, the inaugural joint exhibition will unveil sustainable and cost-effective solutions to buyers in China and the rest of Asia. It provides a one-stop business platform for leading manufacturers seeking to penetrate the dynamic marketplace in Asia. The joint exhibition will unveil a high quality showcase to buyers from China and other parts of Asia. It will follow the strong tradition of major exhibitions in Europe, where strict exhibitor admission rules, intellectual property protection and live demonstrations of exhibits are featured. With key industrial sectors like electronics, steel, chemicals, pharma and industrial machinery, Shanghai is an important manufacturing hub in China and is geographically located near Hangzhou, Nanjing, Ningbo, Shaoxing, Suzhou and Yangzhou, all of which are manufacturing bases for automotive, industrial machinery and metals. For more information, visit www.emte-eastpo.com

August 26–28 – International Gear Conference 2014.

Lyon-Villeurbanne, France. Mechanical transmission components (gears, bearings, CVTs, belts, chains, etc.) are present in every industrial sector and range from nano-gears to large gearboxes. Over recent years, increasing competitive pressure and environmental concerns have provided an impetus for cleaner, more efficient and quieter units. Moreover, the emergence of relatively new applications in wind turbines, hybrid transmissions, jet engines has led to even more severe constraints. The main objective of this conference is to provide a forum for the most recent advances, addressing the challenges in modern mechanical transmissions. Topics include gear noise, gear design, gear materials, gear failure, lubrication, gearbox efficiency and more. For more information, visit <http://int-gear-conf14.sciencesconf.org>.

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

September 8–13 – BSA Fall Meeting. Rosemont, Illinois. The Bearing Specialist Association (BSA) committee members meet three times per year to continue their work - in the Fall (usually late September to mid-November), in the Winter (usually in late January) and at the Annual Convention. Attendees at the Fall and Winter committee meetings have an unprecedented opportunity to network with their industry peers in a more intimate setting than at the BSA convention. Committee participants also can influence the direction the industry takes over the coming years. BSA is an Illinois not-for-profit corporation whose policies and direction are determined by elected officers and a board of directors, who report to the general membership. The officers and directors represent member firms from worldwide geographic areas. For more information, visit www.bsahome.org.

October 22–25 – PTDA 2014 Industry Summit. Orlando, Florida. Join more than 550 delegates representing 240 companies for a networking and business event that includes keynote speakers Mike Ditka and Alan Beaulieu. Workshops include increasing your online presence, providing top notch customer service, maximizing your technology budget, embracing global opportunities and how to earn the respect of your peers. A social media learning lab will help attendees build and enhance their social media profiles. The Summit also includes the PTDA Foundation Milton B. Schott, Jr. Memorial Open, a gold event taking place at the Waldorf Astoria Golf Club and a series of Spouse/Companion events. For more information, visit www.ptda.org.

Bearing Specialists Celebrate Successful Convention

The Bearing Specialists Association held its annual convention at the Fairmont Resort in Scottsdale, Ariz. from May 3-7. More than 160 distributors and manufacturers attended the convention, which included committee meetings, business meetings, guest speakers, and social events.

At the meeting, the association elected Brian Negri of Jamaica Bearings as its incoming president. The association also announced its 2014-2015 board of directors, including Jack Simpson of Applied Industrial Technologies as chairman, Tim Breen of Motion Indus-



tries as vice-president and John Ruth of BDI as treasurer. Other members of the board are Jim Scardina of Bearing Headquarters, Steve Smidler of Kaman Industrial Technologies, Todd Hamlin of DXP Enterprises and Alfredo Bichara of Baleromex S.A. de C.V.

William J. (Bill) Stevens, chairman and CEO of Motion Industries, received the association's Lifetime Achievement Award in a surprise presentation that included video clips with comments and congratulations from colleagues, friends and family, many of whom spoke of Stevens' contributions both inside and outside the bearings industry. Stevens became actively involved with the BSA in 1989 and has attended every annual convention since then, except for one. He is a past president of the association and is one of the most active members of the Past President's Council. To learn more about Stevens, his life and

achievements, you can watch the same video that was presented to attendees by visiting youtu.be/cgxmzFOPZqk.

Among the highlights of the convention were the three guest speakers, who gave presentations aimed at helping distributors remain competitive in the era of universal global information. Dr. Barry F. Lawrence, coordinator of the Industrial Distribution Program at Texas A&M University, presented "Industry Trends and Growth Opportunities," which focused on the changing nature of industrial distribution, with a special look at the disruptive change being

caused by the likes of Amazon.com and other online distributors who are becoming more and more involved with industrial products. Lawrence outlined ways for traditional distributors to shift their organizations to more service-intensive strategies in order to drive growth in their businesses.

Courtney Killion, market research analyst with Cleveland Research, also spoke in depth about how the Internet is changing industrial distribution. Her presentation, "Our Evolving Industry: Analysis and Insight," also included statistics and information about how the industrial distribution landscape is changing. The top 10 industrial distributors have gained significant market share since



2005, in some cases through acquisition (big companies getting bigger), and in other cases because new players have emerged on the market. For example, she said, Amazon.com now has more than 134,000 skus in power transmission categories, up from 86,000 last year.

