

# Power Transmission Engineering®

OCTOBER 2013

## EDUCATING OEM COMPONENT BUYERS

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- Spur/Crown Design Tips
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[Which Grease? It's Complicated]

[Step Motors Explained]

[Drive/Motor Basics]



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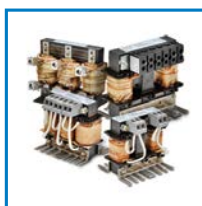
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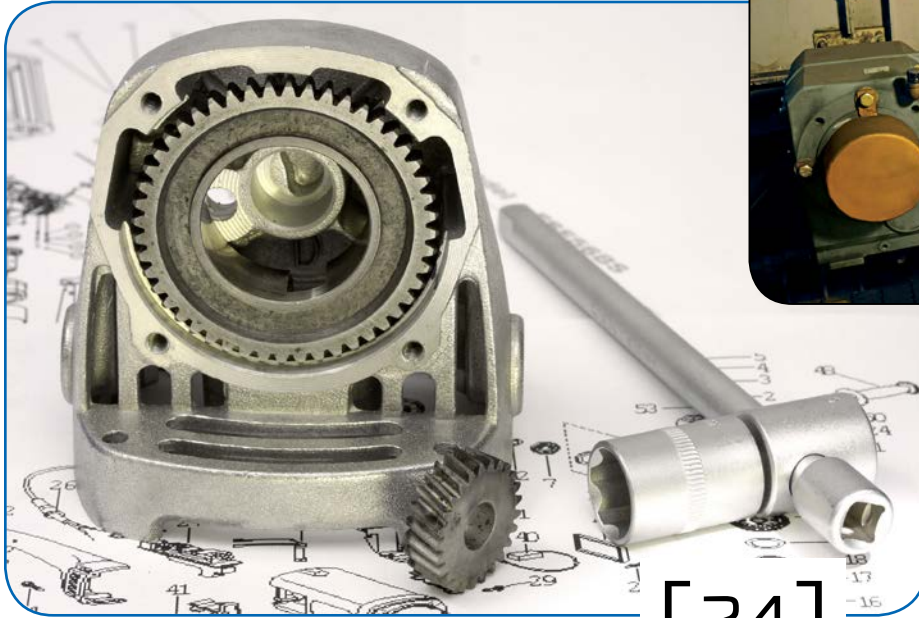
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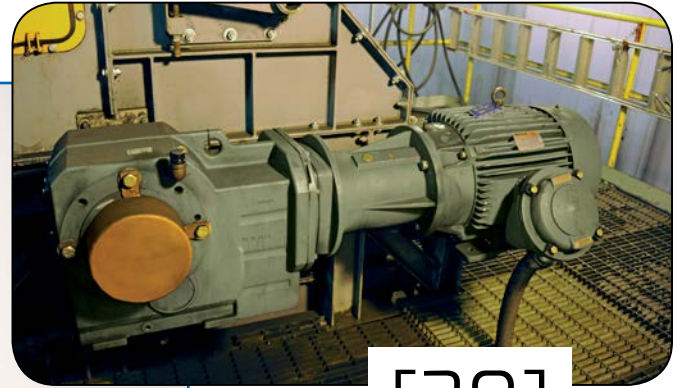
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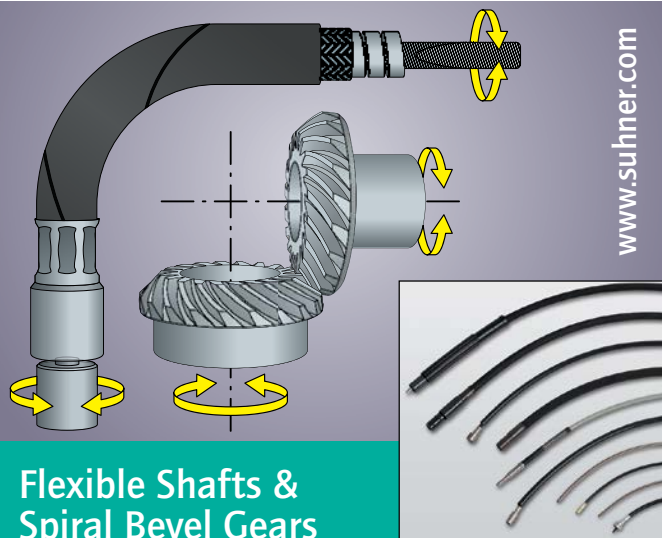


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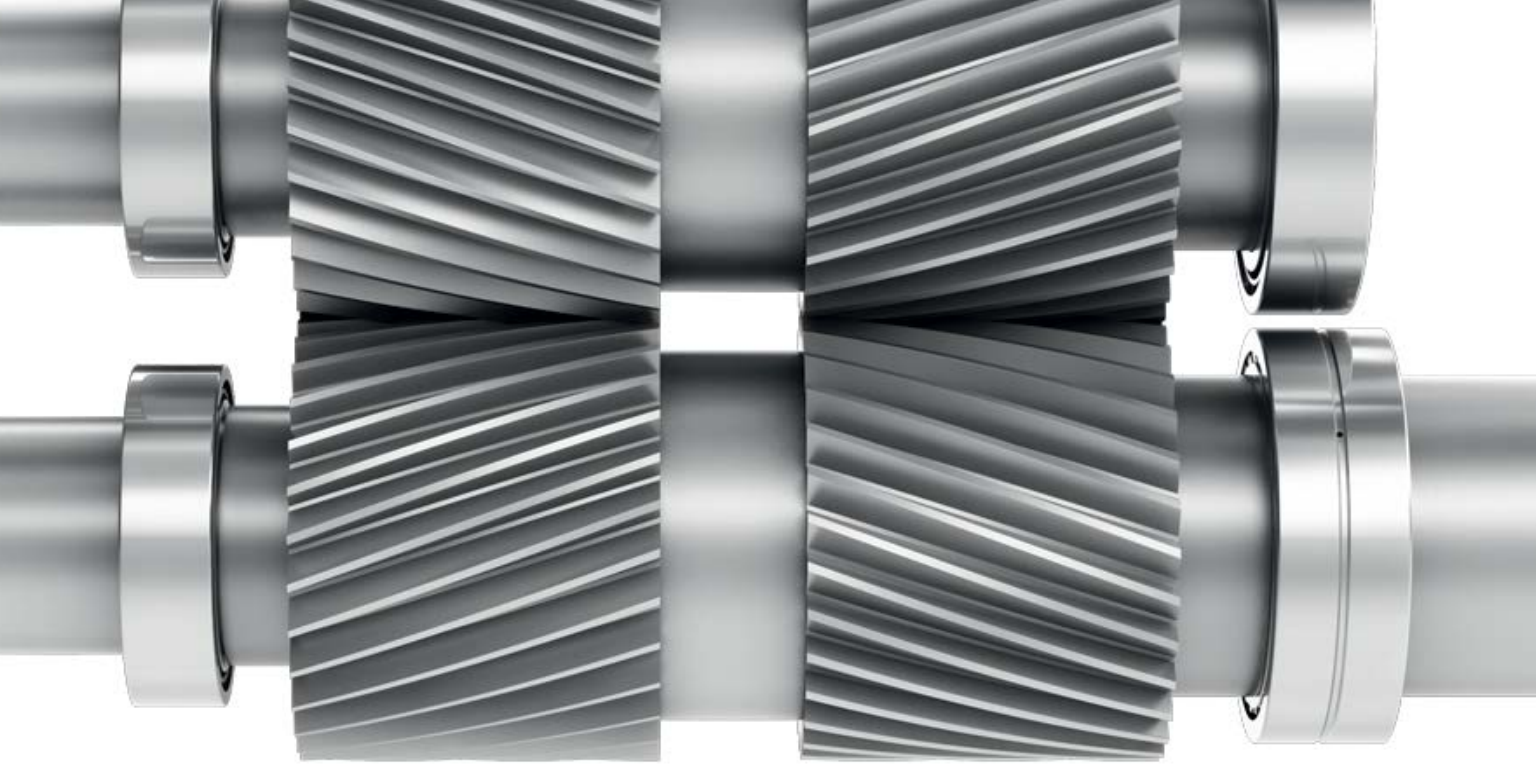
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## Buyers Guide 2013

Does your company appear in the *Power Transmission Engineering Mechanical Components Directory*? If not, visit [www.powertransmission.com/getlisted.php](http://www.powertransmission.com/getlisted.php) to create a new account or update a current listing. The buyer's guide will be included in the December issue of *PTE*.

**PTE Videos:** Groschopp Tech Tips is a series of how-to and how-it-works videos presented by its engineer and sales staff. Currently on [www.powertransmission.com](http://www.powertransmission.com), the company shows how to perform three quick checks to test a DC motor armature.



**LinkedIn:** The latest discussions on the PTE Group page include GE's Mind + Machines event in Chicago, Process Expo in Chicago and a look at some of the gear manufacturers on hand during Gear Expo in Indianapolis. Join the discussion at:

[http://www.linkedin.com/groups?home=&gid=2950055&trk=anet\\_ug\\_hm](http://www.linkedin.com/groups?home=&gid=2950055&trk=anet_ug_hm).

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

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

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# Seeking Suppliers

Last month's Gear Expo in Indianapolis provided a great opportunity to meet potential suppliers of mechanical power transmission components—mostly gears and gear drives, of course, but also a smattering of suppliers of bearings and motors as well.

We met with a number of gear manufacturers we'd never met before, including some new players in the industry, like bevel gear specialist Rave Gears from Seguin Texas, some newcomers to the North American marketplace, like plastic gear manufacturer Nichiei Ltd. of Japan, and a number of new faces at some of the companies we've known for many years.

Quite a few of those old regulars have expanded their manufacturing capacities, introduced new product lines or improved their processes over the past several years, enabling them to take on projects they couldn't previously handle, provide quicker turnaround or offer services they hadn't offered before.

So even if you thought you knew all the potential suppliers in the gear industry, you were probably pleasantly surprised to learn that the industry continues to evolve. Not only do suppliers come and go, but the technology they employ is constantly evolving as well. A number of gear buyers who visited the show told me they found a number of new potential gear manufacturing suppliers—including parts like plastic gerotors, splined shafts for oilfield equipment, automotive gears, complete actuator assemblies for medical devices and much more.

One particularly savvy gear buyer from Caterpillar told me he comes to the show not only to talk with potential suppliers of gears and geared parts, but also to better understand the technology those companies use to make the parts. A large part of understanding a gear manufacturer's capabilities is understanding the machinery they use to make the parts, he said. There's no better place for that than Gear Expo.

Unfortunately, attending trade shows can be expensive. And it's not just cost of meals, hotels, flights and so forth. It's the time away from work that really costs. So it's understandable that many of you probably didn't have the opportunity to attend Gear Expo.



Fortunately, we have a solution for you, in the form of our Buyers Guide. You can find it at our website, [www.powertransmission.com](http://www.powertransmission.com). And not only can you find suppliers of gears, but also bearings, motors, clutches, couplings, brakes, speed reducers and every other type of mechanical power transmission component. Hundreds of suppliers are listed there, ready to help you make your next project a success.

In addition, the next issue of the magazine will include a printed version of the Buyers Guide. This hands-on reference provides you with a quick and easy way to find the right supplier based on specific product categories.

We work very hard to ensure that this list is as up-to-date as possible, so you can be confident the information is accurate and reliable. With that in mind, we'd like to encourage all suppliers of mechanical components to make sure their companies are listed. To do so, just visit [www.powertransmission.com/getlisted.php](http://www.powertransmission.com/getlisted.php). There's no charge for being listed, so there's no excuse to put it off.

Just remember, the supplier base is continually changing. With new companies coming and going all the time, it pays to stay informed about which ones will make your next project most successful and profitable.

And as always, we're glad for whatever small part we're able to play in that.

A handwritten signature in black ink that reads "Randy Stott". The signature is written in a cursive, flowing style with a large, prominent "R" and "S".



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# Energy Efficient Solution Packages Integrate Motor Drive Sizing and Technologies

CRAIG DAHLQUIST, AUTOMATION TEAM LEADER, LENZE AMERICAS

Virtually every aspect of automation and plant infrastructures rely on electric drives. Given that electric drives account for such a high proportion of overall energy consumption and are in such widespread use, they are also the most effective means of increasing energy efficiency. Saving energy can be one of the toughest challenges in power system design.

The greater the efficiency of a drive, the more efficiently it runs and same is true not just of individual components, but the complete system. Uniform drive systems not only optimize processes, but permanently reduce life-cycle costs. To avoid squandering energy, the right choices must be made from the point at which drive components are selected. By using intelligent and integrated drive solution packages, energy consumption can be reduced up to 30 percent.

Motor drive sizing and technologies have expanded support for multiple applications, with fully integrated energy efficient packages comprised of engineering design software, MF (multiple frequency) gear motors with beveled gearboxes and highly efficient and economical variable frequency inverter drives. In designing and specifying 'right sized' motor drive and control components, the ideal energy efficient package comprises a powerful trifecta of tools that take into account the entire drive system.

## Efficiency At-A-Glance with Drive Solution Software

An efficient design process starts with the right design software to ensure precision drive dimensioning by tailoring the drive system specifically to the application requirements. This can prevent the common problem of overdimensioning of motors and inverter control and regulation of the drive systems. Lenze *Drive Solution Designer (DSD)* software can record and save the resulting projected energy consumption. By using *DSD* to select drive packages with MF motors, the

engineer can quickly achieve optimal energy balance with efficient drive dimensioning and assure fully integrated system components. Design software shows potential energy savings options at a glance, which makes it possible to compare several different solutions and ensure selection of the right sized components for the task.

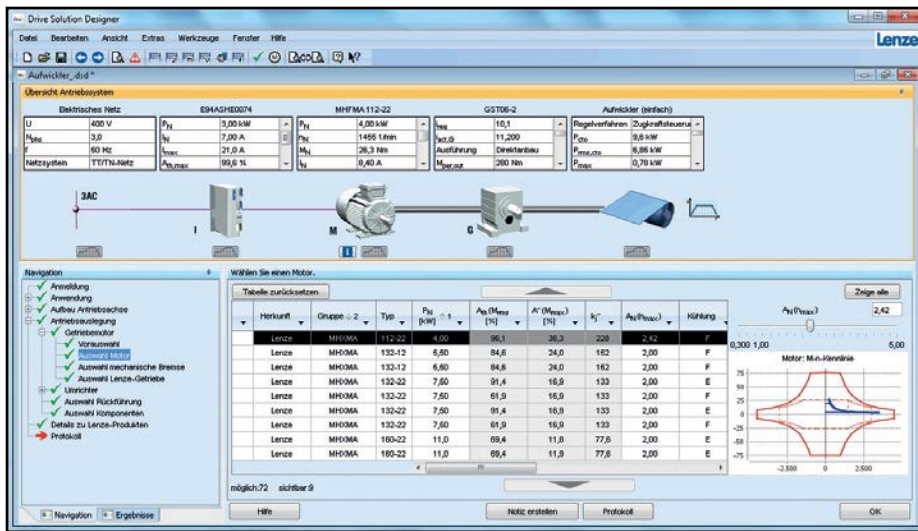
In a side-by-side project comparison, one can compare the different mechanical concepts and the different drive components with respect to their energy demands and energetically optimize them. It generally applies that a complete drive system should take into account motion, mechanical components, and drive components. The total energy efficiency can be calculated, e.g. for a complete production

line, and the energy part of the production costs and, additionally, CO<sub>2</sub> emissions can be determined. Additionally, it is possible to determine the potential savings by using DC power recovery instead of a brake resistor. Overdimensioning should be avoided, but the components should not be subjected to extreme overloads. In general, the longer the drive operating time, the higher the cost savings.

## Small, Yet Powerful MF Three-Phase AC Geared Motor

Classic three-phase AC motors generally increase in size as their energy efficiency improves. This not only leads to space issues inside the machine, but other negative effects, since greater inertia actually increases energy con-





assumption when changing speeds. An energy efficiency solution package offers greater design freedom and ensures a 'right sized' motor providing equal or greater output to replace larger, more costly and less energy efficient motors.

The ideal operating condition for the most commonly used 4-pole three phase AC motor is roughly 120 Hz to achieve high power output, a wide speed range and a high degree of efficiency. Multiple frequency motors provide a wide speed range and a high degree of efficiency, while concurrently reducing cost and energy usage. High performance Lenze L-force MF three-phase AC motors were developed based on these goals. The electrical winding design is geared to a rated frequency of 120 Hz with a supply voltage of around 400 V or roughly 3,500 rpm can increase both dynamic performance and productivity. Compact and highly efficient MF three-phase AC geared motors with a 96 percent efficient GKR bevel gearbox are inverter optimized for variable motion in power ranges of 0.55 to 22 kW. Two stage GKR bevel gearboxes are characterized by high efficiency, lightweight aluminum housing and wear-free gear teeth.

For variable speed applications, L-force MF three-phase AC motors provide added value, including a compact design for space savings. Designed for tasks demanding variable setting rang-

es with minimal sizes, MF geared motors exceed efficiency class IE2 and deliver constant torque in speed ranges of 24:1. In comparison, conventional motors offer an adjustment range of only 12:1. Since the speed setting range is double that of conventional motors, MF motors allow applications that require both slow and fast speeds to be implemented using a single motor, with constant torque throughout the entire setting range. A single MF motor version can serve varied application for standardized processes. Compact L-force MF three-phase motors enable energy-efficient drive solutions without costly design alterations. Inverter-optimized asynchronous MF motors can be up to two frame sizes smaller than conventional IE2 motors, while offering the same performance output. The inertia is lower than standard AC motors, which results in high dynamic response time from 0-3500 rpm in 500 milli-seconds.

### Optimized Frequency Inverter Drive for Intelligent Energy Savings

Optimized for frequency inverter operation, more than a third of newly installed three-phase AC motors are now operated using electronic control systems. The advantages of L-force MF three-phase AC motors become even more apparent in drive packages with gearboxes and frequency inverters. By combining a decentralized inverter

drive with a high efficiency geared MF three-phase AC motor, the connection is straightforward, energy efficient—and eliminates the need for a control cabinet.

Proven in a range of industries to deliver not only optimal energy efficiency, but longer service life, the Lenze 8400 motec features a power range of 0.5-10.0 hp (0.37-7.5 kW) and offers an innovative eco energy saving function for optimizing energy in no-load and partial load operation. In parallel with MF geared motors, they form a complete mechatronic unit, with a compact structure ideal for installation directly in the system outside the control cabinet for additional space savings. The motec can eliminate wiring by daisy chain the power source among the adjacent units and with built in 24vdc to handle onboard I/O. No additional wiring is needed if a brake is required due to the brake output.

The decentralized 8400 inverter is particularly compact with a low peak height when mounted directly on the MF motor. Thanks to efficiency levels of 92 to 98 percent, the right-angle and axial gearboxes in the L-force range ensure that the energy output by the motor is transferred directly to the application with minimal losses. The inverter features the innovative energy-saving function VFC eco (Voltage Frequency Control economic). This intelligent energy saving function adapts the motor magnetizing current to actual process needs and, consequently, reduces losses, particularly in partial load operation, which in turn dramatically improves efficiency and reduces energy consumption by up to 30 percent.

### For more information:

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# Brevini

DELIVERS CUSTOM GEARBOXES FOR OFFSHORE OPERATION

By the end of 2014, the world's largest platform installation/decommissioning and pipe laying vessel will be ready for offshore operations; and on board will be 32 high power gearboxes from Brevini Power Transmission. Capable of producing 2,000 tonnes of tension, the abandon and recovery winches will be used as part of the pipe laying equipment on board the Pieter Schelte, which is currently being built by the Korean shipyard Daewoo.

In the world of offshore oil and gas, everything is built big, and the Pieter Schelte is no exception. Owned by the Swiss-based Allseas Group, this vessel will surpass the current largest platform installation/decommissioning and pipe laying vessel by 50 percent. Measuring 382 m long and 124 m wide, the vessel is designed for the installation and removal of entire gas/oil rig topsides and their corresponding steel jacket-based platforms, as well as being able to lay pipe up to 68 inches in diameter. Once complete, the Pieter Schelte will be able to lift entire topsides weighing 48,000 tonnes and steel jackets weighing up to 25,000 tonnes in a single lift. Specialist pipelaying equipment will allow the vessel to operate in ultra-deep water and continue to push the boundaries of what was previously possible.



During pipe laying operations, it is crucial to keep the pipe under tension to maintain the bending and axial stresses within acceptable range. Through continually controlling the tension on the pipeline being laid, integrity of the pipeline is guaranteed without the necessity of extensive support structures. If poor sea conditions result in an unworkable situation, i.e. the pipeline integrity cannot be guaranteed anymore, then the abandon and recovery (A&R) winches are used

to lower the pipeline to the seabed in a precautionary abandonment procedure. When the conditions have improved, the pipe is recovered and the pipe laying operation can be continued.

The A&R winch manufacturer required a reliable and very compact design as well as fast production times, and for these reasons Brevini was selected to supply the gearboxes. The custom-made gearboxes were based on the Posired 2 High Power series, a combination of the Posired 2 product and the S series planetary reduction. This extremely powerful and efficient gearbox is capable of an output torque of 135 kNm at a speed of 23.1 rpm with an installed power of 520 kW.

The custom gearboxes were supplied with a custom-made bell housing and an integrated disc brake as well as temperature sensors for bearing and oil temperature. The specification also called for an offshore coating to be applied to ensure the package could withstand operating in the tough marine environment.