Dr. Jeff Dyer, Chair of the Department of Organizational Leadership & Strategy at Brigham Young University, presented "The Innovator's DNA," in which he described strategies for business innovation.

All three presenters participated in a panel discussion, moderated by Ellen Holladay, BSA past president and senior VP, CIO and Operational Excellence Officer for Motion Industries. The panel also included questions and answers from the attendees.

Everyone seemed very satisfied with this year's event location, sessions and planned activities. Frank Mascia, managing director for Timken Canada, said that "BSA is considered one of the first class associations for Timken, creating solid relationships and business opportunities." Mascia also said, "The programming of speakers and industry updates keep us informed on growth trends and offers relevant information for our fast changing industry and company."

For more information about the Bearing Specialists Association, visit www.bsahome.org. **PTE**

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

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DESTINATION MARS!

The boss wanted something on transportation for this installment of Power Play.

Trans-por-ta-tion — it's only four syllables, yet a word with nearly boundless application.

Much like an even shorter word — *gear* — the impact wrought by “transportation” in actual practice affects just about everything that happens in everyday life, significant or otherwise. Whether it is commuting to work via car, train or bus, or jetting a harvested kidney from LA to NYC, transportation — or, more precisely — transportation *technology* — has been central to all commerce — licit or illicit — regardless of century or place — in even its crudest forms.

Fact: In the rip-roaring mining towns of the West in the late 1800s, it's common knowledge that the dirt “streets” turned to rivers of mud after a rainfall. But did you know that in true, American entrepreneurial style, sturdy, industrious “teamsters” began charging 25 cents in return for hauling on their backs “commuters” who could afford it across the street — dry as a Presbyterian picnic.

And now in 2014 here we are — when some combination of the words “transportation,” “tourists” and “Mars” seem to be appearing with some frequency on the same page in publications other

than *National Geographic* or *Travel*. Seemingly overnight, it no longer appears to be a question of *if* — but *when* the Red Planet will finally be within our reach.

Just this month in fact, NASA is testing two experimental, interrelated technologies which, if successful, will help bring a handful of early explorers that much sooner to a Mars landing.

Landing, it so happens, appears to be one of — if not the — most daunting hurdles facing a manned trip to Mars. NASA engineers point out that ships attempting to land on Mars will be carrying significantly heavier payloads than for any past manned Moon or unmanned Mars landing. A partial reason for that may lie in the fact that, according to most press reports, those who choose to make the trip and are selected — through whatever the selection process might be — won't be coming back. Aside from the fact that it seems most of the people interviewed who have a chance of going via one organization or another say they don't *want* to come back, the other reason is that, for now, we can't get here from there. We don't know how. So if you go, expect a long stay and bring a Kindle.

But here's what we do know: to land on Mars carrying a payload of any consequence, a deceleration system operable in a low-density atmosphere is needed.

Which brings us to NASA's LDSD (Low Density Supersonic Decelerator) project; the mission: “Advance the technology of decelerating large payloads traveling at supersonic speeds in thin atmospheres to a new level of performance.”

The LDSD is a rocket-powered, quaintly *saucer-shaped* test vehicle. The experimental flight is intended to help test the potential of other new deceleration technologies for help in enabling future manned Mars missions. The LDSD, backed by its Star-48 booster rocket, was built at NASA's Jet Propulsion Lab-

oratory in Pasadena, California, and shipped to Kauai, Hawaii for final assembly and preparations.

“During the experimental flight test, a balloon will carry the test vehicle from the Hawaii Navy facility to an altitude of about 120,000 feet,” said Mark Adler, project manager of the LDSD project. “There, it will be dropped and its booster rocket will quickly kick in and carry it to 180,000 feet, accelerating to Mach 4.”

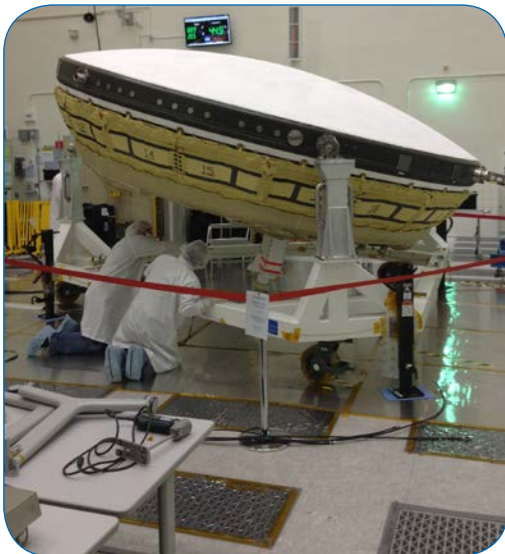
This is where it really gets tricky.