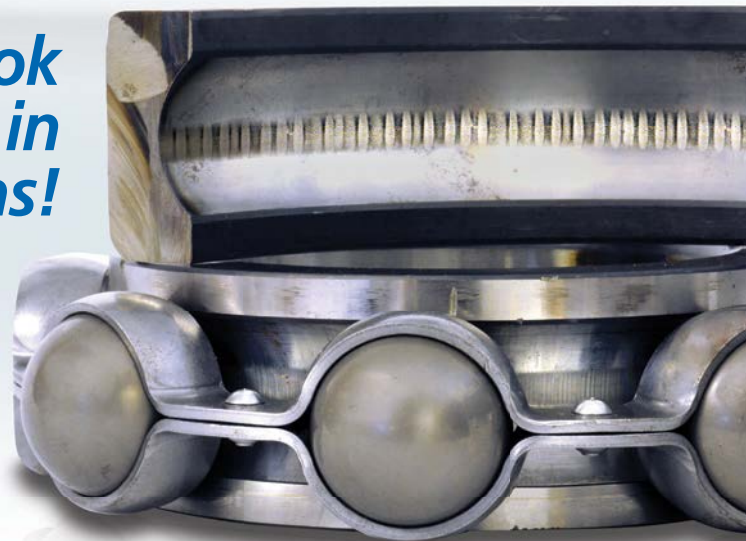
Part of the procurement process required a complete factory acceptance test (FAT), where eight units were tested under full load for eight hours. As part of this process, four of the tests were witnessed by a surveyor from the own-





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ers of the vessel as well as the winch manufacturer. Having successfully completed assembly and testing, all 32 gearboxes were delivered, with eight being fitted to each winch assembly.

Jeff van Nobelen, project engineer at Brevini, comments, "The scale and capacity of the Pieter Schelte demanded a high powered, high quality transmission with a proven track record. We were able to provide a flexible, adaptable product that could be designed around their requirements and still delivered at a competitive price and on realistic time scale. The High Power series basically combines the benefits of both the Posired 2 range and the S series gearboxes to produce a very compact gear drive with high thermal efficiency and high torque output. Our very compact design coupled with our ability to produce 32 units of a bespoke design within a tight timeframe was instrumental in being awarded this contract."

**For more information:**  
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Phone: +(44) 1925-636682  
[www.brevini.co.uk](http://www.brevini.co.uk)

## Igus

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Igus recently announced that iglide self-lubricating, maintenance-free plastic bearings are being used in the design and development of a single-passenger, urban commuting vehicle. The Personal Transport Vehicle - Ground, or "PTV-G," is the brainchild of Redbud Technology LLC of Union Grove, Alabama. Its unique design uses an articulated steering geometry, which means

the inclined steering pivot is positioned just behind the occupant, and as a result reacts like a high-performance, two-wheeled motorcycle.

Iglide plastic plain bearings are used in both the independent rear suspension and in the rear wheel lean-and-tilt mechanisms. Iglide plastic bearings are suitable for the harsh, dirty operating environment



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of the vehicle since they will not corrode and require no maintenance or external lubrication. The low cost and easy installation of the bearings is also an important benefit.

In conjunction with the company's Y.E.S. (Young Engineers Support) Program, Igus donated the bearings at no cost to a group of students working on the project. This vehicle's subsystems are being assigned to high school seniors and community college and university programs as special projects in order to encourage a younger generation to participate and excel in the study of science, engineering and manufacturing technologies.

Redbud is committed to projects which serve as educational resources to advance the knowledge of those who study and practice design, engineering and manufacturing in the United States of America. Redbud seeks to establish relationships with educational institutions and seasoned mentors to foster new learning models. Igus' Y.E.S. Program has a similar mission: to foster the mechanical design ideas of students with a passion for engineering, while at the same time educating them on the merits and benefits of plastic components.

Redbud Technology is actively evolving the design and engineering of an urban commuting vehicle based on the plan form of a delta trike. The Redbud PTV-G will serve as an educational resource to help technical high school, community college and university students develop and analyze advanced single passenger commuting concepts through fundamental 3-D CAD/CAE/CAM, design, innovative engineering and economical manufacturing, assembly and lifecycle maintenance.

### For more information:

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Siemens Opens Geared Motor Assembly Plant in South Carolina  
Randy Stott, Managing Editor

Need customized gearmotors in a hurry? With the opening of its Mauldin, SC assembly facility, Siemens now believes it has a solution. At the facility's grand opening May 21, company executives explained how assembling its Simogear geared motors closer to the customers allows them to provide exactly the right configuration in a timely fashion...  
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# Nexen

CLUTCHES/BRAKES HELP REDUCE MAINTENANCE COSTS

Nexen Group, Inc. announces that its high-capacity clutches and brakes, including pilot-mounted clutches, are designed for high torque, up to 302,000 inch pounds. Nexen engineered the clutches and brakes without expensive air bladders, with a design that reduces maintenance costs and improves efficiency. Specifically, the brakes and clutches include a simple piston and cylinder actuator, which is sealed with O-rings that require minimal servicing. Designed for heavy-duty industrial applications that require high torque and low inertia, the air-actuated, dual-faced brakes (DFE) and clutches as well as the quad-faced brakes (QFE) and clutches have double-disc assemblies. They are intended for applications such as conveyors, punch presses, shears, rock crushers, mills, agitators, wire winders, spoolers and similar equipment. They are available in disc sizes from 11.5 to 25 inches. The rugged clutch and brake elements have static torque ratings up to 302,000 inch pounds at 80 psi, with a bore range of up to 6.5 inches. Combined with bearing supported devices such as flywheels, pulleys or gears, the brake and clutch elements efficiently perform high torque starts and stops, reaching speeds up to 1,600 rpm and a horsepower rating of 14.7. Nexen's dual-faced, air-engaged friction clutches—DFC-1650 and DFC-2200—have a bearing mounted plate (pilot) for mounting pulleys or sprockets. Pilot mount clutches have torque capacities up to 66,800 inch pounds at 80 psi and bore sizes up to 3.375 inches. DFC clutches are capable of speeds up to 1,200 rpm and thermal horsepower dissipation of up to 10 horsepower. The clutches also have a heat sink capacity of 1.46 million foot-pounds.

## For more information:

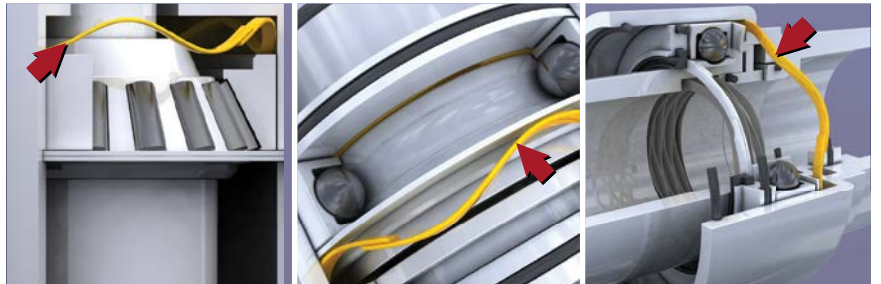
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# SKF

## OFFERS AUTOMATIC LUBRICATION SYSTEM

New SKF System 24 LAGD Series single-point automatic lubricators are timely and accurate “hands-off” solutions that deliver the proper pre-set amount of lubricant needed for bearings in machinery across industries.

These cost-effective, gas-driven feed versions are

engineered to perform reliably on a 24-hour basis without manual intervention and can resolve issues typically associated with hard-to-access or potentially hazardous lubrication points. Ultimately, they optimize the accuracy, reliability and cleanliness of lubricant delivery, contributing to increased uptime of assets, reduced maintenance and favorable environmental impact.

Compared with manual lubrication, the automatic lubricator’s continuous and controlled supply of fresh and clean lubricant minimizes the ingress of potentially damaging contaminants, prevents the overheating, waste and seal damage caused by over-lubrication, and eliminates excessive wear from over-lubrication.

The lubricator features flexible and user-adjustable dispense settings (ranging up to 12 months) and transparent lubricant containers for visual

inspection of dispense rate. A patented gas cell generates the proper pressure to dispense lubricant consistently from containers filled with SKF high-quality lubricant specially formulated for the application. Custom lubricant fills can also be evaluated upon request. Users can additionally benefit from the unique SKF DialSet program (available free for downloading from [www.skfusa.com](http://www.skfusa.com)) to determine precise lubricant-dispensing calculations. LAGD Series lubricators are supplied ready-to-use in two sizes (60 ml and 125 ml) and integrate tool-free activation. Various lubricator accessories, including connectors, brushes and no-return valves (for oil applications), and mounting and protecting devices, can be specified.

**For more information:**  
SKF USA Inc.  
Phone: (267) 436-6000  
[www.skf.com](http://www.skf.com)



# Micronor

## INTRODUCES ABSOLUTE ROTARY ENCODER

Micronor introduces an MRI-compatible fiber optic absolute rotary encoder system. The all-optical, non-metallic MR338 passive sensor provides precision absolute angular measurement from 0° to 360° with 13-bit (8,192 count) resolution and 12-bit multi-turn tracking. A duplex multimode fiber optic link connects the passive MR338 Sensor to the active MR330 Controller Module installed outside the MRI area. This absolute encoder system is designed for use in functional-MRI research, MRI training phantoms, EMC test facilities and other challenging electromagnetic environments where EMF and RF transparency is required.

The Micronor MR330 series absolute encoder system uses a novel optical technique. The controller transmits a burst of light to the code disk in the sensor, which accurately modulates the spectral components of the light based on angular position. The position information is imprinted in the

optical spectrum of the light and guided back to the controller for a precise position readout. The sensor requires no electrical power and houses

no electronic components whatsoever. The innovative technique was recently awarded U.S. patent 8,461,514.

Model MR330-1 SSI Controller’s powerful embedded processor and firmware offers performance plus an extended set of built-in functions and interfaces not available with resolvers or conventional electronics-based encoders. Built-in interfaces include SSI, USB, RS485, RS232, Modbus RTU, programmable digital set points and analog outputs (4-20 mA and ±10 V). The DIN-rail mount module operates from 24 VDC and supports encoder links extending up to 2,500 meters.

The MR338 MRI Absolute Position Sensor complements Micronor’s

MR328 MRI Incremental Rotary Encoder introduced three years ago. Users can now select the encoder type that best matches the feedback needs of their application. The MR338 13-bit absolute encoder is ideal for MRI applications requiring precision monitoring of absolute angular position. The MR328 incremental encoder provides 360 ppr resolution and A/B quadrature (pulse) outputs which are suited for monitoring speed and relative position tracking. Linear encoders are in development.

**For more information:**  
Micronor Inc.  
Phone: (805) 499-0114  
[www.micronor.com](http://www.micronor.com)



# ABB

PLC SIMPLIFIES EXTREME ENVIRONMENT CONTROLS

A new rugged PLC system from ABB provides an easy-to-implement solution for controlling equipment operating in harsh conditions and extreme climates. ABB's "extreme conditions" AC500-XC PLC is protected against a wide variety of threats, including high and low temperatures, high humidity, low air pressure, salt mist and hazardous gases, and vibration and shock. This typically reduces system building costs by eliminating the need for sophisticated protective enclosures with special seals, HVAC, shock absorbers, EMC protection, etc.

The embedded protection features ensure that AC500-XC PLC based control systems stay functional and reliable even when operating in hostile environments. Such conditions can be found in many common automation applications including mines, tunnels, vessels, cranes, water and wastewater plants, offshore platforms, wind turbines, solar trackers and weather and navigation stations.

The AC500-XC PLC is a ruggedized variant of ABB's well-known modular AC500 PLC. Almost all of the modules in the extensive AC500 range are available in XC (eXtreme Conditions) variants, providing users with a modular control platform offering almost limitless flexibility and scalability.

AC500-XC PLCs also run exactly the same program code as the AC500, allowing users to migrate to more robust solutions easily, and simplifying development for large systems that require control systems for both standard and extreme conditions. This inter-range compatibility also extends to ABB's safety PLC, the AC500-S-XC. The mechanical dimensions and electrical specifications of connections are also the same as the standard AC500, allowing existing panel layouts and wiring harnesses or designs to be re-used.

Embedded environmental protection opens up extensive applications potential for the ABB AC500-XC. Extended



temperature operation allows the PLCs to operate in temperatures from -30 to +70 degrees C, with reliable system start-ups in temperatures as low as -40 C. With few limitations, the AC500-XC operates at up to 70 C. Circuit boards are coated to protect against high humidity levels. The PLC has extended immunity against salt mist and atmospheres with corrosive gases such as H<sub>2</sub>S, SO<sub>2</sub>, Cl<sub>2</sub> and NO<sub>2</sub>. High levels of vibration and shock can be tolerated, with accelerations up to 4 g from random vibrations up to 500 Hz, or 2 g from sinusoidal vibration. The PLC is capable of operating at altitudes up to 4,000 m. It also offers extended EMC protection against voltage surges and fast transients, as well as electrostatic discharge. "ABB's extreme conditions PLC allows automation to be sited right where the control I/O is needed," says ABB's Thomas Boenig. "The technology opens up new and more profitable design approaches for a very wide variety of automation users."

## For more information:

ABB  
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## DieQua offers more gearboxes

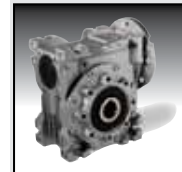
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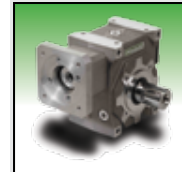
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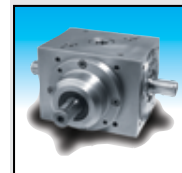
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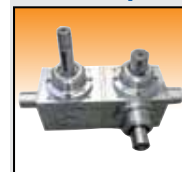
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## Tsubakimoto

LAUNCHES LN SERIES OF COUPLINGS

Tsubakimoto Chain has launched its LN Series of Jaw-Flex coupling to the European market. The high-precision coupling is specifically designed for use with servomotor drives such as those on machine tool feed shafts. Featuring vibration damping characteristics, and a simple design which makes installation extremely easy, the new range is suitable for OEM and maintenance requirements alike.

Derek Mack, sales director for Tsubaki U.K., comments: "Tsubaki is dedicated to manufacturing power transmission solutions for its customers that will improve productivity and offer industry leading reliability. The LN Series offers a choice of materials to suit specific requirements and a design which is designed to provide excellent shock absorbing qualities and superior vibration damping; both of which improve overall machine performance."

The coupling consists of two hubs, which use a simple clamping design to locate onto the drive shaft, and a spider which is available in two different materials types depending on the application. End-users can specify between material type 98A, which features excellent vibration damping, or 64D, which offers rigidity and high wear resistance. Currently there are six couplings available in the LN Series range with the ability to deliver a torque transmission range of 60 Nm to 405 Nm and accommodate shaft diameters from 12 mm to 42 mm. In applications where precision and reliability is key, such as robotic servomotor control and machine tool applications, the LN Series offers the key characteristics required within these and similar applications.

**For more information:**

Tsubakimoto Chain Company  
Phone: (800) 323-7790  
[sales@ustsubaki.com](mailto:sales@ustsubaki.com)  
[www.ustsubaki.com](http://www.ustsubaki.com)



## Thomson Industries, Inc.

INTRODUCES MAX JAC ACTUATOR

Thomson introduces Max Jac - a heavy-duty linear actuator that delivers reliable and virtually maintenance free operation while maintaining accuracy in the harshest application conditions. The IP69K rated Max Jac has a stainless steel adapter and extension tubes to help prevent leakage. Additionally, a non-contact feedback signal assures accuracy over time and eliminates the



need for re-calibration. The Max Jac has been subjected to rigorous testing and was proven to withstand: 500 hours of salt spray, exposure to aggressive substances such as fertilizers, acid, oil, grease and cleaning agents, rigorous vibration testing and continuous operation in extreme temperatures ranging from -40°C to +85°C.

"The Max Jac offers stroke lengths from 50 to 300 mm with a potential speed of 60 mm/s giving a very short overall length versus stroke. Using the latest technology and best materials available, Thomson has created an electric linear actuator designed specifically for rugged use in mobile

off-highway vehicle applications, including fertilizer or salt and sand spreaders, throttle or seeding applications, in marine, offshore, rail, mining and any other application with a large amount of wash down or exposure to aggressive substances,” says Håkan Persson, product line manager, Thomson Actuators.

The Max Jac can be custom designed by Thomson engineers to fit the widest

possible range of application needs. It comes with the option of an analogue or digital encoder output, as well as self-locking worm screw or ball screw models to accommodate the demands of the specific application.

**For more information:**

Thomson Industries, Inc.  
Phone: (540) 633-3549  
thomson@thomsonlinear.com  
www.thomsonlinear.com

## Boston Gear

### EXPANDS STAINLESS STEEL GEAR DRIVE LINE

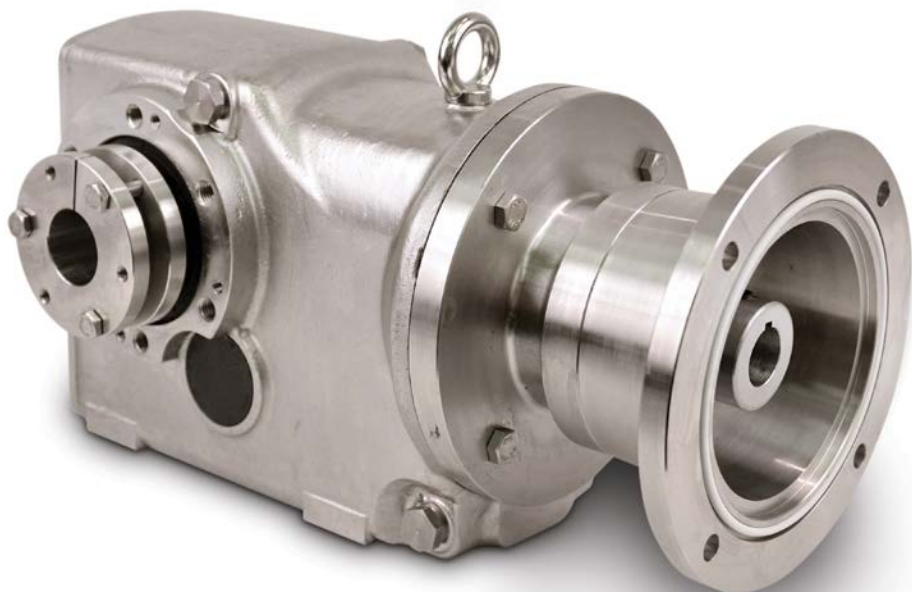
A new line of Boston Gear stainless steel, right angle helical bevel gear drives is now available with output torque up to 7,700 lb.in. (870 Nm) and input power to 10 HP (7.5kW). SS2000R models are designed to meet the demands of washdown applications including cheese slicers, dairy and bakery mixers, spiral heating and cooling racks, produce drying bins (tumblers), meat forming and carcass processing equipment, bottling lines, conveyors and palletizers.

Units feature a 316 Series stainless steel housing with domed crown and rounded corners for superior wash-down runoff in harsh environments where high-pressure caustic solvents and cleaners are utilized. A laser-marked nameplate is imperious to the effects of caustic washdowns. Stainless steel shafts and a high-pressure wash-down deflector are also available. Boston Gear Series SS2000R C-face gear

drives feature unique mounting registers and keyless tapered bushings for fast and easy installation. Other advantages include automatic entrapment of wear debris, large diameter oil fill/drain holes, synthetic lubrication and O-rings for high leak and ingress resistance. Design flexibility is enhanced with a large assortment of shaft options, a variety of optional hollow bore sizes and input styles. With the premium efficiency of ground helical gearing (98 percent per gear mesh) and increased tooth contact area, SS2000R helical bevel drives are suitable for use in high torque applications with continuous or high duty cycle operations, high-ratio reduction, and limited access installations where long life is a necessity.

**For more information:**

Boston Gear  
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# Slogging Our Way to Recovery

Brian Langenberg, CFA

**It was a pleasure meeting so many of you at Gear Expo in Indianapolis last month.**

I always appreciate when owners, salespeople and engineers teach me about their company, the business and the technology of gear cutting and power transmission. It is equally gratifying to share with you my insights on global demand, as well as your customers' broader strategies, risk profile and capital spending outlook. Since our last installment we've met with C-level executives of 3M, Wesco International and Broadwind Energy, as well as attending other trade shows. This is what we see:

**Replacement demand is driving modest growth.** Aging installed base - be it automotive, truck, construction equipment - is underpinning most capital spending activity. Automotive demand will remain strong as old fleet and new model rollouts continue to drive capital spending globally. Truck remains tepid - most public truckers are running at 3-7 percent net margin - which is actually pretty good - but forward uncertainty and weak employment leave truckers unconvinced they need to grow their fleets. Construction

equipment - ditto on construction, but mining will continue to decline.

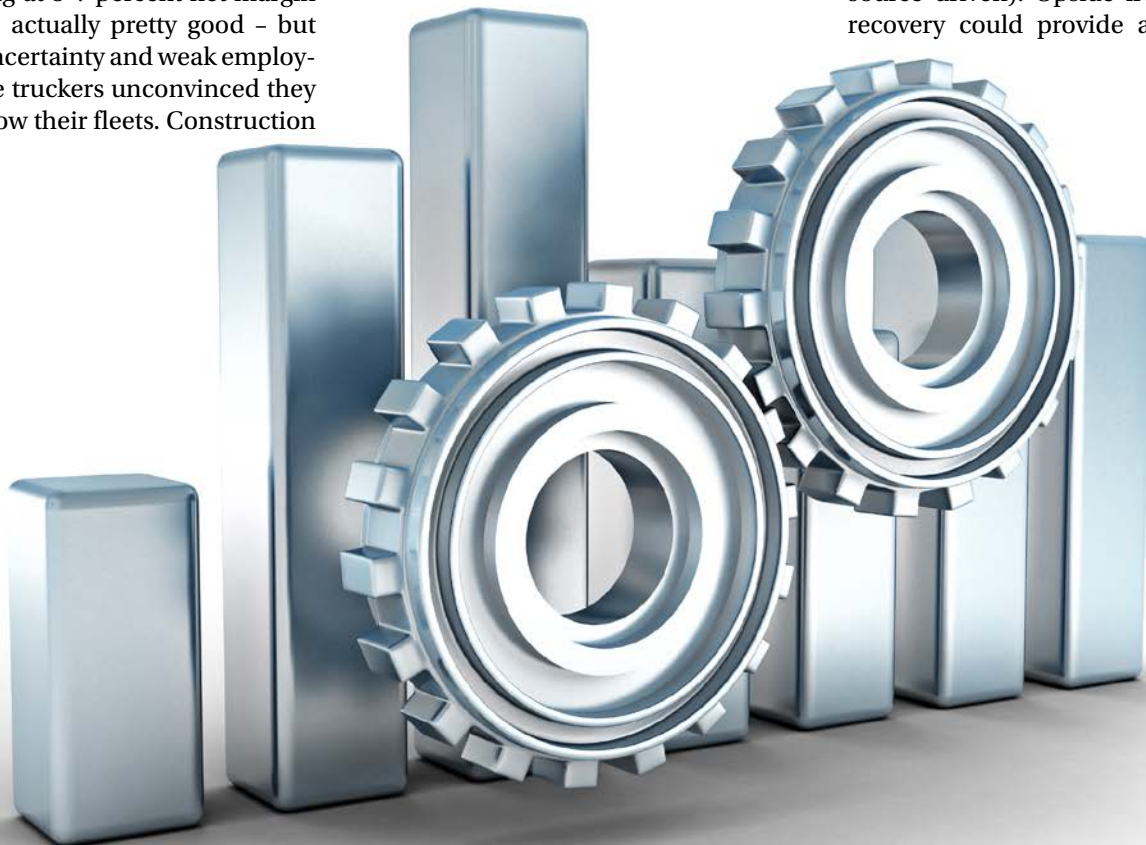
**Exceptions include aerospace and wind.** Global growth is sufficient, in our view, to consider supporting production ramps in commercial aerospace, not to mention airline cash flow (strong) and the need to upgrade their fleets with more efficient aircraft. Winners include GE and United Technologies. Wind - near and dear to the hearts of power transmission and gears - is re-ramping off low levels, and though we don't see a return to 2012 we see sustainable demand, particularly in the U.S. where coal is under attack politically and by regulation, and putting up an incremental \$2-5 million wind turbine is easy to get done.

**Power generation remains solid globally.** Emerging markets continue to add capacity to support growth and economic development in both steam power and gas. GE just booked a \$2B+ order (including service) for 26 gas turbine engines out of Algeria. Siemens is

also well positioned, despite another round of turmoil at corporate.

**Second half comparisons will be "easy."** We expect improving year/year results in the second half in construction equipment and truck engines, particularly in North America.

**Regionally we anticipate more of the same, but with a modest China kicker.** In the U.S. the combination of an election year and political dysfunction (BOTH "parties") means you can forget about anything really good happening that would drive infrastructure spending, power generation or big pipelines. Or, anything really bad (tapering - really? - all the candidates - not just Janet Yellen - are printing press operators (*Editor's Note: Janet Yellen was named head of the Federal Reserve by President Obama as this issue went to press.*)). Europe will be flattish for you, if only because markets that go to zero can't really go lower (Spain), and most of the heavy capital equipment market is Northern Europe (read: resource driven). Upside from a China recovery could provide a boost (ex-



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ports from Germany). Internationally, China is now improving and provides opportunities, while India will remain painful owing to a combination of political dysfunction at least as bad as the U.S., but without the benefit of built up capital (or willingness to borrow) to spend through problems.

We remain in a moderate global economic growth environment that should continue to support maintenance capital spending, selected expansion, but no significant increases. For detail, eight of the ten industry verticals in our broader GIO are detailed below:

**Oil & Gas:** Within the U.S. a combination of rig count, utilization and mix (gas is more intensive than oil) will support modest growth in the second half and into 2014. Globally, the dash for carbon, even in deeper, tougher, more inaccessible locations, provides multi-year opportunities for growth and advanced applications. I was surprised at how very few participants at Gear Expo brought it up without prompting, but would encourage your organization to ensure you are not missing out on supporting companies who are making a concerted effort to grow in this space.

**Mining:** New equipment demand will continue to plunge. How bad is it? Glencore Xstrata (GLEN) recently “bragged” that it found \$2 billion of merger savings vs. the original \$500 million. What that really meant is they are firing a lot of people because they overpaid and had to write off over \$7 billion in goodwill. All the big players are slashing capital spending – though utilization should support aftermarket demand.

**Power generation:** Globally, the demand growth is coming from emerging markets – Middle East, China, Latin America. The U.S. is going nowhere, owing to a combination of a), little need – conservation and green initiatives have materially affected demand growth, and b), regulatory and political pressure. The President hates coal and gas pipelines – therefore the EPA does as well. Suffice to say that leaves wind turbines and with the new PTC they will grow significantly in '14. Offshore demand for coal- and gas-powered generation remains strong and is turn-

ing into new orders and backlog with major engineering and construction firms. General Electric's recent \$2.2 billion win for 26 gas turbines to Algeria is a testament to this growth. For “small power” – which ties into oil and gas – inventories are coming back into balance.

**Transportation infrastructure:** Anything road building-related is stagnant in the U.S. and Europe (government budgets being what they are). Rail is a mixed picture; in the U.S., weak coal is driving lower rail car and locomotive orders. Internationally, passenger rail is in high demand and beneficiaries include Bombardier, Siemens and Alstom.

**Water & environmental:** Municipal budgets in the U.S. and Europe remain weak and industrial customers are not investing – particularly those involved in gas fracking and mining (dewatering pumps and mobile equipment). E&C contractors are talking about improved demand, but we've seen little flow into the order books (we will know more after WEFTEC in October). We think the tone is improving with home prices – but orders for you are a couple years out.

**Machinery: Overall picture continues to improve.**

**Construction equipment** production is now rising sequentially as Caterpillar has worked off excess inventory, and the 3Q comparison will be “less bad” and turning into positive comparisons by 4Q. China is improving – and should help CAT *there*. **Mining equipment** is going to be a disaster, but you already know this since *it wasn't even mentioned* at Gear Expo. We expect a further decline of up to 20-30 percent in spending over the next two years and even worse on new equipment. **Truck:** Production outlook for '13 has glided downward on Class 8 throughout the year, but strong August orders and aged fleet argue for stability. **Agricultural equipment:** Our view remains unchanged. North America remains stable while John Deere growth investment emphasizes Brazil, China, India and Russia. While we've seen no major new expansion plans since 2012, the company continues to invest in those offshore projects.

**Consumer (auto, appliances):** Good news continues. In the U.S., improving real estate prices are helping bolster consumer balance sheets and thus pent up demand for durable goods. We expect continued growth in auto, appliances and housing. Expect the Fed to keep interest rates low at least through the November 2014 elections. European comparisons are now easier against a low basis, but we do not see any real pickup on the horizon. Emerging market growth will continue and, along with it, the service and aftermarket infrastructure needed to support larger auto fleets.

**Aerospace/defense:** Commercial production schedules are increasing and even aftermarket service work is improving (albeit against weak comparisons); but we continue to see, and anticipate, a pattern of lower yields on shop visits as airlines minimize upgrades on old planes in anticipation of getting the new ones. Airfreight does, we concede, remain weak as modest economic growth means people are content to ship slower but cheaper (ships don't have to fly and they carry more!). Commercial engine deliveries, particularly out of GE, will rise to support production rates, while UTX is positioned on the C Series (Bombardier) next year and other platforms with its highly efficient geared turbo fan (GTF) engine.

Military is another matter – budget battles, sequestration and political dysfunction, along with a fundamental lack of understanding of geopolitical realities and responsibilities on both sides of the aisle in the U.S.— are resulting in a significantly negative impact on military readiness. Meanwhile, others are spending to replace U.S. “defense capacity” – Japan unveiled an 820 foot carrier and China seeks to add a second. Expect both nations to source largely from their domestic industrial base.

**Capital spending – flat at best – no better. Deals create risk for you.** This point is unchanged from our last installment. The global economy continues to grow but not fast enough to drive significant growth in global fixed investment. Generally speaking, the C-suites are focused on optimizing footprint, improving supply chain



and driving productivity. There is no time like the present to *think very hard about business risk*. Urge to merge is high – and usually leads to delayed or cancelled capital spending at the target. If a single client or factory generates more than 10 percent of your sales, we should talk. We can help you assess your risk and develop a growth strategy to protect your company.

Conversely – supply chain concern may create an opportunity for you. Many larger companies appear to have realized that “cheap now” is hardly “low cost,” and presenting your capabilities—along with deliverability (geographic proximity, operating performance)—may provide incremental revenue. While the big guys want price – as always – many have learned, painfully, that deliverability is at least as important.

**Focus company: General Electric (GE).** We selected GE because of its high-exposure, multiple- end markets that use power transmission and gearing, including power generation, oil and gas, aviation and rail. General Electric made it through the '08 downturn—with temporary government help—before writing some huge checks to acquire oil and gas assets. Additionally, the company has closed deals that increase vertical integration—both to control supply chain and to capture gross profit. Right now their focus is to shrink GE Capital, integrate back-office costs (a lot of deal clean-up to do), and deploy excess cash into share repurchases. Within their operations we see good growth potential in gas turbine generation from emerging markets, along with a recovery in wind turbines. Coal will also benefit outside the U.S. In aerospace their incumbent position with Boeing will allow continued growth in deliveries and installed base. In oil and gas, high performance and hazardous environment capabilities associated with deep offshore activity remain a strong driver of order growth. Our Integrated Company Dashboard (ICD) on GE will give a better sense of these trends. *(Please Note: These analyses are available on our website for \$199, but readers of Power Transmission Engineering magazine can email me directly at Brian@Lan-*



genberg-llc.com and ask for a copy by putting “PTE Offer” in the subject line.) We expect GE will continue seeking to optimize its supplier base, and playing ball with the company requires high relevance and no/few alternatives to do well. Capital spending will remain focused on R&D, adding incremental capacity only where necessary.

Previously, she was President and Chief Executive Officer of the Federal Reserve Bank of San Francisco, Chair of the White House Council of Economic Advisers under President Bill Clinton, and Professor Emerita at the University of California, Berkeley’s Haas School of Business. **PTE**

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



# Buying in to Commodity Buyers

## Adding Value to OEM Procurement

Marlia Fontaine-Weisse

(Reprinted courtesy THORS LLC.)

The economic outlook for the future of the manufacturing industry is unstable, especially with the volatility of raw materials costs and fluctuating consumer demand. According to an article published by Thinking Cap Solutions Inc., even though materials are currently at a manageable price, overall “margins have slumped below year-ago levels for 59 percent of U.S. manufacturers” between January 2012 and January 2013 (Ref. 6). As growth margins decrease, it becomes increasingly important that OEMs do more with less and find ways to shave costs. Integral in this cost-savings strategy are procurement organizations that proactively manage company assets efficiently and can negotiate with suppliers to help drive down costs.

The challenge facing OEM procurement organizations is that the orga-

nizations themselves need improving before they can be proficient in a cost reduction program. In the Ardent Partners’ *CPO Rising 2011: Innovative Ideas for the Decade Ahead*, 250 chief procurement officers reported on the current state of procurement and suggested ways to increase successful performance for the future. According to respondents, the areas “that CPOs typically decry as the two areas most in need of significant improvement and the major constraints to success—their people and their processes,” a problem that can appear daunting without a viable strategy in place to appropriately counteract both areas of need (Ref. 2).

Procurement personnel need to understand the importance of the materials they purchase, be knowledgeable

about the various processes by which these materials are manufactured, the factors affecting their cost, and the criteria for their selection; otherwise, quick decisions are made that will negatively affect a company’s bottom line. A knowledge base that captures manufacturing process information, combined with a system that captures supplier capabilities, can be a powerful combination to facilitate right value decisions. Making right value decisions will increase cost savings and the value and functionality of the procurement procedure. This article offers a practical solution to overcoming the learning obstacle and the challenges in storing and accessing institutional knowledge that procurement organizations currently face.



## Challenges Facing OEM Procurement Organizations

One of the biggest challenges facing procurement organizations is acquiring knowledgeable and skilled personnel. Andreas Gocke, managing director of Boston Consulting Group, explains that at the BCG-sponsored procurement roundtable, “Surprisingly enough, people—training and development—was the number one topic as the key challenge for procurement organizations” (Ref. 4). The reason is easy to explain: “Unlike most other functions, there is not the academic purchasing manager education. You don’t find, or very seldom find, a master education in purchasing. Very few universities around the world really focus and specialize on purchasing as an education path by itself” (Ref. 4). Not only that, universities seldom offer courses specific to the manufacturing industry, so finding a candidate with the appropriate background in either manufacturing, procurement, or both, is proven difficult. Most employees who join the procurement function learn about manufacturing processes on the job, leading to a drawn out onboarding process. Similarly, it is difficult to gauge the competency of an individual’s manufacturing exposure since some manufacturing experience may not develop the right capabilities for procurement.

Additionally, the processes and tools currently utilized by procurement organizations do not contain all the necessary information to properly input and retain important details, or are too difficult to maintain. ERP and MRP systems, for example, attempt to standardize data stored; however, the categories are often generic and do not allow users to input commodity-specific supplier capabilities. Given the challenges in bandwidth, the supplier capabilities are rarely kept up to date by

“Procurement leaders overseeing fully manual processes are not well-positioned to take on the challenges of the decades ahead.”

**Andrew Bertolini**, Ardent Partners Buying



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companies who use spreadsheets or home-grown databases to organize their data, forcing expensive purchasing decisions to be made from outdated information. As stated in the Ardent Partners' report, since "63 percent of CPOs believe that their procurement departments are short-staffed, the ability to use technology to, among other things, help scale resources, gain greater visibility, and make smarter decisions becomes a critical competency" (Ref. 2). But the right kind of technology is crucial. A.T. Kearney's 2011 "Assessment of Excellence in Procurement" study suggests procurement organizations "get connected" by focusing "on technology, the kind that will fundamentally change processes, not just automate them" (Ref. 1). With companies like THORS (The Helpful Online Resource Site), OEM procurement organizations can increase the knowledge of their employees and increase the efficiency of their processes in one convenient online portal.

### E-Learning and the Benefits of Commodity-Specific Training

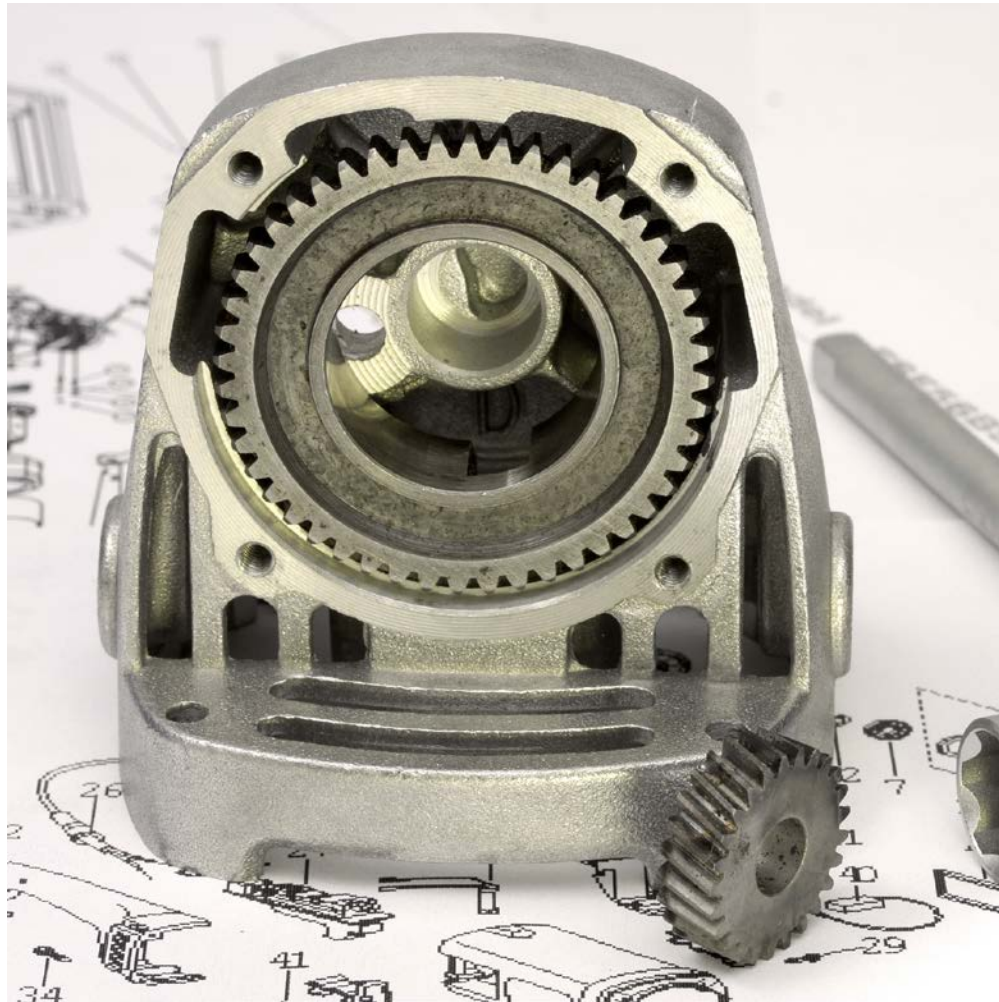
Currently, a typical person entering the purchasing field has a liberal arts degree or a business background, while there is a smaller subset of people entering with a supply chain, accounting, or engineering background.

Although taking the time to attain a degree highlights a number of transferrable skills, the lack of commodity-specific foundational knowledge in manufacturing procurement is troublesome for OEMs. Buyers make expensive, real-world decisions daily without a deeper understanding of how the commodities they purchase are manufactured, the factors affecting their cost, and the criteria for their selection, which result in companies' finished products becoming more costly in the long run. While liberal arts, business, supply chain, and accounting degrees do not cover manufacturing processes in their curriculum, even engineering students are usually only given a crash course on manufacturing processes. How can the right purchasing decisions be made without the

right knowledge? How does one fill the knowledge gap?

Companies try to solve this problem with one of two conventional methods: sending people to seminars, or letting them learn on-the-job. Educating people by sending them to seminars is an expensive proposition, where too many PowerPoint slides are presented in a short amount of time, and usually one leaves with a three-ring binder. The three-ring binder usually sits on a desk where it is rarely referred to because of the difficulty in searching for information, and it is usually not shared with other people in the organization. Learning on the job, with or without a mentor, is a challenge, as generally there is no structure to the entire process. If in fact the mentorship approach is followed, its effectiveness is based on the time available to the mentor, as today people are spread thin. With the onset of the baby boomer retirement, this poses a huge challenge.

A much more viable option for education than expensive seminars that allow little time for knowledge retention or unstructured on-the-job mentor training is e-learning. Ellen Wagner explains that "E-learning is gradually upstaging conventional training methods, thanks to the immense benefits e-learning offers in terms of cost savings and employee productivity" (Ref. 7). Although there are different kinds of e-learning atmospheres, a "common type of e-learning is online learning, where the personalized learning environment is contained within the internet and not also associated with a formal education space" (Ref. 3). Advantages of online learning include ease of access, increased knowledge retention, and, as Tom Snyder, president of Ivy Tech Community College, states in a *Huffington Post* article, "Online learning not only trains the workers of the future, it can also provide a career path for someone employed, who



needs to learn new skills” (Ref. 5). With an online learning solutions provider like THORS, procurement organizations can provide the vital commodity-specific manufacturing education purchasers need to make better value decisions, which effectively overcomes all of the challenges with the conventional methods of seminar and on-the-job-based learning.

Developing content pertinent to the manufacturing industry makes companies like THORS unique. Online learning centers spanning large industry-specific categories like castings, machining, gears, steel manufacturing, polymer manufacturing, forgings, motors, reading engineering drawings for non-engineers, and so on contain easy-to-understand courses purposely created to build foundational knowledge and expand on it with advanced courses. Subject matter experts with decades of experience collaborate to

“THORS’s commodity management solution is certainly a procurement solution that doesn’t exist anywhere else.”

**Tim Mohs, Sivyer Steel**

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ensure content remains relevant and accurate, and the infusion of computer-generated animations and frequent quizzes helps users easily break down complex concepts and test retention.

Learning management systems (LMS) are just as essential to the effectiveness of online learning as the content that is available. "When used in conjunction with reliable, valid, and predictive assessments, and when correlated with an individual's learning path," Wagner tells us, "a learning management system can generate data for diagnosing skills gaps and prescribing activities and experiences that link learning events with on-the-job experience" (Ref. 7). Through LMSs like the one THORS created, users can "create, house, administer, and monitor courses and users' progress through these courses" (Ref. 3). Additionally, administrators can create custom learning paths for specific roles within their organization.

The distinctive education experience provided by THORS has been proven to positively impact learning. In a study conducted for a \$4 billion OEM customer with a \$500 million spend, six procurement personnel completed a pre-assessment quiz testing their knowledge of castings processes. The same test was administered to participants after learning from the THORS Castings Knowledge Center for one year. Despite this customer identifying a fundamental challenge to the knowledge their purchasing employees con-

tained, it is clear from the results below that using THORS works.

Knowledge gained through online learning environments is only part of the solution; procurement personnel need to also apply the manufacturing knowledge they gain to purchasing processes and supply management. In addition, procurement organizations need to take advantage of newer technologies to increase productivity. In fact, "Procurement departments cannot afford to wait for the current generation of less tech-savvy staff to retire before using supply management solutions to drive greater value" (Ref. 2).

Supplier management tools allow suppliers to enter and maintain their capabilities themselves, relieving the purchasing organization of maintaining the constantly changing supplier capability on spreadsheets or internal databases. Purchasers can classify each of their suppliers by commodity to stay organized. They can also search suppliers in their network or in the THORS network based on their capabilities, store important supplier documentation for easy access, and keep current with real-time, automated certification management.

*Intelligent Supplier Selection* solves a very important problem of selecting the wrong supplier for a package of parts. Manufacturing companies state that 40 percent of RFQs are sent to the wrong supplier. THORS's *Intelligent Supplier Selection* solves the problem by the system intelligently mapping

the part profile to the supplier capability and recommends the right supplier for each part. RFQs are then sent to suppliers for a package clearly identified as a fit for their company, enhancing productivity on both sides. This tool also contains a quote comparison tool, tracks communications between suppliers and buyers, and stores old quotes for instant retrieval.