In addition to the LDSD vessel are two experimental, balloon-like pressure craft, or, to be NASA-technical — Supersonic Inflatable Aerodynamic Decelerators (SIADs). Pushed beyond the speed of sound, the SIADs will break all speed barriers for such craft. Specifically the other test vessels — 20 (SIAD-R) and 26 (SIAD-E) feet wide — are inflated with pressurized hot gas (SIAD-R) or ram air pressure (SIAD-E). These drag devices, which are attached to the outer rim of a capsule-like atmospheric entry vehicle, will inflate when the test vehicle is flying at Mach 3.5 or greater and decelerate the vehicle to Mach 2, where it becomes safe to deploy a supersonic parachute. Yet another new parachute with a modified design — approximately 100 feet (30.5 meters) in diameter — also will be developed to further slow the entry vehicle from Mach 2 to subsonic speeds.

This reminds of a tune by the obscure-yet-amusing singer-songwriter Dan Hicks. It's about a down-on-his-luck guy trudging along who is confronted by a little green man — a Martian of course — who asks him what he'd do if were asked to accompany the Martian back to his planet Mars. The man's answer?

“Hell, I'd go.” **PTE**

(Editor's Note: Unfortunately, the test flight was scrubbed for the time being, as was announced in a NASA June 13 press release. “NASA did not conduct the flight test of the agency's Low-Density Supersonic Decelerator (LDSD) during its designated launch” window, which closed June 14 due to continuing, “unfavorable weather conditions.”)





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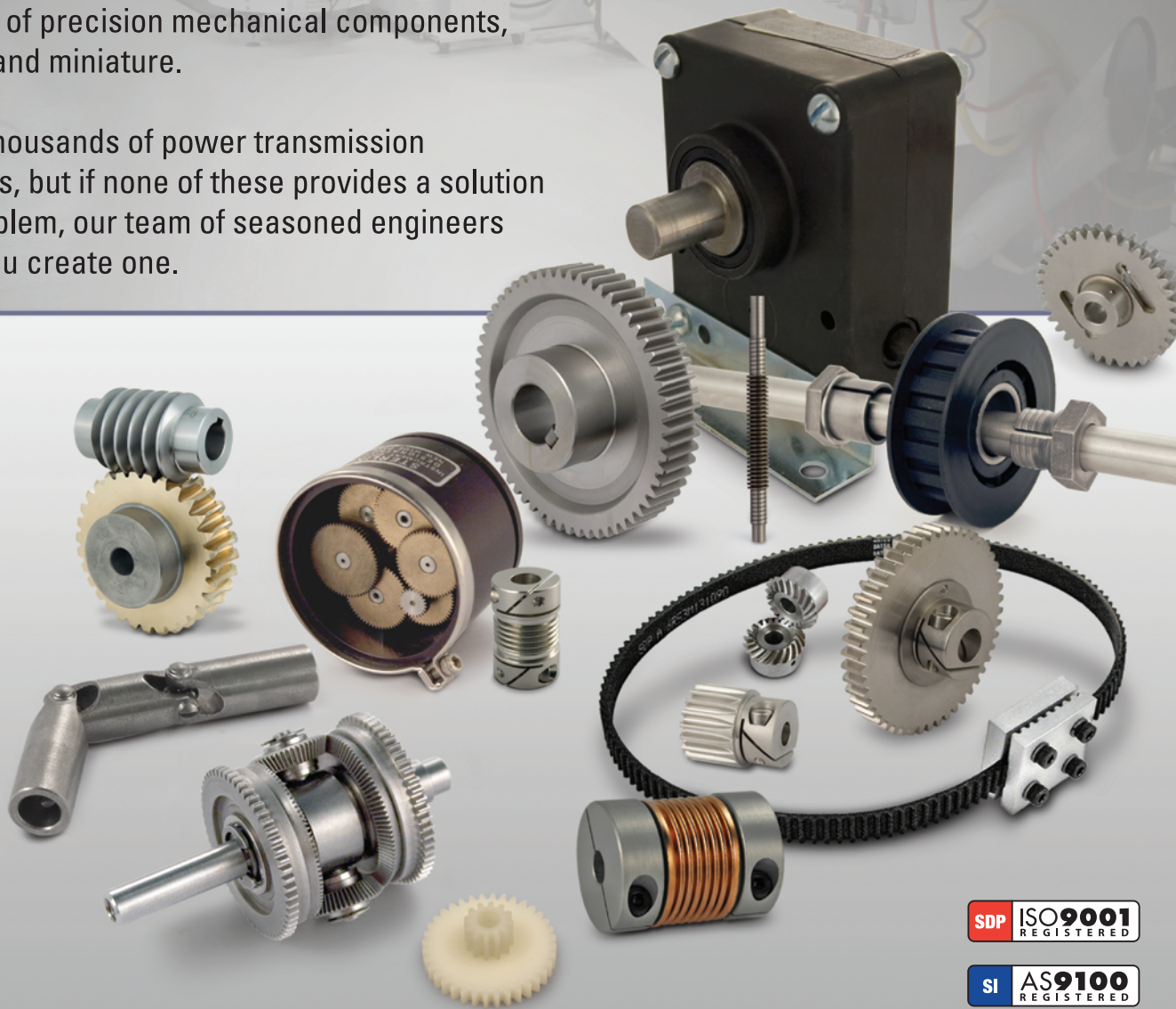
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