THORS also solves the big problem of efficiently tracking all tooling, like pattern equipment, dies, cutting tools, gauges, and fixtures, and organizes tools by commodity, part, supplier, and process. With the *THORS Tooling Manager*, data can be entered and maintained in commodity-specific templates by the suppliers or the procurement teams. The *Tooling Manager* also lets you proactively manage replacement schedules, maintenance, and repairs, with a robust change log to track changes and tooling history. And the *Parts Manager* further helps with organization by linking parts with suppliers and the tooling used to manufacture each part. Through e-learning solutions providers like THORS that offer commodity-specific training with commodity management solutions, procurement organizations can streamline workflow, thus adding value to their teams while saving time and money.

### Summary and Conclusions

A substantial portion of the CPOs surveyed in the Ardent Partners' report, "Roughly three-quarters (76 percent)...feel that the skills of their staff either 'need improvement' (65 percent) or have a "significant skills gap (11 percent)" (Ref. 2). At a time when profitability is questionable, investing in solutions that provide the commodity- and industry-specific training for procurement personnel and giving them the tools that help them track supplier capability, intelligently select the right supplier for the right part, and keep track of the company assets efficiently, will help them effectively combat costs. **PTE**



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### Marlia Fontaine-Weisse

is the lead instructional writer for THORS, where she collaborates with SME chapters to write online course content for the manufacturing industry.



A former Miss Ohio (2005), she traveled the state as a motivational speaker, vocalist and spokesperson, while also representing her state at the Miss America competition. Fontaine-Weisse used the \$31,000 in scholarships earned to eventually receive a master's degree in English literature from The University of Akron. While pursuing her degree she taught freshman composition, published the English department's first monthly newsletter, *Academic Pursuits*, was editor-in-chief for the department's first ejournal, *First Year Voices*, and was assistant editor and Web designer for the revised ejournal, *Selected Papers of the Ohio Valley Shakespeare Conference*. She also traveled across the United States and Europe presenting scholarly research, which included her essay, "Romantic Poison: Making Grimm Lessons Less Grim," at 2012's *The Brothers Grimm and the Folktale* conference in Athens, Greece.

"(It) pays to invest in new approaches to measure performance, more sophisticated technology to embed best practices and broaden professionals' skills."

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# Musical Gearboxes

## Baldor Combats Downtime for Leland Olds Station

Baldor Electric Company

Dave Soma, the mechanical supervisor at Leland Olds Station, a coal-fired power plant near Stanton, North Dakota, says he and his maintenance team care deeply about keeping the plant running and providing people electricity, especially in the dead of winter. That's why in 2009 he and his team began looking for a better gearbox to use on the plant's coal conveyors.

The plant is owned by Basin Electric Power Cooperative, one of the largest electric generation and transmission cooperatives in the United States, generating and transmitting wholesale bulk electric power to 2.8 million customers in nine states.

Leland Olds Station went on-line in 1966; unit two began commercial operation in 1975. Originally, chain cases were used on gearboxes, but due to issues with grease and improving plant cleanliness, it switched to belt drives. According to Soma, the change from chains to belts added too much tension and overloaded the bearings in the gearboxes, and that's when the maintenance headaches began.



Since being installed in the fall of 2009, Quantis right-angle helical bevel (RHB) reducers, coupled with Baldor-Reliance Super-E premium efficient explosion-proof motors, only require regularly scheduled maintenance.

"For years, we have been playing musical gearboxes on these conveyors," says Soma. "We would take a failing gearbox off and replace it with our spare, and hope that we could fix the gearbox before we needed the spare somewhere else on the line. Most of the time, we were scrambling to make these things work and keep the conveyors running."

Extra time was also needed to realign belts after a gearbox was installed, a job Soma describes as critical, requiring skill, time and effort. The change-outs were also complicated because of where the gearboxes are located: confined, hard-to-reach spaces, with not much room to work.

"This was a big deal because failing gearboxes threatened our ability to generate power," explains Soma. "While we never did lose generation, we had to sweat it out a few times to get the job done. We knew this was not a good situation, and we decided that we needed to do something about it."

Craig Taylor, the manager of the Motion Industries branch in Bismarck, North Dakota, was a frequent visitor at the plant and had helped Soma and his team with several other projects. Taylor, familiar with the issue of the failing units, recommended Baldor's Dodge Quantis right-angle helical bevel gear reducer. Additionally, he suggested a complete Baldor package that also included a Baldor-Reliance Super-E premium efficient explosion-proof motor, a Dodge pulley and shafting, and Dodge ISAF bearings. Taylor chose to work with Baldor's System-1 group, a team that facilitates the design, quotation and order processing of multiple power transmission and electrical products into a completely packaged solution.



In the past, keeping coal conveyors running was a constant concern for the plant's maintenance team because of consistently failing gearboxes. In 2009, the decision was made to install Baldor's Dodge Quantis reducers.



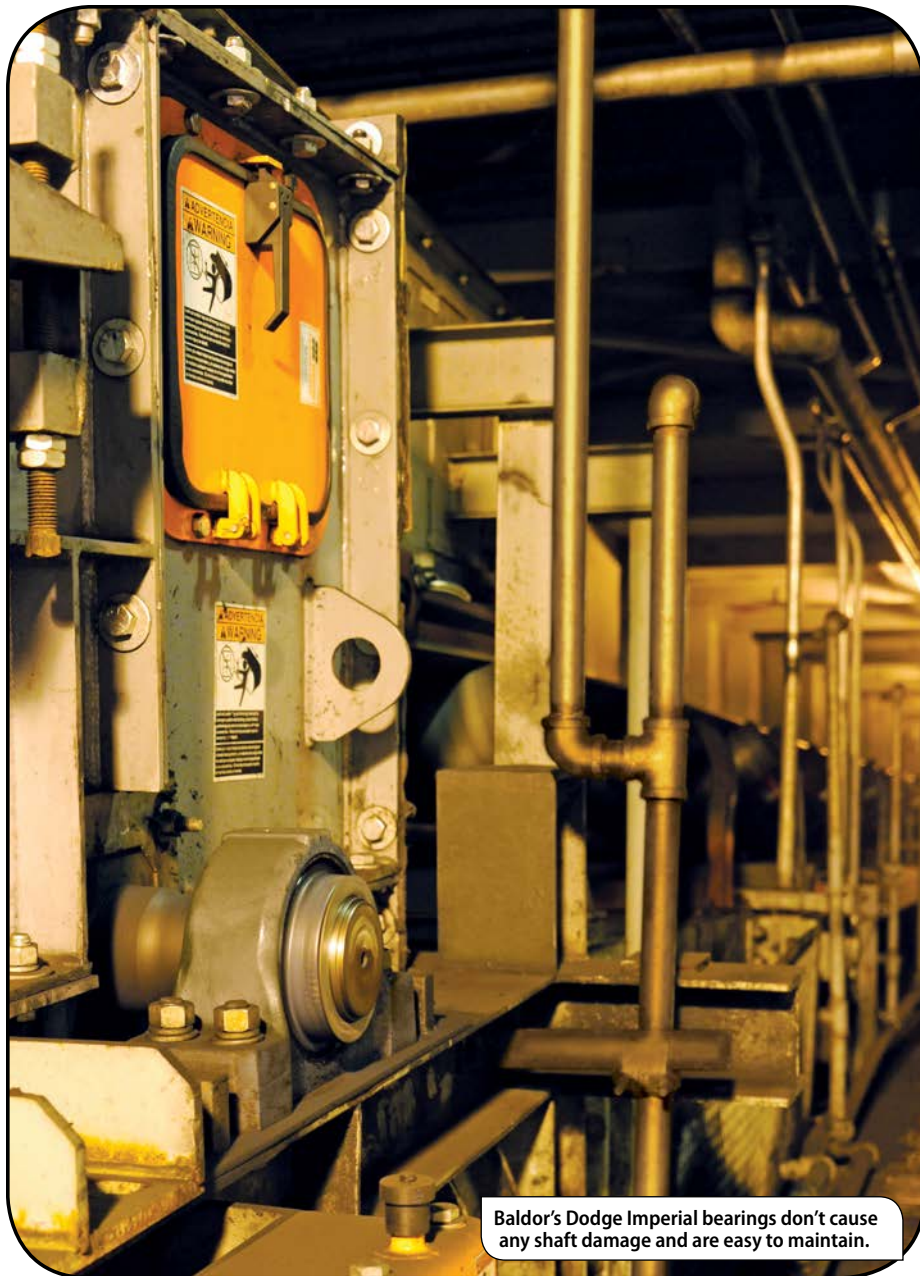
“It was so nice when the packages arrived,” says Soma. “We didn’t have to do a bunch of assembly here at the plant because the drum was mounted on the shaft, and the bearings were mounted. When we got this assembly into position, all we had to do was mount the gearbox and motor package—then our electricians hooked it up and away we went.”

### An End to Musical Gearboxes

Since being installed in the fall of 2009, Soma reports that the Quantis reducers run great and his team only looks at them while performing their regularly scheduled preventive maintenance program. He says it’s a nice change not to be worried about failing gearboxes, but he and his team also appreciate the benefits of getting the power they need from a compact unit. “Because space is a premium in the locations where gearboxes are used, having a smaller unit makes it so much easier for us to get to all of the other equipment,” explains Soma. “Another nice feature is that these gearboxes have a built-in roll-back clutch, instead of a separate piece of equipment that took up space and required additional maintenance. Fewer moving parts means there is a lot less for us to deal with.”

Soma is equally pleased to have a Baldor-Reliance motor as part of the package. “We have a lot of Baldor-Reliance motors in the plant and we’ve had good luck with them,” says Soma. “We have used other brands that haven’t performed as well. So it was really positive when we could get the brand of motor we prefer on the gearbox we needed from the same company.”

Baldor’s Dodge ISAF bearings have also been well received by the maintenance team. In the past, set screw bearings were used but caused severe damage to the shaft over time, which meant machining a new shaft as well as replacing the bearings. According to Soma, because of the way the adapter mount style of the Dodge bearing attaches to the shaft, it offers a concentric grip that reduces shaft damage. “This



Baldor’s Dodge Imperial bearings don’t cause any shaft damage and are easy to maintain.

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is the thing that we really like about these bearings, the way they offer 360 degrees of support," explains Soma. "They support the shaft so much better, won't cause any damage and are easy to maintain. These bearings have been the answer to a lot of problems."

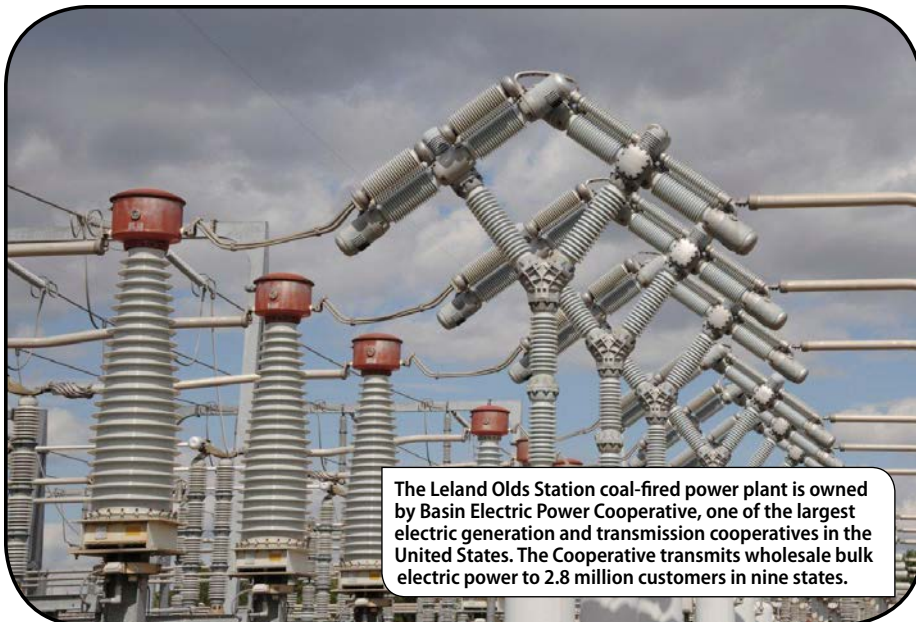
Soma reports that he and his team are enjoying maintaining the plant without the panic they experienced in the past from constantly failing gearboxes. Now when peak demand hits, he doesn't worry about meeting critical demand. He believes the plant's strategy of choosing a package based on total cost of ownership was the right decision and he couldn't be happier about the outcome. "The headaches have gone away," says Soma. "It would be nice if everything worked this way."

#### PTE

#### For more information:

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# How to design a spur/crown gear set.

## THE QUESTION

**W**hen designing a spur/crown pair, is there a formula/guideline/design guide for adapting the spur teeth for the radial angle of the teeth in the crown?

Response provided by Chuck Schultz, P.E., (gearmanx52@gmail.com).

The beginning of wisdom, and this answer, is calling things by their proper name. While there is some standardization in terminology for the worldwide gear industry, “spur/crown pair” sent me to the Internet in hopes that this term had somehow eluded my vocabulary. Alas, Wikipedia did not settle the matter other than to assign the term “crown” to a face gear. We are aware of some engineers calling a bevel gear a “crown gear,” as well, so I will offer two separate answers to your question.

### **If you meant a straight bevel gear set:**

Straight bevel gears mesh with intersecting shafts and can be made for right-angle and other angular configurations. The teeth in both members taper in cross-section—from outside diameter to inside edge. There are two commonly used “systems” for designing these gear sets: 1) the Gleason System employs a tapering tooth depth as well as tapering tooth thickness; 2) and the Klingelberg system employs a constant tooth depth with a tapering tooth thickness.

Neither system has shown a power capacity advantage for equivalent designs.

Design guidance can be obtained from Gleason and Klingelberg, who supply manufacturing equipment and cutting tools. Many gear reference books also discuss the design of straight bevel gear sets. You may also find *Gear Design Simplified*, by Franklin D. Jones and Henry H. Ryffel (Industrial Press, 1961, ISBN 978-0-83311-0209-8), helpful as well. I was pleased to learn this old reliable reference has been reprinted in paperback.

Diagrams for straight bevel gear sets can be found in *An Introduction to Gear Design*, which is available for free download at this author’s website — [www.beytagear.com](http://www.beytagear.com).

### **If, on the other hand, you meant a face gear set:**

Face gear sets mesh with intersecting shafts and are generally made for right-angle configurations. Face gear sets use a conventional spur or helical pinion with *constant* cross-section teeth to drive a gear that has *tapered* cross-section teeth. The pinions are hobbled or ground; the gears are milled or shaped to match the pinion.

The design of these gears has never been standardized for larger gears. AGMA standard 203.03 — Fine Pitch On-center Face Gears for 20 Degree Involute Spur Pinions — has been withdrawn from the active files, but may contain the information you need. Darle Dudley’s *Gear Handbook* (McGraw-Hill, 1962, Library of Congress Catalog Card Number: 61-7304), devotes pages 5-71 through 5-74 to the design of face gears. This book should be considered an essential for any gear engineer’s library.

Diagrams for face gear sets can also be found in *An Introduction to Gear Design*, which is available for free download at this author’s website: [www.beytagear.com](http://www.beytagear.com).

**Charles D. Schultz, PE**, is chief engineer for Beyta Gear Service, Winfield, Illinois, longtime Gear Technology technical editor and life-long gear guy.



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# Grease Lubrication Mechanisms in Rolling Bearing Systems

Piet M. Lugt

Grease lubrication has clear advantages over oil lubrication: Grease does not leak easily; it has sealing properties; and it protects bearing surfaces from corrosion. Its disadvantages are grease-life limitations and a limited cooling ability. Moreover, in some applications there is a risk of grease starvation, which leads to reduced lubricating films. However, if the right grease, sealing system and/or lubrication system are chosen, then grease lubrication offers clear benefits. This article summarizes aspects of grease lubrication mechanisms in rolling bearings.

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## Phases in Grease Lubrication

Grease lubrication is a dynamic process that can be divided roughly into three phases (Fig. 1). After the initial filling or during re-lubrication, the grease will be located between the rolling elements, leading to high churning losses during start-up or running-in. During this phase, also called the “churning phase,” the grease will be pushed into the unswept volume of the bearing (onto the seals or onto the bearing ring shoulders) or will end up attached to the cage. From these locations the grease will slowly provide the raceways with lubricant by either bleeding or shear. In this second phase, the bleeding phase, the lubricating film will be governed by a feed-and-loss mechanism (Ref. 20) in which the raceways are fed by grease from the reservoirs but also lose lubricant due to side flow and oxidation. This may lead to starvation, especially in sealed bearings where the grease reservoirs are smaller. Another feed mechanism is occasional replenishment caused by softening of the grease close to the contacts due to local heat

development (Ref. 14), which is again caused by occasional film breakdown.

At some point, the reservoirs may be empty or deteriorated to the point that replenishment can no longer happen. If re-lubrication has not taken place, severe film breakdown will result, called the end of grease life, which subsequently leads to bearing damage and failure.

**Grease reservoir formation.** The rate at which the reservoir formation will take place is governed by the flow properties of the grease, also called its “rheological properties.” This will also determine the physical degradation of the grease.

Lubricating grease shows visco-elastic behavior, meaning that the viscosity of the grease is a function of both shear and shear rate. Figure 2 shows viscosity as a function of shear rate in terms of the various models that are often used. It shows that the viscosity is very high at low shear rates. This means that the resistance to flow will be very high if the grease is not touched - i.e., when it is located in the upswept volume. This property is also called consistency.

During the churning phase the grease may lose some of its consistency. This property is called mechanical stability.

The viscosity of lubricating grease is so high at very low shear rates that only creep-flow will occur, and the grease has an apparently solid behavior. Figure 2 shows grease shear thinning, which is when the grease viscosity decreases substantially with increasing shear.

At very high shear rates, the grease viscosity may approach the base oil viscosity. Such high shear rates occur in the lubricating films between rolling elements and raceways.

Together with oil bleeding, this is the reason why the film thickness in grease-lubricated bearings is usually calculated using the base oil viscosity,  $\eta_{oil}$ . The grease rheology can be described using various models (Fig. 2).

**Film thickness.** Both base oil and thickener are known to enter the bearing (Ref. 2). The lubricating film thickness in grease-lubricated bearings is determined by boundary layers formed by thickener material  $h_R$  and by the hydrodynamic action of the base oil  $h_{EHL}$  (elastohydrodynamic lubrication, EHL)

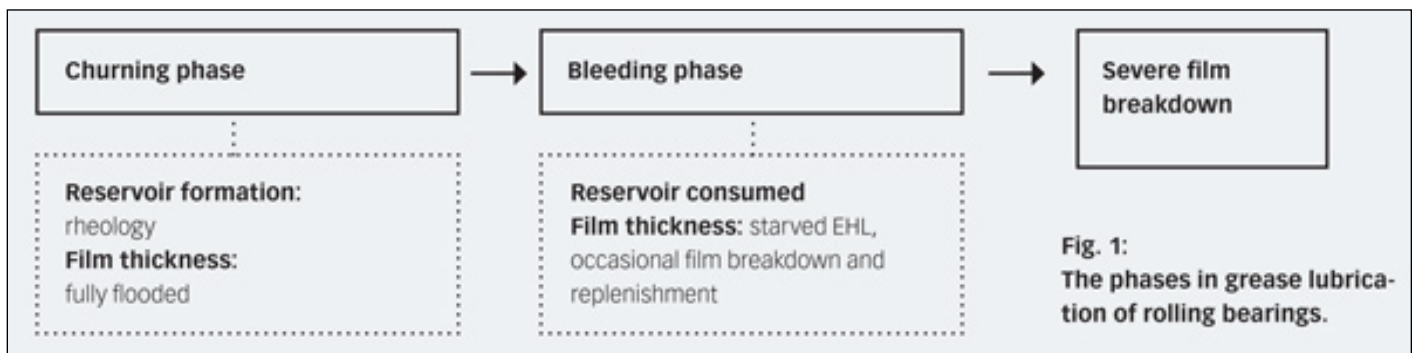


Figure 1 The phases in grease lubrication of rolling bearings.

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(Ref. 4). For the latter, the base oil can also be taken into account for the reasons mentioned above. The film thickness,  $h_T$ , is therefore:

$$h_T = h_R + h_{EHL} \quad (1)$$

Grease-lubricated bearings often run under so-called starved lubrication conditions where only very thin layers of oil are available and where the film thickness is primarily a function of the thickness of these layers (Fig. 3). The change in thickness of these layers is given by the difference between the feed (bleeding, Refs. 3, 21) and loss flow rates of lubricant into or out of the raceways (Ref. 20). The oil in the track is lost due to the transverse flow caused by the high pressure inside the rolling element-raceway contacts (Ref. 18); some replenishment may take place (Ref. 6). However, except for very low speeds and low-viscosity base oils, this will be a very slow process (Ref. 7). Shear and drag due to ball spin will probably have a greater effect (Ref. 5). Both ball spin and the narrower contact sizes make replenishment easier for ball bearings than for roller bearings. This is one of the reasons why roller bearings require grease with more bleeding than ball bearings (Ref. 11). At higher temperatures, oxidation and evaporation will have an impact on film thickness. Material will be lost due to oxidation and evaporation (Refs. 19, 15); however, this will also change the viscosity and lubricity.

**Dynamic behavior.** Starved lubrication will cause a decrease in film thickness that will proceed until the bearing is no longer well lubricated. Metal-to-metal contact will cause bearing damage or may cause enough heat development to occur to reduce the viscosity of the lubricant close to the contact for replenishment—leading to an event. In the latter case, the film thickness will increase again, resulting in sufficient lubrication until the next event takes place. This may occur a number of times, depending on the healing ability of the grease, which is a function of the ability of the grease to maintain its fluidity. Figure 4 shows an example of the temperature profile of a cylindrical roller bearing running under self-induced contact temperature (Ref. 14).

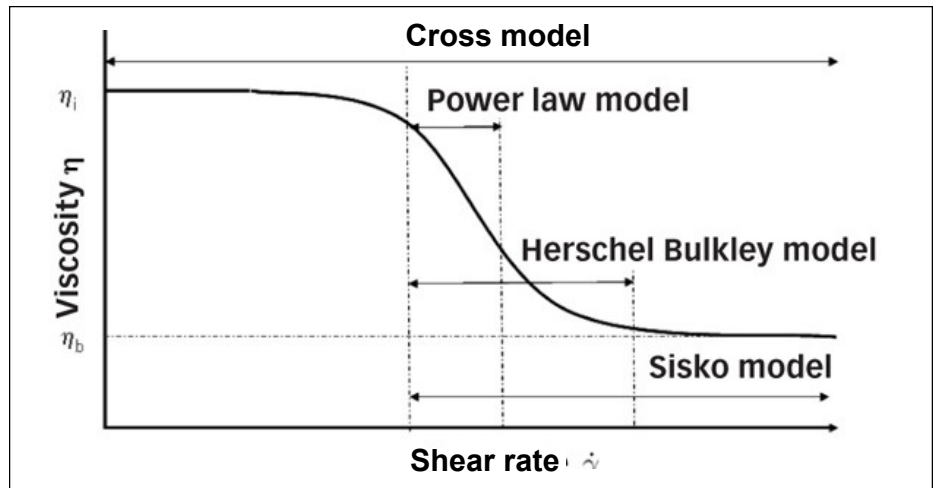


Figure 2 Schematic representation of the viscosity shear rate curves for lubricating grease on a double-logarithmic scale. At very high shear rates, the viscosity  $\eta_b$  approaches the base oil viscosity  $\eta_{oil}$ .

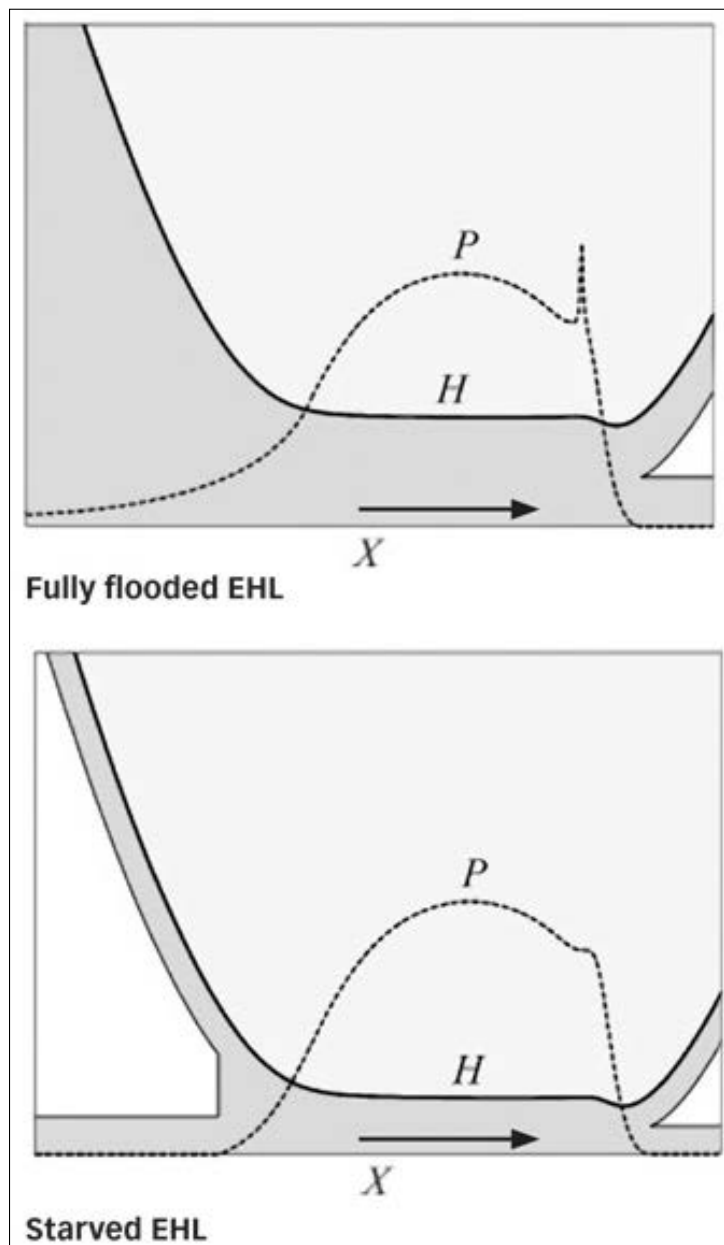


Figure 3 Schematic representation of film thickness and pressure in a fully flooded and starved HL contact (Ref. 17). The film thickness is reduced due to a lack of lubricant in the inlet side of the contact.

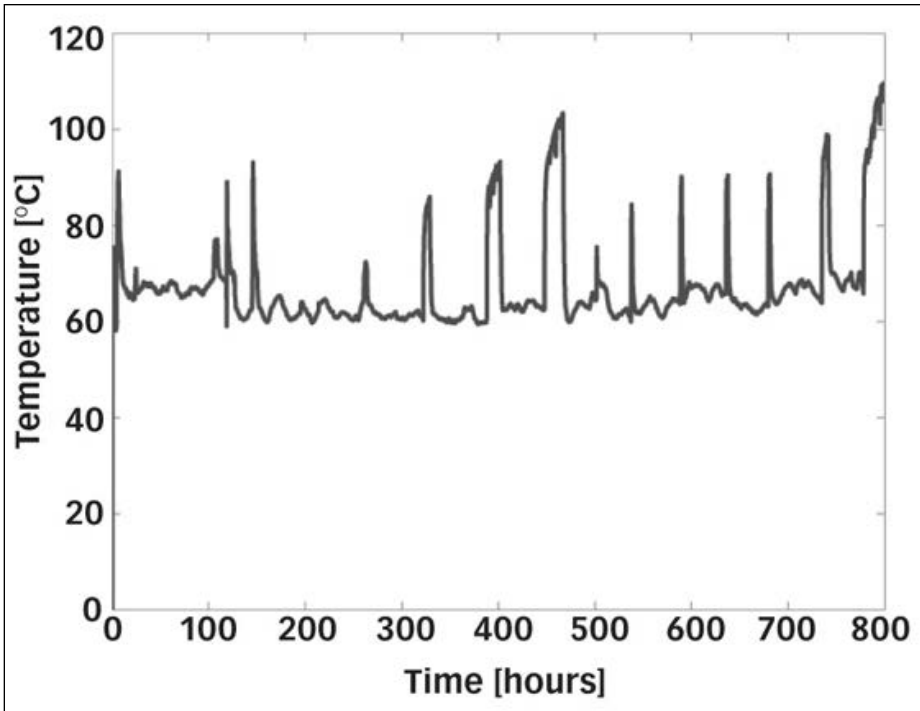


Figure 4 Temperature measurements from grease-lubricated, cylindrical rolling bearings (Ref. 14).

**Grease life and re-lubrication.**

Grease life is defined by the point in time where the grease can no longer lubricate the bearing. This time span may be very long and therefore difficult to measure in a bearing test rig. To accelerate such a test, the outer ring of the test bearing is heated, which accelerates the aging process and reduces the viscosity of the grease. An example of such a test rig is the ROF+ grease life tester (Ref. 13).

**Safe operation.** Lubricating greases are developed to operate in a limited temperature window. The maximum temperature, called “high-temperature limit (HTL),” is determined from the dropping point when the grease loses its structure irreversibly. This temperature may not be exceeded at any time. The safe maximum temperature is lower, or called “high-temperature performance limit (HTPL).”

The low-temperature limit (LTL) is determined by the temperature at which the grease will enable the bearing to start up without difficulty; it is usually measured by a start-up torque test. The safe minimum temperature therefore is higher, called “low temperature performance limit (LTPL)” (Ref. 1). In the zone between these safe temperatures, the grease life is a function of temperature, where, as a rule of thumb,

grease life halves with every 15°C temperature increase.

**Grease life models.** Various models exist that can be used to predict grease life (or re-lubrication intervals). All models are empirical, based on grease life tests. Grease life is defined as the  $L_{10}$  life: the time at which 10 percent of a large population of bearings has failed. Re-lubrication should be carried out before the end of grease life so that no damage to the bearing has taken place. The SKF re-lubrication model is based on  $L_{01}$ , assuming  $L_{10} = 2.7 L_{01}$ , which is the time where only 1 percent failure would take place. Re-lubrication is not a straightforward process; too much grease will keep the bearing in the churning phase, with high frictional losses and high temperatures. Figure 5 shows the grease life for lightly loaded, capped deep-groove ball bearings as a function of rotational speed, mean bearing diameter, operating temperature and grease type (grease performance fac-

tor). Correction factors can be applied for the impact of load. Models for other bearing types are based on this model where other correction factors are applied, and can be found in the SKF rolling bearings catalog (Ref. 1).

**Aging.** Both the mechanical and chemical properties of the grease will change while the grease is exposed to milling and oxidation in the bearing. The type of oxidation depends on the operating conditions: Physical aging dominates at lower temperatures and higher speeds, whereas chemical aging dominates at high temperatures (Ref. 9). Physical aging results in a change to the grease’s rheological properties, which results in leakage, reduced bleeding properties and a reduction in its ability to replenish the contacts. Chemical aging is primarily caused by oxidation. Anti-oxidants retard this process, but when these are consumed, oxidation leads to a loss of lubricant due to a reaction into volatile products and to lacquer formation, which no longer lubricates the bearing (Ref. 9).

**Grease lubrication mechanisms in seals.** The main differences between grease and oil for seal lubrication are related to starvation (replenishment of the seal lip) and boundary film formation by the thickener material. Replenishment of the contact is caused by shear and oil bleeding from the grease. The sealing action of grease is ascribed to its stiffness, meaning that the grease will not easily flow away from the sealing contact. In addition, the grease will form pockets in multiple-lip seals where the flow of contaminant particles

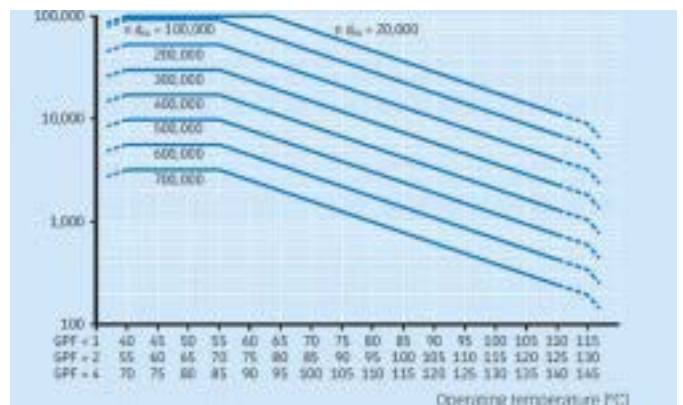


Figure 5 Grease life in lubricated-for-life, standard radial deep groove ball bearings operating at light loads (C/P 15);  $L_{10}$  as a function of  $n \times d_m$ , temperature, and grease type (Ref. 8). The grease performance factor is a measure for the quality of the lubricating grease and is determined using ROF+ test method.



will be very slow. In the case of pressure differences across the seal, it will only be a fraction of the grease that will flow and cause migration of contaminant particles.

**Lubrication systems.** In situations in which the grease cannot provide the bearing with sufficient service life, or in the case of contamination by particles or water, re-lubrication may be applied by means of lubrication systems. These systems consist of pumps, pipes, valves, distributors and controllers. There can often be competing properties of grease as to what is good for a lubrication system to pump and what is good for the bearing. The lubrication system should be designed to handle a grease that is best suited for the bearing.

The design is given by the flow properties of the grease, also called “pumpability.” SKF has developed a grease pumpability test program that addresses various aspects listed below with the SKF test method in parentheses:

1. **Delivery:**

- (a) Flow resistance (FTG5 and Lincoln ventmeter)
- (b) Compressibility (FTG1)
- (c) Pressure venting (FTG3 and Lincoln ventmeter)

2. **Flowability:**

- (a) Flow pressure
- (b) Unworked penetration
- (c) Deliver index for the pump unit (FTG4)
- (d) Functioning of the pump unit

3. **Oil separation (and hardening):** Grease hardening under pressure (FTG2).

**Condition monitoring.** To measure the bearing (lubrication) condition on-line, generally vibration levels are measured; however, increasingly acoustic emission techniques (Ref. 16) are being used. Off-line techniques to measure the grease condition are oil bleeding, oil content, consistency, particle contamination and oxidation (FTIR spectroscopy). Methods are available to determine the remaining grease life with the results of these methods (Ref. 10).

## Conclusions

Over the past few decades, SKF’s knowledge of grease has improved substantially. Today it is possible to predict,

to a good extent, the lubricating life of grease and to monitor its remaining life. Sealing prolongs the service life of the bearing in contaminated environments where the grease provides an additional sealing effect. Lubricating systems can be used to provide the bearing occasionally with fresh grease.

## In Summary

Selecting the right grease is complicated. Understanding the lubrication mechanisms will help in selecting the right grease with the right amount for a specific application to meet bearing life expectations. To help understand grease lubrication, a new book—*Grease Lubrication in Rolling Bearings*—written by this author with other SKF engineers, was published in January 2013 by John Wiley & Sons Ltd. (Ref. 12) that covers the latest information and knowledge about grease lubrication. **PTE**

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# Microstepping Tutorial

Rob Steves

## Introduction

A bipolar stepper motor has two windings. The current through each winding is varied in order to rotate the stepper motor. When considering stepper motor drive techniques, a “phase diagram” is a useful visualization tool. The current through one winding  $I_a$  is plotted against the current through the other winding  $I_b$ . Modes of operation such as full-stepping, half-stepping, microstepping, and operation at different current limits can be easily visualized on such a diagram. In addition, it is possible to visualize changes in both power consumption and torque as a function of angular position. Simple stepper motor controllers are only capable of driving a winding with full-positive current, no current, or full-negative current. Given these available outputs, it is only possible

to implement full-stepping, half-stepping, or wave-stepping.

The arrows in each phase diagram are called “phasors.” The angle theta that the phasor moves from one position to the next is the step- or microstep-angle. On a phase diagram, 90° corresponds to one full-step and 360° corresponds to a “full-step sequence.” A full-step sequence is a sequence of steps or microsteps which, when repeated, will produce continuous rotation of the motor. Assuming adequate torque, any continuous path that traverses the four quadrants of the phase diagram with at least one point-per-quadrant will suffice to rotate the stepper motor. If the controller is designed with the capability to control the magnitude of the current in each winding, then microstepping can be implemented. The phase diagrams (Fig. 2) all show different implementa-

tions of “divide-by-four” microstepping. Note that it is the phasor angle (not its length) that determines the microstep position. The phasor length affects power consumption and available torque, as we will see later.

While it is convenient to think of the  $I_a$  and  $I_b$  axes as representing full-step positions, it should be recognized that this is an arbitrary choice and any four positions in the phase diagram that are 90° apart from each other could be considered full-step positions. However, for the sake of simplicity, let us consider the positive  $I_a$  axis to represent  $\theta=0^\circ$ . As theta increases, the phasor moves counter-clockwise from this position. At  $\theta=90^\circ$  the phasor lies along the positive  $I_b$  axis—one full-step from its starting position. Any angle theta between 0 and 90° represents a possible microstep position (a

**FULL-STEPPING.** In full-stepping operation, the current required in each winding is either  $-I_{max}$  or  $+I_{max}$ . A step sequence of four full-steps makes up one complete step cycle. Note that these full-step positions are the same as the odd numbered positions from the half-stepping sequence.

**HALF-STEPPING.** In a half-stepping operation, the current required in each winding is either  $-I_{max}$ , 0, or  $+I_{max}$ . A step sequence of eight half-steps makes up one complete step cycle.

**WAVE-STEPPING.** Wave-stepping is another method of full-stepping, but with reduced power requirements (and corresponding torque output), since only one winding is powered at a time. The current required in each winding is either  $-I_{max}$ , 0 or  $+I_{max}$ . A step sequence of four full-steps makes up one complete step cycle. Note that these full-step positions are the same as the even numbered positions from the half-stepping sequence.

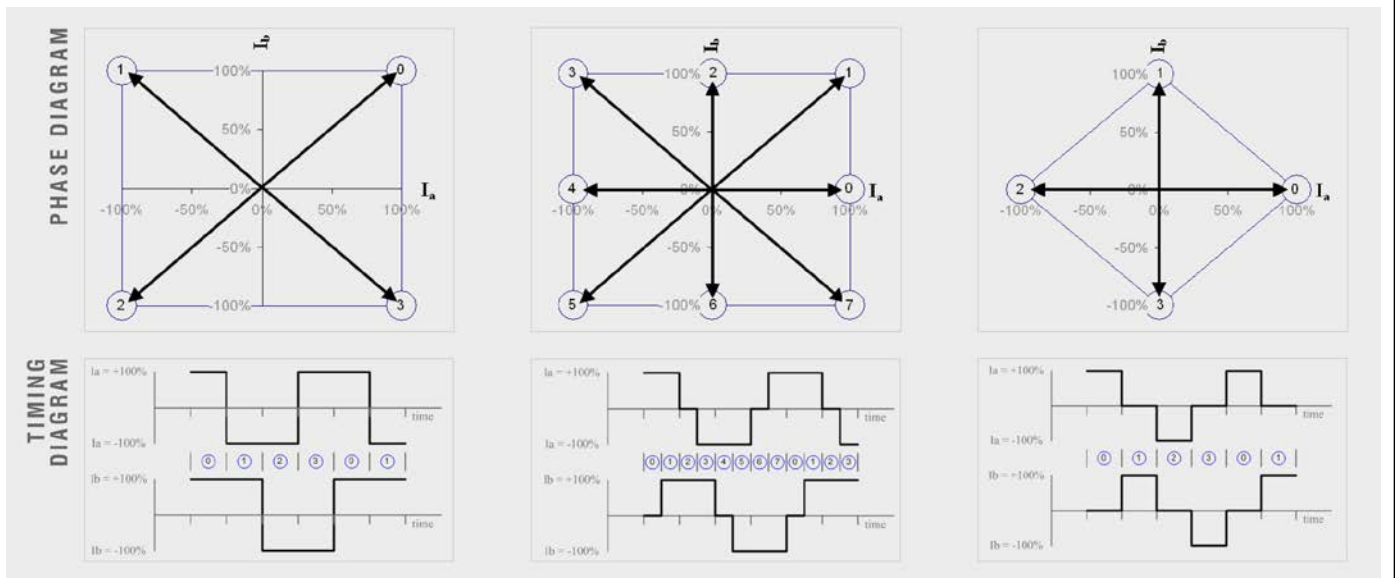


Figure 1

Reprinted courtesy of Zaber Technologies ([www.zaber.com](http://www.zaber.com)).

**MICROSTEPPING:** square path. This method of microstepping provides the highest peak torque if you are limited by available supply voltage.

**MICROSTEPPING:** circular path. This method is also referred to as sine-cosine microstepping and is usually what people are referring to when they talk about microstepping, although it is in fact only one method.

**MICROSTEPPING:** arbitrary path. There would be little reason to use a method such as this. It is presented only to illustrate the possibilities. Although it looks very strange compared to the other two methods, in theory it will produce the same angular rotation of an ideal motor. Only the available thrust would differ.

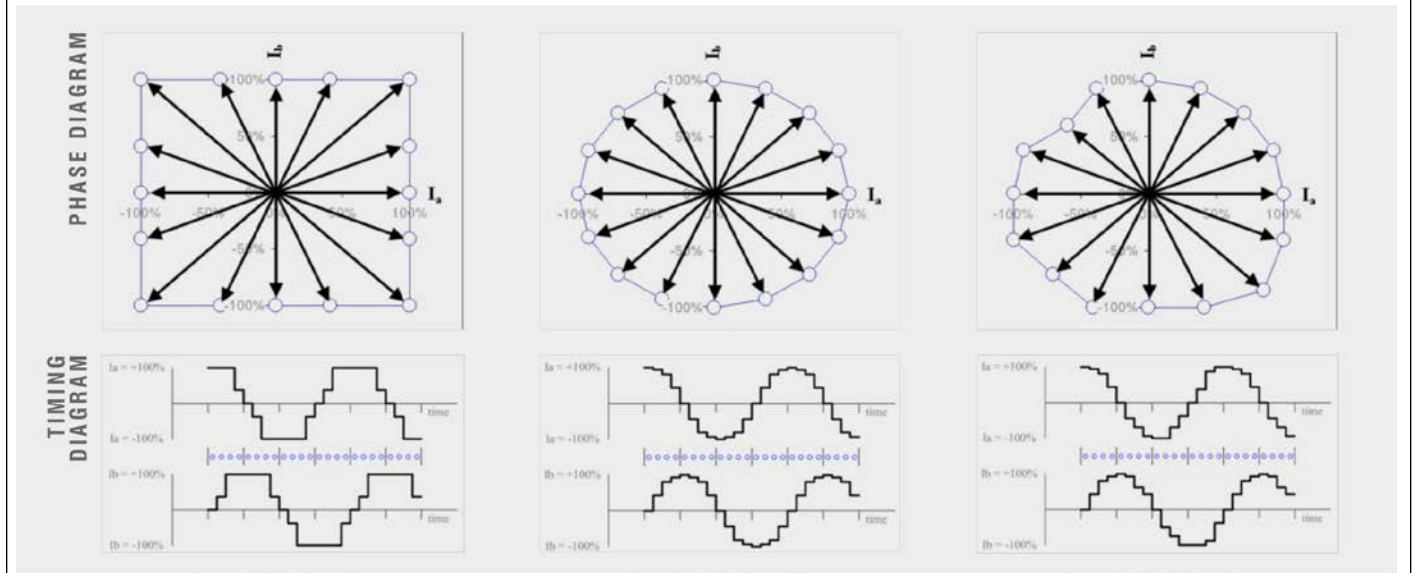


Figure 2

position between full-step positions). If you wish to implement “divide-by-10” microstepping, then you must generate values of  $I_a$  and  $I_b$  that correspond to values of theta equal to 0, 9, 18, 27 ... 81, 90°, etc.

$$\theta = \tan^{-1}(I_b/I_a) \quad (1)$$

There are many values of  $I_a$  and  $I_b$  that could be chosen to produce the same phasor angle theta. The choice of phasor length is typically decided based on the motor power rating and the application’s torque requirements. Power and torque are both related to phasor length. The power draw at any given angular position is given by the formula:

$$\text{power} = I_a^2 R + I_b^2 R \quad (2)$$

where:

$R$  is the winding resistance (both windings should have the same resistance)

The length of the phasor is given by the formula:

$$\text{phasor\_length} = \sqrt{I_a^2 + I_b^2} = \sqrt{\text{Power}/R} \quad (3)$$

Thus the phasor length gives an indication of the power draw at each microstep angle. Torque is directly proportional to current (assuming magnetic saturation is not reached). As such, the available torque is directly proportional

to phasor length, and the phase diagram gives an indication of how torque may vary with microstep position.

(Aside: note that phasor length is proportional to torque and to  $\sqrt{\text{power}}$ . Therefore torque is proportional to  $\sqrt{\text{power}}$ . In other words, a 2x increase in torque requires a 4x increase in power—assuming magnetic saturation is not reached.)

A phasor of constant length is typically used for smoothest operation (minimum torque ripple) and constant power output. This results in a circular path around the phase diagram, the phasor length being the radius of the circle. This technique is referred to as “sine cosine microstepping” because the target values for  $I_b$  and  $I_a$  are proportional to  $\sin(\theta)$  and  $\cos(\theta)$ , respectively. In practice, the term microstepping usually refers to sine cosine microstepping; but in theory, sine cosine microstepping is only one method of microstepping. As mentioned above, a functioning microstepping algorithm may be designed around any arbitrary path that traverses the four quadrants of the phase diagram and has at least one point per quadrant.

The maximum continuous power output of a motor is usually specified

by the manufacturer. This places an upper limit on phasor length,  $\sqrt{I_a^2 + I_b^2}$ . The effective limit that this places on  $I_a$  and  $I_b$  will depend on the geometry of the path chosen around the phase diagram.

One must also consider the limitations of the power supply being used to drive the motor. In voltage-controlled products, the maximum values of  $I_a$  and  $I_b$  may be limited by the power supply voltage ( $I = V/R$ ). In this case, using a square phase profile is a way to achieve higher torque without requiring a higher voltage power supply.

Zaber devices are driven in a circular phase path to achieve smooth motion and constant power output. The current limit is user-configurable and specifies the value of  $I_a$  at  $\theta = 0$ . In some Zaber devices (T-series), square-phase mode is also available. Square-phase mode offers about 40 percent higher torque for the same current limit. However, there is a price to pay—i.e., torque ripple. You can see that as you move around the phase diagram, along a square path, the torque (proportional to the length of the phasor) will be constantly increasing and decreasing. This results in less smoothness of operation and less microstepping accuracy. Generally, it is easier to achieve higher torque simply by increasing the current limit. However, at times your maximum current limit is restricted by your supply voltage or the capabilities of your controller. In this case, reduced smoothness and accuracy may be an acceptable compromise for additional torque.

### Sources of Error in Microstepping Systems

Stepper motor control systems are usually open-loop. That is, the controller does not have position feedback and therefore is not aware of the “actual” position of the motor. Therefore, it is important to be aware of possible sources of error that will result in the actual position being different from the calculated position.

**Quantization error.** In any digital controller, it is impossible to achieve infinitely variable  $I_a$  and/or  $I_b$ —only discrete or “quantized” values are possible. The number of discrete values depends on the resolution achievable by the controller. For example, if the maximum current output of the controller is 1A, and the controller has a resolution of 0.1A, then there are 10 possible current values for  $I_a$  and/or  $I_b$ , not including 0. The number of discrete values possible determines how close mathematically the phasor can be set to a particular length and microstep angle. The error between the desired phasor angle and the actual phasor angle achieved is the quantization error.

A maximum quantization error equivalent to 0.5 microsteps is a typical design requirement in any microstepping control algorithm. Note that by adjusting the phasor end-point to a nearby  $I_a/I_b$  point, rather than sticking to a strictly circular or square profile, can often reduce the quantization error, but may add some torque ripple. Thus, the current resolution you require for  $I_a$  and  $I_b$  will be determined by the number of microsteps-per-step you want to achieve, the quantization error you can

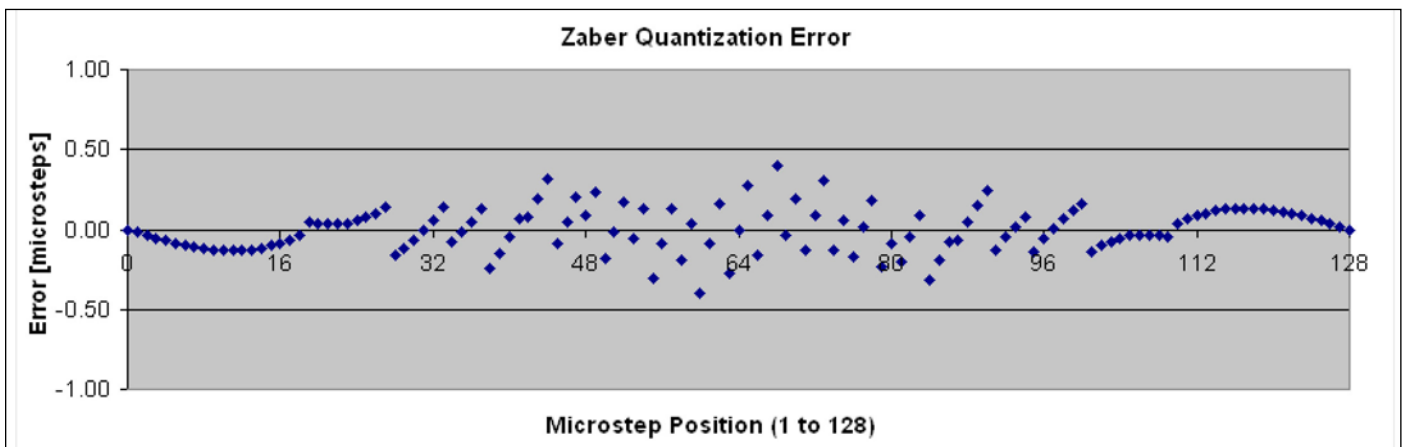


Figure 3 — Zaber quantization error.

tolerate, and the torque ripple you can tolerate.

In Zaber's stepper motor control algorithm, the design requirements were 128 microsteps-per-step, with a quantization error less than 0.5 microsteps and a torque ripple less than 2.5 percent. Determining how many discrete current values are required for  $I_a$  and  $I_b$  is a task best left to a spreadsheet application, such as *Excel*. Even then, it requires a certain degree of trial and error. As it turns out, 80 discrete current settings (between 0 and the running current) are required to achieve 128 microsteps-per-step with a quantization error less than 0.5 microsteps, and a torque ripple less than 2.5 percent. The resulting quantization error at each microstep position is plotted (Fig. 3).

**Detent error.** Detent torque is the maximum torque that can be applied to a non-energized stepper motor without causing continuous rotation. If you plotted torque-vs.-shaft-angle as you slowly rotate the stepper motor—with no current in either winding—you then would find that the torque is approximately sinusoidal with shaft angle. The detent torque is just the amplitude of the sine curve. In an ideal motor the torque curve would be perfectly sinusoidal. What is commonly referred to as "detent error" isn't due to the existence of the detent torque per se, but due to the non-sinusoidal component of the detent torque. The shape of the torque curve is affected by motor pole geometry. In that sense, detent error is really pole geometry error. Because different motor manufacturers use different pole geometries, this error can vary from one manufacturer to another, as well as from one motor to another.

**Motor pole placement error.** Motor pole placement error results in a varying step size. There is typically an error that repeats every four steps (one complete step cycle), as well as an error that repeats every full revolution. This has an obvious effect on microstepping. The microstep size within large steps will be proportionally larger than the microstep size in small steps. Pole placement error in a typical motor is less than 0.5 steps of cumulative error over half a revolution of the motor. Given that a typical motor has 200

steps-per-revolution, that translates to an error in step size of roughly  $\pm 0.5$  percent. It is possible to eliminate pole placement error in any application simply by moving in increments of one full revolution of the motor. If that is not possible, then some error can be eliminated by moving in increments of four steps. However, moving in increments of four steps or full revolutions is clearly not microstepping. Therefore, all microstepping applications invariably suffer from some pole placement error.

**Leadscrew pitch error.** Many motorized systems convert rotary motion to linear motion via leadscrew; stepper motor applications are no exception. In these types of systems, any error in the leadscrew pitch will contribute to total system error.

**Stiction and backlash error.** In microstepping systems, mechanical stiction and backlash are frequently much larger than the microstep resolution. There are many systems on the market capable of microstepping at 256 microsteps-per-step, but there is little point to this if mechanical stiction in the system will be on the order of five to ten microsteps at that microstep resolution.

## Conclusion

This discussion has centered on the challenges of designing a microstepping system, but there are also challenges when implementing any system. If the load on a stepper motor exceeds its maximum torque, then the motor poles will not follow the changing magnetic field and the motor stalls. To avoid this type of failure, microstepping systems must either keep the load below the maximum torque, or include position sensors to detect and compensate for stalls.

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# Drive and Motor Basics

Allen Bradley (Rockwell Automation)

## Introduction

An adjustable speed drive is a device that controls speed and direction of an AC or DC motor. Some high-performance drives are able to run in torque regulation mode.

## DC Drives

**DC drive control system.** A basic DC drive control system generally contains a drive controller and DC motor as shown (Fig. 1).

The controls allow the operator to start, stop and change direction and speed of the motor by turning potentiometers or other operator devices. These controls may be an integral part of the controller or may be remotely mounted.

The drive controller converts a 3-phase AC voltage to an adjustable DC voltage, which is then applied to a DC motor armature.

The DC motor converts power from the adjustable DC voltage source to rotating mechanical force. Motor shaft rotation and direction are proportional to the magnitude and polarity of the DC voltage applied to the motor.

The tachometer (feedback device) (Fig. 1) converts actual speed to an electrical signal that is summed with the desired reference signal. The output of the summing junction provides an error signal to the controller and a speed correction is made.

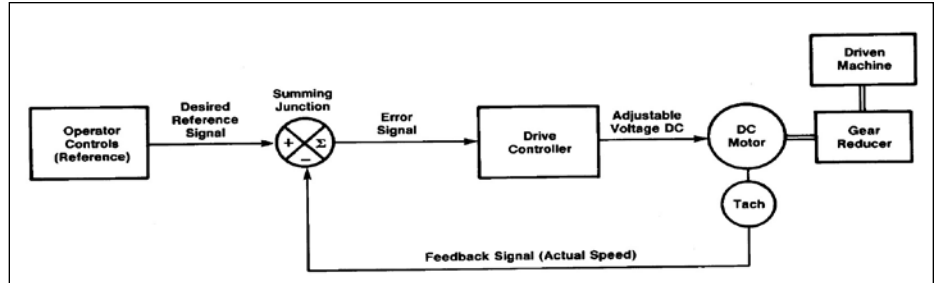


Figure 1 DC drive control system.

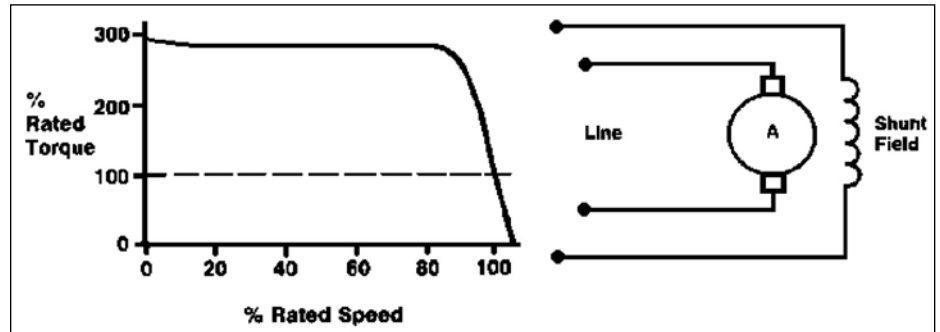


Figure 2 Shunt-wound DC motor.

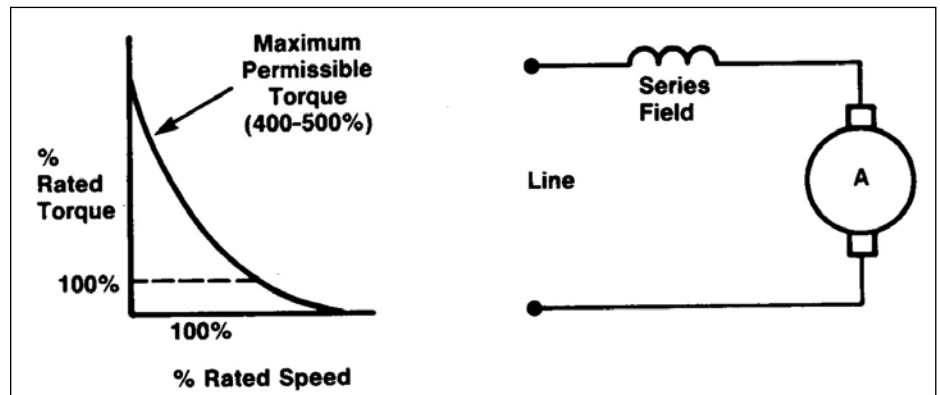


Figure 3 Series-wound DC motor.

## DC Motors

The following are the four basic types of DC motors and their operating characteristics:

**Shunt-wound.** Shunt-wound motors have the field controlled separately from the armature winding. With constant armature voltage and constant field excitation, the shunt-wound motor offers relatively flat speed-torque characteristics. The shunt-wound motor offers simplified control for reversing, especially for regenerative drives.

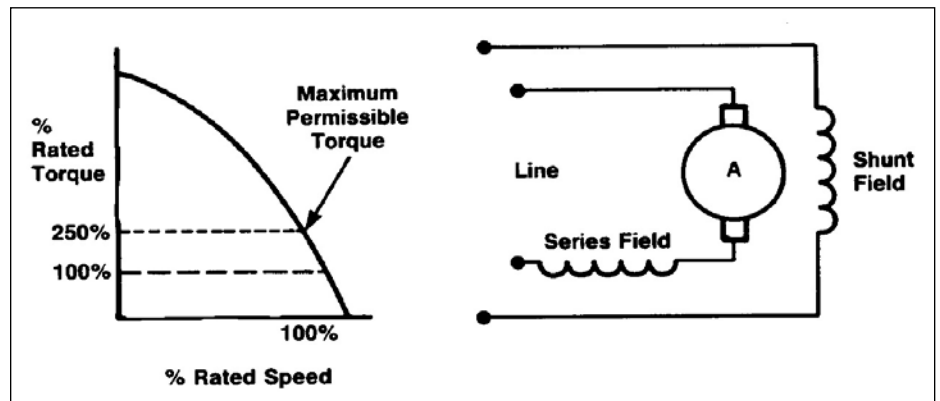


Figure 4 Compound-wound DC motor.

**Series-wound.** The series-wound motor has the field connected in series with the armature. Although the series-wound motor offers high starting torque, it has poor speed regulation. Series-wound motors are generally used on low speed, very heavy loads.

**Compound-wound.** The compound-wound DC motor utilizes a field winding in series with the armature in addition to the shunt field, to obtain a compromise in performance between a series- and a shunt-wound type motor. The compound-wound motor offers a combination of good starting torque and speed stability.

**Permanent-magnet.** The permanent magnet motor has a conventional wound armature with commutator and brushes. Permanent magnets replace the field windings. This type of motor has excellent starting torque, with speed regulation slightly less than that of the compound motor. Peak starting torque is commonly limited to 150 percent of rated torque to avoid demagnetizing the field poles. Typically these are low horsepower.

Armature voltage controlled DC drives are capable of providing rated current and torque at any speed between zero and the base (rated) speed of the motor. The motor output horsepower is directly proportional to speed (50 percent horsepower at 50 percent speed).

The term constant torque describes a load type where the torque requirement is constant over the speed range. Horsepower at any given operating point can be calculated with the following equation:

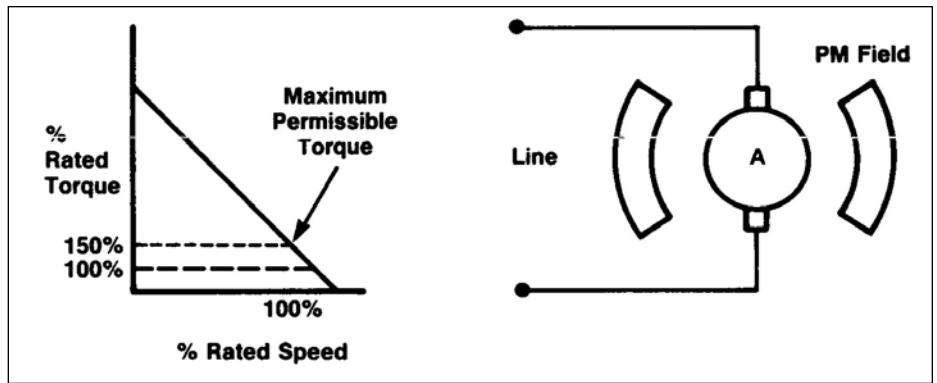


Figure 5 Permanent magnet motor.

$$HP = \frac{\text{Torque} \cdot \text{Speed}}{5250}$$

(1)

$$N = \frac{120f}{P}$$

(2)

where:

Torque is measured in Lb - Ft  
Speed is measured in RPM  
Constant Horsepower

where:

N = RPM  
f = Frequency  
P = number of poles

**Armature and field-controlled DC drives.** The motor is armature voltage controlled for constant torque-variable HP operation up to base speed. Above base speed, the motor is transferred to field current control for constant HP-reduced-torque operation up to maximum speed.

**Operation above base speed.** One characteristic of a shunt-wound DC motor is that a reduction in rated field current at a given armature voltage will result in an increase in speed and lower torque output per unit of armature current.

Some motors, such as in a typical paddle fan, have the capability to switch poles in and out to control speed. In most cases, however, the number of poles is constant and the only way to vary the speed is to change the applied frequency. Changing the frequency is the primary function of an AC drive. However, one must consider that the impedance of a motor is determined by the inductive reactance of the windings, in which:

$$X_L = 2\pi fL$$

(3)

where:

$X_L$  = Inductive reactance in Ohms  
f = Line frequency  
L = Inductance

## AC Drives

The speed of an AC motor is determined for the most part by two factors: the applied frequency and the number of poles.

This means that if the frequency applied to the motor is reduced, the reactance and therefore impedance of the motor are reduced. In order to keep current under control, we must lower

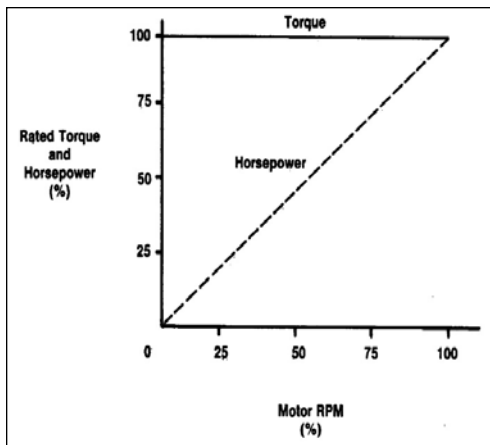


Figure 6a Armature voltage-controlled DC drive.

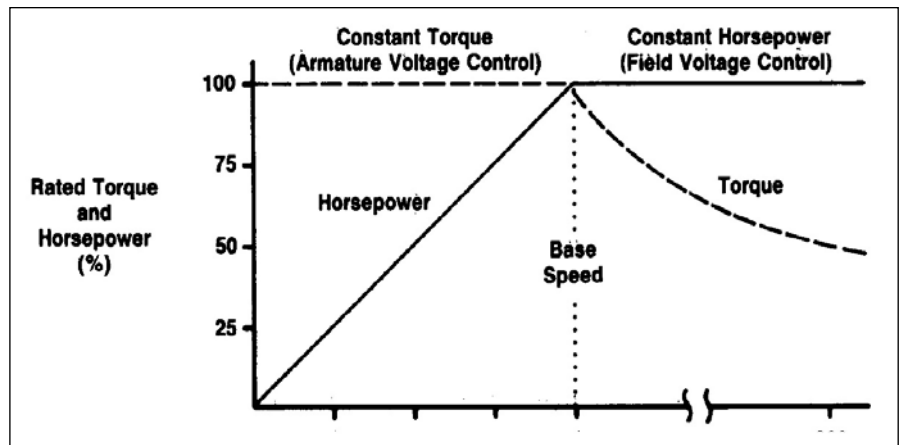


Figure 6b Armature and field-controlled DC drive.

the applied voltage to the motor as the frequency is reduced. This is where we get the phrase “volts-per-hertz.” The most common method of controlling the applied voltage and frequency is with a pulse-width-modulated “PWM” technique. With this method, a DC voltage is applied to the motor windings in time-controlled pulses in order to achieve current that approximates a sine wave of the desired frequency. IGBTs (isolated gate bipolar transistors) are the latest technology and offer the ability to switch the PWM pulses very quickly. This allows several thousand pulses to be applied in one cycle of the applied motor frequency. More pulses in a given cycle result in a smoother current waveform and better motor performance.

**AC Motor Types**

AC motors can be divided into two main types: induction and synchronous. Induction motors are most common in industry. Synchronous motors are special-purpose motors that do not require any slip and operate at synchronous speed.

The induction motor is the simplest and most rugged of all electric motors. The induction motor is generally classified by a NEMA design category. But before a meaningful discussion on NEMA-type motors can take place, we should first look at what makes up a speed-torque curve.

**Anatomy of a speed-torque curve.** Generally speaking, the following can be said about a speed torque curve when starting across the line. Starting torque is usually around 200 percent, even though current is at 600 percent;

this is when slip is the greatest. (*Starting torque is also called blocked-rotor torque, locked-rotor torque or break-away torque.*) Such a large onset of current may cause the supply voltage to dip momentarily, affecting other equipment connected to the same lines. To prevent this, large motors will connect extra resistors to inductors in series with the stator during starting. Extra protective devices are also required to remove the motor from the supply lines if an excessive load causes a stalled condition.

As the motor begins to accelerate, the torque drops off, reaching a minimum value — called “pull-up torque” — between 25–40 percent of synchronous speed (Point B). Pull-up torque is caused by harmonics that result from the stator windings being concentrated in slots. If the windings are uniformly distributed around the stator periphery, pull-up torque is greatly reduced. Some motor design curves show no actual pull-up torque and follow the dashed line between points A and C.

As acceleration continues, rotor frequency and inductive reactance decrease. The rotor flux moves more in phase with the stator flux and torque increases. Maximum torque (or breakdown torque) is developed at point C, where inductive reactance becomes equal to the rotor resistance. Beyond point C, (points D, E and F) the inductive reactance continues to drop off — but rotor current also decreases at the same rate, thus reducing torque.

Point G is synchronous speed and proves that if rotor and stator are at the same speed, rotor current and torque are zero.

At running speed the motor will operate between points F and D, depending on load. However, temporary load surges may cause the motor to slip all the way back near point C on the “knee” of the curve.

Beyond point C the power factor decreases faster than current increases, causing torque to drop off. On the linear part of the motor curve (points C to G), rotor frequency is only one-to-three Hertz — almost DC. Inductive reactance is essentially zero and rotor power factor approaches unity. Torque and current now become directly pro-

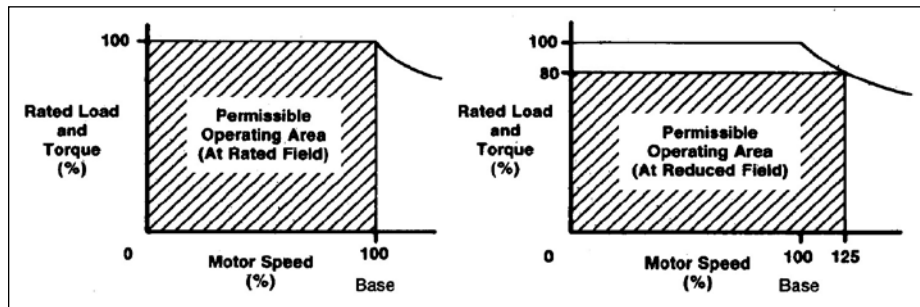


Figure 7 Motor speed and load characteristics.

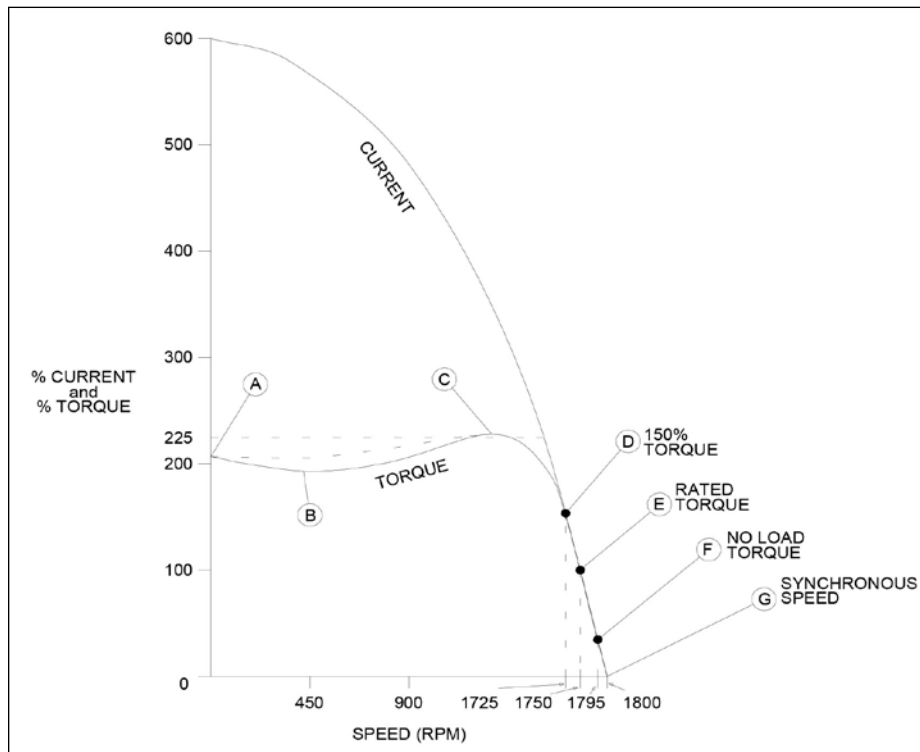


Figure 8 Speed torque curve.



portional—i.e., 100 percent current produces 100 percent torque. If a 1-HP motor has a nameplate current of 3.6 amps, then when it draws 3.6 amps (at proper voltage and frequency) it must be producing 100 percent of its nameplate torque. Torque and current remain directly proportional up to approximately 10 percent slip.

Notice that as motor load increases from zero (point F) to 100 percent (point E), the speed drops only 45–55 RPM—or about 3 percent of synchronous speed. This makes the squirrel cage induction motor very suitable for most constant-speed applications (such as conveyors) where, in some cases, 3 percent speed regulation might be acceptable. If better speed regulation is required, the squirrel cage motor may be operated from a closed-loop regulator such as a variable-frequency drive.

The locked rotor torque and current, breakdown torque, pull-up torque and the percent slip determine the classifications for NEMA design motors. The speed-torque curve and characteristics of each design are as follows:

**Design A.** Low-resistance, low-inductance rotor producing low starting torque and high breakdown torque. The low-resistance characteristic causes starting current to be high. It is a high-efficiency design; therefore the slip is usually three percent or less.

**Design B.** Higher impedance rotor producing a slightly higher starting torque and lower current draw. For this reason, Design B motors are a general-purpose-type motor and account for the largest share of induction motors sold. The slip of a Design B motor is approximately 3–5 percent or less.

**Design C.** Uses a two-cage rotor design—high-resistance for starting and low-resistance for running (Fig. 12). This creates a high starting torque with a normal starting current and low slip. During starting most of the current flows in the low-inductance, outer bars. As the rotor slip decreases, current flows more in the inner, low-resistance bars.

The Design C motor is usually used where breakaway loads are high at starting, but are normally run at rated full load and are not subject to high overload demands after running speed

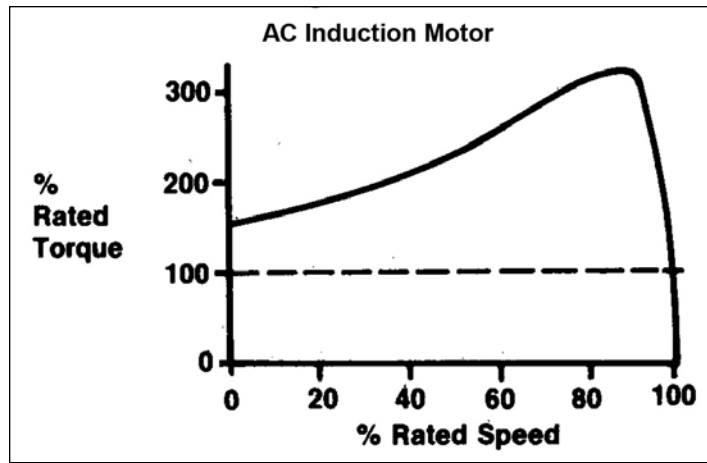


Figure 9 AC induction motor: Design A.

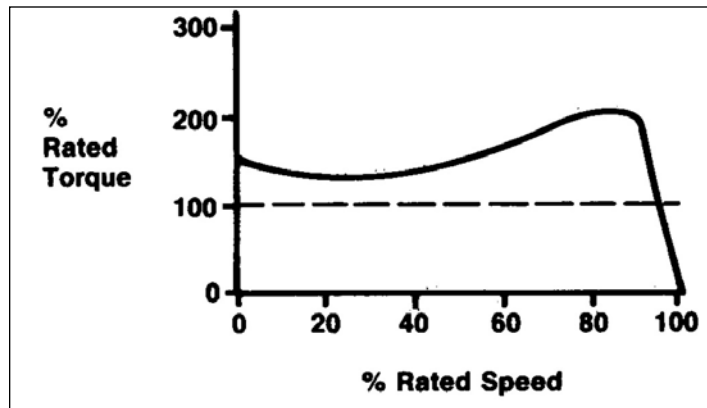


Figure 10 AC induction motor: Design B.

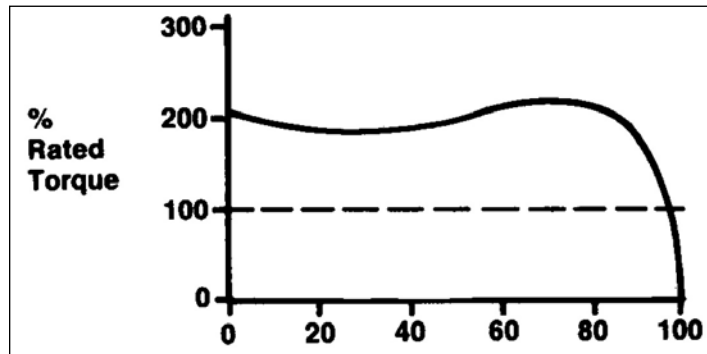


Figure 11 AC induction motor: Design C.

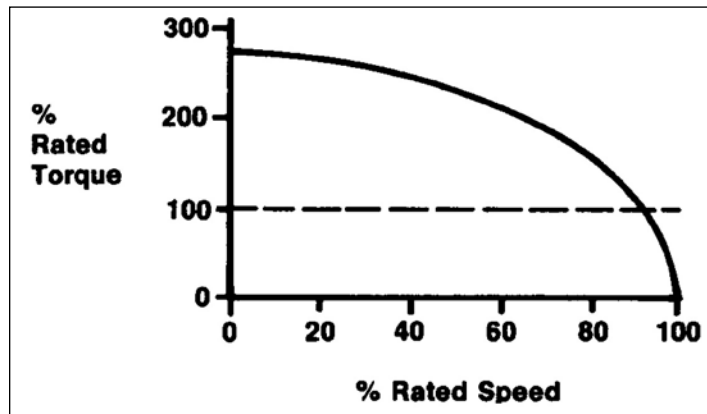


Figure 12 AC induction motor: Design D.

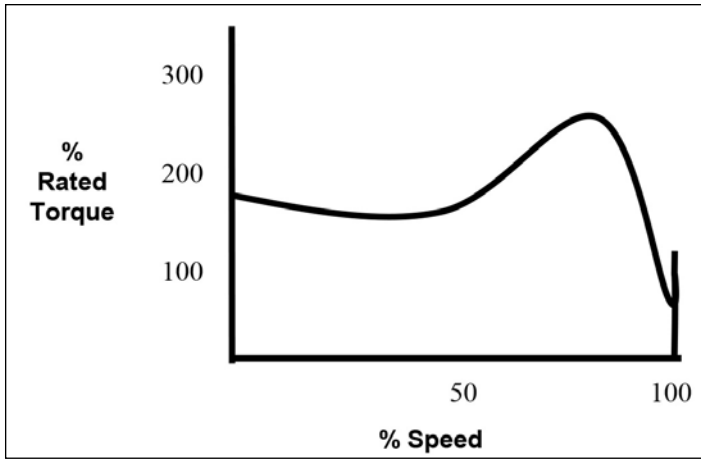


Figure 13 Synchronous motor: Percentage rated torque and speed.

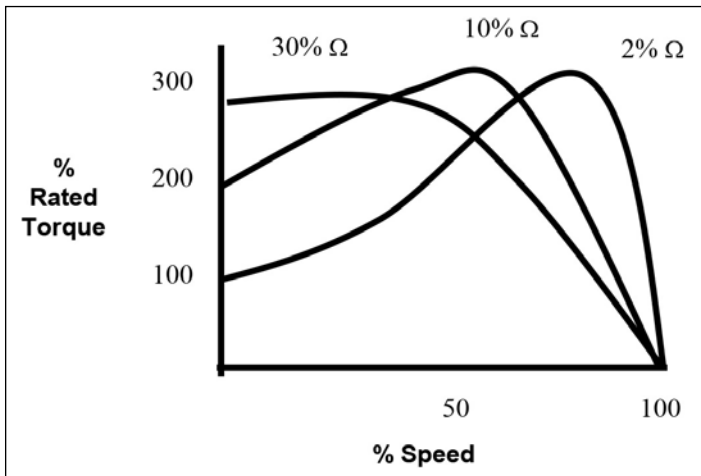


Figure 14 Wound rotor: Percentage rated torque and speed.

has been reached. The slip of the Design C motor is five percent or less.

**Design D.** Highest resistance rotor creating high slip, high starting torque and low starting current. Because of the high amount of slip the speed varies dramatically with load. The slip of this type motor is approximately five to eight percent. This high slip characteristic relates to a low-efficiency design and a motor that runs hot.

### Synchronous Motors

Synchronous motors operate at synchronism with the line frequency and maintain a constant speed—regardless of load—and without sophisticated electronic control. The two most common types of synchronous motors are reluctance and permanent magnet. The synchronous motor typically provides up to a maximum of 140 percent of rated torque. These designs start like an induction motor but quickly accelerate from approximately 90 percent sync speed to synchronous speed. When operated from an AC drive they require boost voltage to produce the required torque to synchronize quickly after power application.

Also available in high-horsepower motors is the separately excited synchronous motor; this design requires a load-commutated inverter (LCI).

**Wound rotor.** Some large motors may have a “wound rotor,” allowing the motor characteristics to be altered by adding resistors in series with the rotor. This effectively lets the user define the motor torque curve as NEMA A, B, C or D. More resistance means higher slip and higher starting torque across the line, while using a low value

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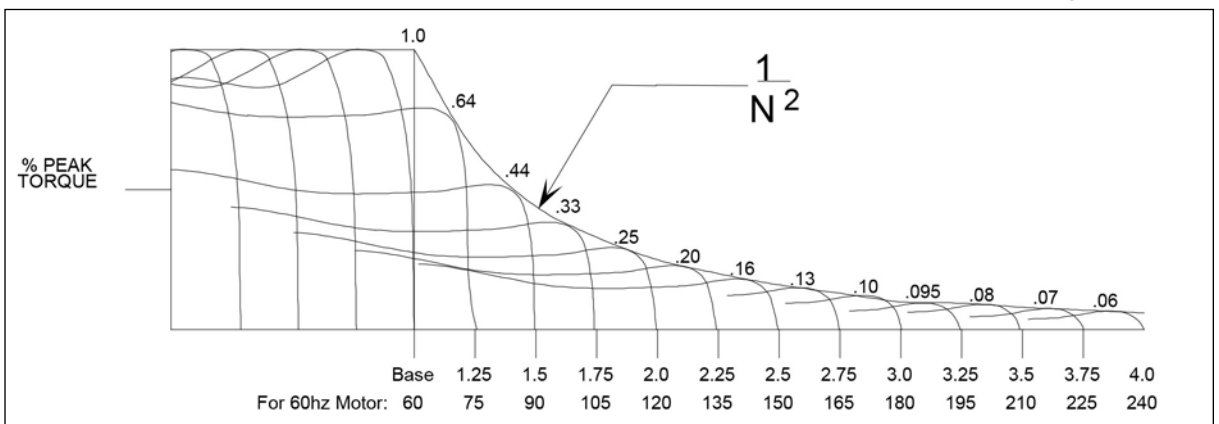


Figure 15 Peak torque curve for constant-voltage operation from base speed to four times base speed.

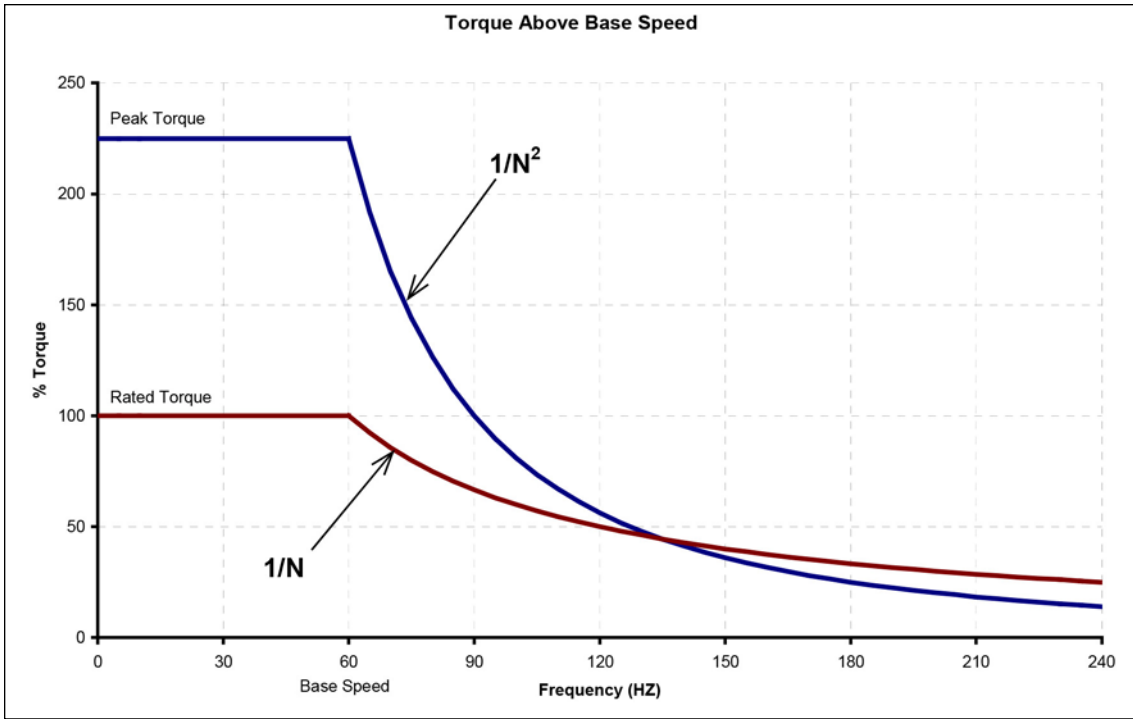


Figure 16 Comparison of peak torque to rated torque.

of series-resistance results in lower slip and greater efficiency. Often the resistors will be present for start-up and then jumped out while running.

In a case where a wound rotor motor is fed by an AC drive, the wound rotor connections should be permanently jumpered (no series resistance added).

A motor rated for 60 Hz operation may be run at higher frequencies when powered by an AC Drive. The top speed depends upon the voltage limits of the motor and its mechanical balancing. 230 V and 460 V motors normally employ insulation rated for as much as 1,600 V, so the voltage limit is not usually a problem. An average two-pole industrial motor can safely exceed its base speed by 25 percent. Many manufacturers balance their three- and four-pole rotors to the same speed: 25 percent over the two-pole base speed. A four-pole motor may therefore operate up to 125 percent over base speed before reaching its balance limit. A 60 Hz four-pole motor might run up to 135 Hz, whereas a 60 Hz two-pole motor would reach its balance limit at 75 Hz; both motors would run at the same RPM. Always contact your motor manufacturer if you plan to operate at these speeds.

**Constant-voltage operation.** What happens to the volts-per-Hertz ratio above rated frequency? If output frequency is increased to 120 Hz with 100 percent voltage applied to the motor, the volts-per-Hertz of the drive is no longer 7.6 but rather 3.83. The same volts-per-Hertz ratio results when a line-started motor is operated at 60 Hz with only a 50 voltage applied (for reduced voltage starting). As might be expected, the effect on torque is the same; recall that torque varies as the square of the applied voltage:

$$T = K_1 x E^2 \quad (4)$$

As such, maximum torque at 120 Hz is only 25 percent of the maximum torque at 60 Hz.

If the AC drive output frequency is reduced from 120 Hz to 90 Hz at a constant voltage, the volts-per-Hertz ratio improves from 3.83 to 5.1 V/Hz. This is the same as providing 66 percent voltage at 60 Hz to a line-started motor. Torque will be 0.662, or 44 percent of the full voltage torque at 60 Hz. Figure 15 illustrates the peak torque curve for constant voltage operation from base speed to four times base speed.

Since the voltage, in reality, is not changing above base speed, it is more appropriate to define torque in terms of frequency change instead of voltage change. It can be stated then that torque above base speed drops as the square of the frequency; i.e.: doubling the frequency quarters the available torque. Applied frequency and synchronous speed are equivalent; going one step further, torque may be defined in terms of speed. So in the constant voltage range, motor torque drops off as the inverse of synchronous speed squared, or  $1/N^2$ . (Fig. 16).

Many machine applications are constant-horsepower in their load characteristics. As speed increases, the torque drops off as the inverse of speed, or  $1/N$ . The torque drop-off is not as severe as the motor's peak torque— $1/N^2$ . Figure 16 compares peak torque to rated torque. **PTE**

**For more information:**

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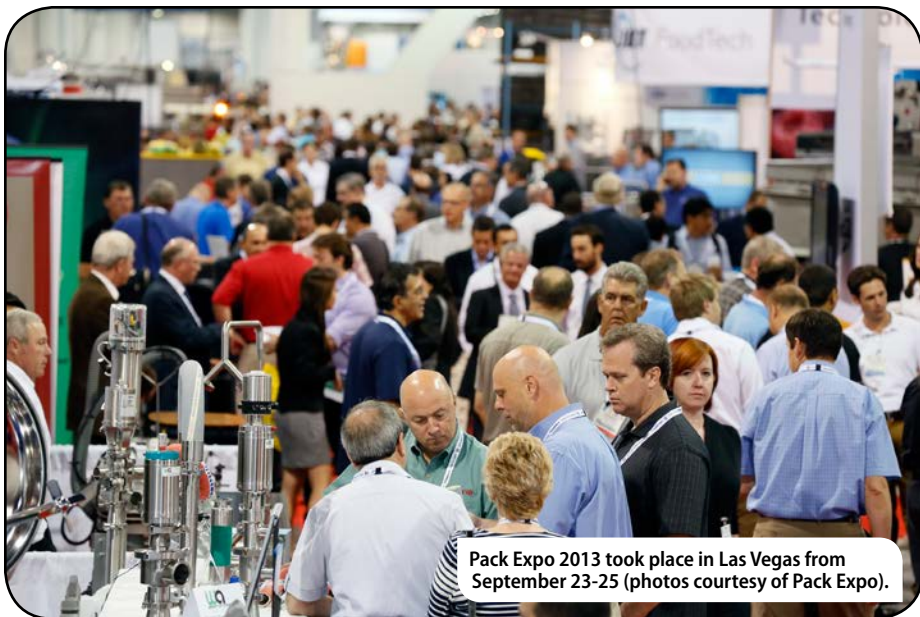
# A Focus on the Future at Pack Expo 2013

More than 27,000 packaging and processing professionals attended Pack Expo 2013 in Las Vegas from September 23–25. In addition to launching new products, creating brand awareness, achieving sustainability goals and generating new business contacts, Pack Expo was an opportunity to engage the next generation of workers in packaging, robotics and processing applications.

Local FIRST Robotics teams demonstrated their entries in the 2013 FIRST Robotics Competition during the exhibition. FIRST is a national organization that strives to connect students to “real-world engineering,” and show where STEM subjects—science, technology, engineering and math—can lead them. Five teams of students from local Nevada high schools displayed and demonstrated Frisbee-throwing robots they entered in this year’s “Ultimate Ascent” contest, a game designed to test the accuracy of the robots’ aim. High schools involved in the contest included: Cimarron-Memorial High School (Las Vegas), Northwest Career & Technical Academy (Las Vegas), Coronado High School (Henderson, Nev.), Boulder City High School (Boulder City, Nev.) and Foothill High School (Henderson, Nev.).

Teams spent half the day demonstrating their robots in action and the rest of the day exploring the show floor. “FIRST allows K-12 students to experience the STEM subjects as practical applications for what they learn in school,” said Maria Ferrante, vice president, Education and Workforce Development, PMMI. “By bringing them to Pack Expo, we also open up to them an environment where they can see technology in action, and can imagine themselves designing and/or using packaging and processing machinery.”

In addition to the FIRST Robotics Competition display, several other Pack Expo programs took place. The



Pack Expo 2013 took place in Las Vegas from September 23-25 (photos courtesy of Pack Expo).

Amazing Packaging Race, sponsored by ASCO Numatics, involved a three-hour dash around the show floor challenging students to compete for points by completing tasks with varying levels of difficulty at the booths of participating exhibitors. The Pack Solutions Challenge, sponsored by B&R Industrial Automation, allowed students to present proposals for a packaging line upgrade commissioned by a fictional processor and packager of health care products to a panel of judges with representatives from Chattem, Keurig, Pepsi Beverage Company and Schrieber Foods, Inc. The Clemson University Packaging Emporium: Design for the Future, sponsored by Esko, was an interactive exhibit featuring Clemson’s biometric technology and exploring the impact of package design on consumer behavior. This is the third such exhibit Clemson students have brought to Pack Expo, and the second time Esko has sponsored the display.

“Each of our student initiatives at Pack Expo allows an inside look at the exciting trends and technologies in packaging and processing. Typically, students have a limited vision of what opportunities exist in our industry.

Pack Expo is a unique opportunity to engage these students, broaden their vision and nurture their interest in STEM,” adds Ferrante.

## Packaging Trends and Technology

PMMI, The Association for Packaging & Processing Technologies, the owner and producer of Pack Expo Las Vegas, offered a comprehensive schedule of educational sessions on topics such as safety standards, the supply chain, lean automation solutions, control panel design, personalized packaging and more. Breakthrough educational sessions of note included “It’s Not Easy Being Green—Consumer Perception of Sustainable Packaging,” and “My Way: Packaging that Helps Consumers Personalize their Experience.”

The CTT (Booth #1358, Central Hall) presented five one-hour conference sessions each day of the show. Led by experts from Cisco, Jacobs Automation, Microsoft, Motorola Solutions, Rockwell Automation and Spectrum Control, the sessions provided insight into a range of topics including securi-

ty, line integration, remote access and cloud strategies.

Kollmorgen (booth 3118) allowed attendees to interact with its motion control technologies during the show. A new Servo Boxing interactive demo included the next-generation AKD PDMM programmable servo drive with the versatility, communications, power and bandwidth customers need to build higher throughput, greater precision and more capable features into their machines. Kollmorgen also featured a large-scale Servo Tennis video game where participants attempted to break high scores while learning about AKD Drives and the R2A Linear Actuators.

The VT Bolt and the Segway PT, both containing Kollmorgen technology as an integral part of their functional-

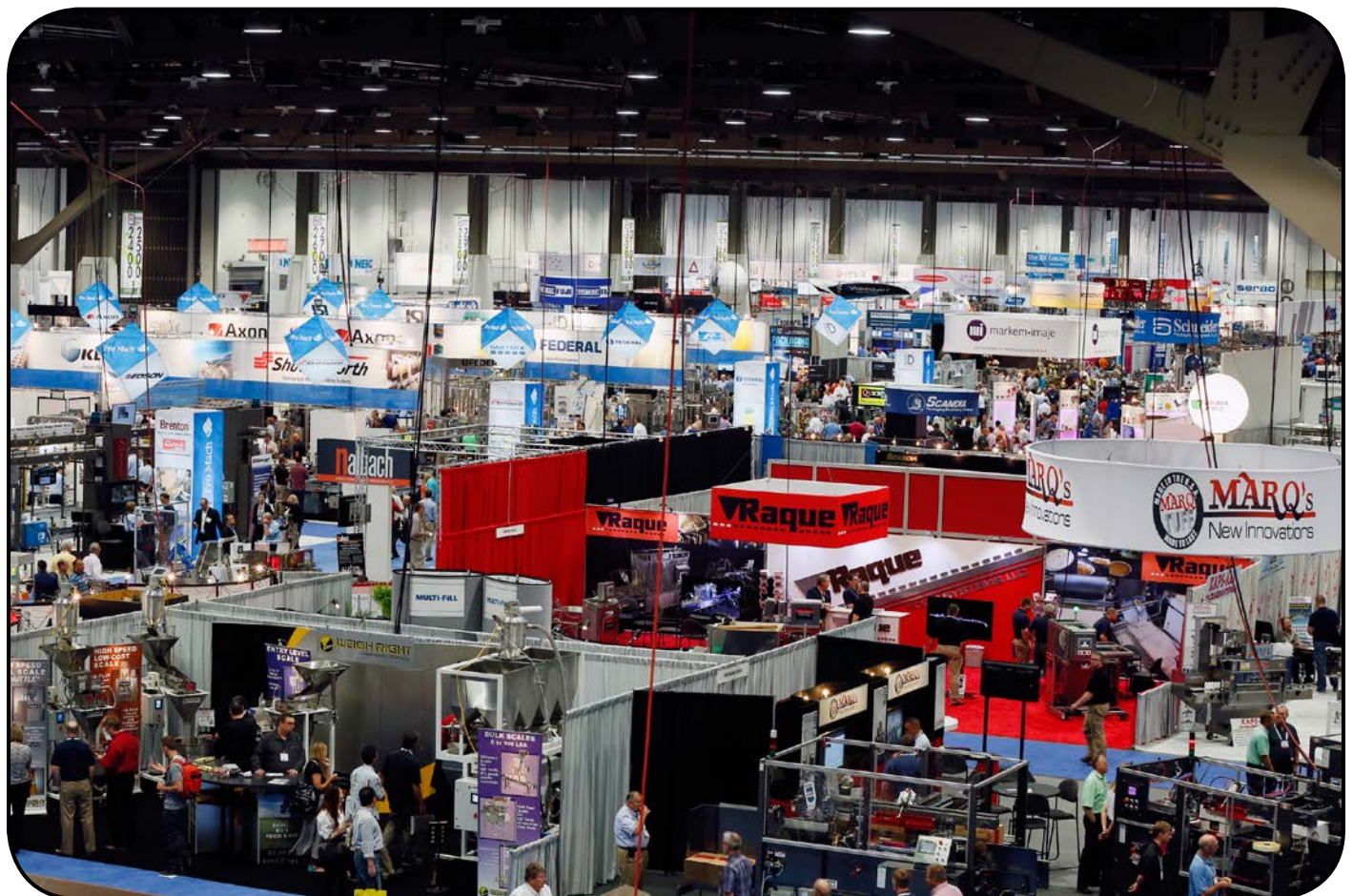
ity, were on display during the show. “Kollmorgen’s culture of engineering collaboration and continuous technology innovation, coupled with decades of motion control and machine automation experience, enables us to help OEMs increase machine flexibility, reliability and throughput. This year at Pack Expo we highlighted our hygienic washdown products and we shared some new solutions to deliver higher levels of processing and packaging innovation and quality – from reduced cleaning time to increased longevity,” says Andy Hansbrough, market development manager.

### Plans for 2014

After another successful Pack Expo in Las Vegas, Show Committee Chairman Emmanuel Cerf reflected on the

bigger and better things to come in the future. “I’m really excited about what’s in store for Pack Expo International 2014 (Chicago, November 2–5, 2014) and Pack Expo East, debuting at the Pennsylvania Convention Center (Philadelphia, February 2–4, 2015).”

In the Pack Expo Show Daily, Cerf reiterated the need in the market for first-class events closer to home in markets like food, beverage, personal care, electronics and pharmaceuticals and medical devices. For more information on Pack Expo, visit [www.pack-expo.com](http://www.pack-expo.com). **PTE**



## Siemens and Kuka

ANNOUNCE COOPERATION AT EMO 2013

Siemens Drive Technologies Division and Kuka Roboter GmbH have announced a comprehensive cooperation at EMO in Hannover. The central pillar of the cooperation is integration of Kuka robots and Siemens CNC solutions for loading machine tools. "With this joint approach, the two companies are strengthening the fundamental idea of integrated production and can, for example, develop new markets by close intermeshing of machine tool tasks and loading tasks," says Manfred Gundel, CEO of Kuka Roboter GmbH. "The CNC control from Siemens and the robot controls from Kuka are ideal for integrating robot and CNC technology. With this cooperation, we are deepening our many years of cooperation and together advancing intelligent automation solutions as outlined by the Industrie 4.0 project for the benefit of both partners and to expand business," says Dr. Robert Neuhauser, CEO of Business Unit Motion Control Systems at Siemens.



Dr. Robert Neuhauser, Siemens (left) and Manfred Gundel, Kuka Robotics (right).

Highly flexible and fully automated production today demands complete integration of robots into the production flow and into the automation environment. In this area, in particular, applications for robots and machine tools are growing together steadily as a result of new requirements and technological progress. Given these developments, Siemens and Kuka are strengthening their cooperation in automation and industrial robots. The aim is to be better able to serve industries with high automation requirements in loading and machining. With the shared development, customers will have access to new products and solutions that are coordinated optimally over their entire life cycle, from design, to production simulation, to engineering and the production shop level. Moreover, in the long term, the two companies will be including aspects of robot automation in their activities as outlined in the Industrie 4.0 project.

With this close partnership, Siemens and Kuka can offer end customers integrated solutions with a high technological demand and level of maturity and position themselves still better on global markets. At the center of the joint development and the closely meshed marketing activities is seamless, operator-friendly integration of the robot for load-

ing the machine tool. The companies will also develop scalable, integrated solutions for machining workpieces with robots, especially for lightweight construction. In this field, in particular, new materials such as composites require innovative machining concepts that the two companies will be intensively advancing as part of the cooperation.

Kuka will provide robot systems that make use of proven solutions in the field of CNC with Sinumerik from Siemens for integration with machine tools. The standard implementation of the concept includes loading by a Kuka robot, which is integrated in Sinumerik. A scaled offer is also planned ranging from a robot with additional CNC machining functionality to a robot as a pure CNC machining unit. Here, too, the aim is complete integration of the robot into the PLM processes. At EMO 2011, both partners have already presented the integration of the robot into the Sinumerik user interface as an application, for programming, teach-in, and diagnostics. The next step will now be the connection to CNC tasks.

## Romax Technology

SELECTED FOR REMOTE MONITORING SERVICES

Infigen Energy, owner and operator of 24 wind farms across the USA and Australia has chosen Romax as its independent provider to support the company in reducing downtime costs on two of its wind farms currently being monitored in the United States. The company is benefiting from the Romax InSight Health Management Solution, a combination of technology and services that provide early warning of upcoming wind turbine failures. Up to 75 percent of the operational expenditure for a large wind farm is typically related to the site's O&M function. To be competitive in terms of the commercial cost per kilowatt hour of electric power generated, every detail of O&M needs to be made as efficient as possible.

Ashley Crowther, Romax VP Engineering, U.S., said "It's great that we are seeing InSight make significant cost savings to owners and operators in predicting turbine failure and correcting this through scheduled maintenance. InSight allows its users to understand their wind turbines and pro-



actively take control of maintenance to ensure maximum uptime and revenue with minimum cost.”

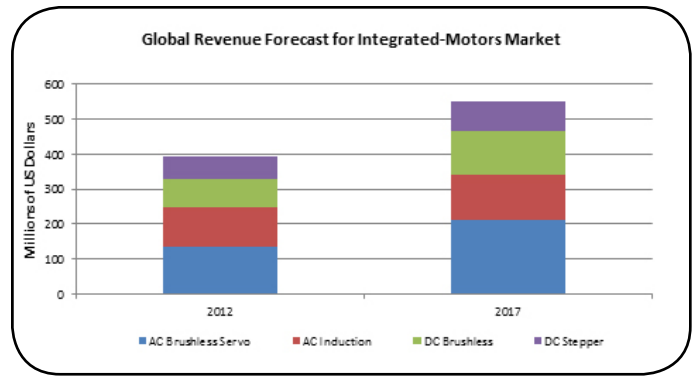
James Snelson, senior mechanical engineer for Infigen Energy, said, “We have chosen Romax to work on our 81 Siemens units in Texas in order to provide a fully transparent, third-party condition monitoring solution. I selected Romax because I felt very confident that they had the expertise and knowledge to meet our needs. A major plus was their level of communication, openness, willingness to collaborate and enthusiasm to drill down to the root cause of any problems.”

## IMS

### REPORTS ON INTEGRATED MOTOR MARKET

Integrated-motor suppliers offering this compact motor type with built-in electronics can look forward to a 40 percent increase in total market revenue by 2017, even though growth as a whole appears to be moderating, according to a new report from IMS Research, now part of IHS, a leading global source of critical insight and information.

Revenue for the integrated-motors market is projected to reach \$553 million by 2017, up from less than \$400 million in 2012. Brushless motors currently lead the way in growth, as shown in the attached figure, with more than 70 percent of additional market revenues from 2012 to 2017 expected to come from the sales of AC brushless servo and DC brushless integrated motors. For perspective, these products represented only 56 percent of market revenues in 2012.



Overall market growth last year, however, was limited by the recession in Europe, which accounted for 65 percent of total market revenue in 2012, noted the recently published report entitled “Integrated Motors – World- 2013.” Business will remain tepid this year, after which higher growth is expected from 2014 to 2017 as the market expands at more than 7 percent each year.

Despite the rise, projected growth rates remain below historical levels. IHS has tracked the integrated-motor market for more than a decade, and yearly growth rates in the past have averaged in the double digits. In particular, the market rose by more than 300 percent between 2002 and 2011.

“With a much higher global market size, the amount of revenue gained in the market each year would have to increase significantly for the historical growth rates to be maintained, and this has not occurred,” explains Michelle Figgs, motor



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controls and switchgear analyst at IHS. “Still, integrated motors continue to take share away from traditional motor and drive solutions, and motor suppliers are increasingly recognizing the importance of including an integrated-motor option in their product portfolios to prevent loss of market share.”

A high growth area for AC brushless servo integrated motors is the packaging industry, as the motors reduce costs associated with cabling and central cabinets for large machines with numerous axes in the low- to mid-power range. “Another advantage of integrated motors is their compact size, which is particularly beneficial in mobile applications like automated guided vehicles (AGVs),” Figgs added. “The increased use of AGVs to transport materials in distribution centers and hospitals, in turn, is driving growth in the market for DC brushless integrated motors.”

Meanwhile, revenue from the sale of AC induction integrated motors is also increasing, although at a slower rate than the other product types.

“AC induction integrated motors were the second-largest product type in 2012, accounting for 28.2 percent of total market revenue, but the transition from traditional motor and drive products in AC induction applications continues to be a slow one,” Figgs noted. Even so, phase 3 of the Energy-related Product (ErP) directive is expected to boost sales in this market in the Eurozone starting in 2017. The ErP is a framework for establishing minimum design requirements for energy-using and energy-related products.

Prospects for the integrated-motor market remain positive going forward, despite a market contraction in 2012 and limited growth this year. Total market revenue is forecast to expand at an average annual rate of 7.1 percent from 2012 to 2017, with AC brushless servo and DC brushless integrated motors leading the space in growth, while sales of DC stepper and AC induction motors rise at a rate below the market average.

## Servometer

WELCOMES TECHNICAL SALES MANAGER

Servometer, the premiere U.S. manufacturer of metal bellows, custom electroforms, flexible couplings and contacts is pleased to announce that Fred G. Poelzing has recently joined the company as the technical sales manager. Poelzing has extensive experience in B2B sales management and customer service with a focus in aerospace, defense, science research and automation sectors. He will be responsible for the company’s growth and development of its products and services both domestic and foreign and will also oversee the management of the sales force including distribution partners and representatives. “Servometer offers a unique electrodeposition technology and I look forward to creating additional opportunities across its customer base and contributing to its expansion into new areas,” says Poelzing.

## QA1

SUPPORTS PEKING TO PARIS MOTOR CHALLENGE

The 5th Peking to Paris Motor Challenge took place in June, with QA1 closely watching and supporting Mike and Peter Armstrong in their 1934 Dodge DR Special. Running QA1 Proma Star shocks in the rear, they finished strong in the longest and toughest challenge anyone can drive in a vintage or classic car. Peking to Paris is a rally that takes place every three years and is put on by The Endurance Rally Association. This year’s route ran from Beijing to Paris over 33 days and covered 28 cities in eight countries.



The Armstrongs, brothers from Australia, finished 11th in the Vintageant Category and earned Gold Medal Status. Receiving any medal is an amazing achievement, but the gold medal is reserved for the strictest adherence to the required schedule. Their QA1 Proma Star shocks helped them finish the 7,610 mile trip in 263 hours, 13 minutes and 16 seconds. This was their first rally of this type, but Mike has competed in the Targa Tasmania three times.

Mike Armstrong was impressed with the performance of his QA1 Proma Star shocks. “The one thing that failed on most cars in the rally were the shock absorbers,” he said. “The roads we traveled through Mongolia and Russia were unimaginably tough and the shocks were the weak link on virtually all cars. The fact that these QA1 shocks performed trouble-free is proof of their quality. I would only use QA1 products again on further rallies.” With QA1 Proma Star shocks in the rear, they chose to keep the original lever action shocks in the front. These original shocks caused a few issues throughout the journey, while the QA1 shocks were trouble-free. Read more about Mike and Peter’s adventure on their blog at [www.pekingtoparis2013.tumblr.com](http://www.pekingtoparis2013.tumblr.com).

The next Peking to Paris event is scheduled for 2016, and the route includes a stop at the foot of Mount Everest, a stop in Kathmandu and some of the highest altitude roads in the world in Tibet.



# Marathon

POWERS INTO SECOND CENTURY

Founded in Wausau, Wisconsin, where it still operates today, Marathon was originally a timber and forestry business. However, it soon moved to electric motor manufacturing when an engineer left Westinghouse Electric and convinced the Wausau group that the small washing machine motor they had designed could be profitable.

Establishing quality-driven manufacturing processes, Marathon quickly became the motor supplier of choice for manufacturers of durable industrial and consumer products. Consistent growth meant that by the late 1940s, Marathon was producing over 300,000 electric motors a year.

Diversification followed with Marathon purchasing generator manufacturer Burke Electric of Erie, Pennsylvania. At the same time Burke's fuse and terminal block division in Bowling Green, Ohio, became Marathon Special Products. In 1986, Marathon became the world's largest independent producer of electrical generators when it purchased Lima Electric in Ohio.

Of course, Marathon always maintained its motor activity, steadily expanding into larger motors and new technologies, often innovating entirely new product categories, developing specialist motors and constantly reviewing materials and manufacturing techniques.



Marathon joined the Regal Beloit portfolio of brands in 1997, where it has since been joined by several other leading players in motor and related technologies. Today, its motor range embraces AC and DC motors from fractional to integral horsepower-sized, imperial and metric designs, NEMA, ISA and other standards, permanent magnet motors, specialist motors, etc.

As Marathon goes into its 101st year, research and development is at the heart of its operations. It is particularly focused on increasing the efficiency and reliability of motors and generators, and rising to the changing needs of motor users throughout the world. Customer service and global reach are also identified as key components for continuing success.

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We are seeking an energetic and experienced person to become our Account Manager. This position has a product focus of selling power transmission components (gearboxes, transmissions and powertrain drives) to specialty markets such as oil and gas, mining, industrial, marine and specialty vehicle. Extensive experience is required in sales management and technical sales support for such products and industries. This can be a home-office based position with up to 75% travel required.

Please go to our Career Opportunities page at: [www.fabcoautomotive.com/careers/index.htm](http://www.fabcoautomotive.com/careers/index.htm) for more details about this career opportunity.

## Schafer

APPOINTS GEAR UNIT MANAGER

Bipin Doshi, president of Schafer Industries, has announced the appointment of Thomas L. Troyan as manager of the company's Gear Unit. Responsible for three plant locations, his duties include managing customer and supplier relations. Troyan joined Schafer Industries when the company acquired two axle manufacturing plants in Ohio, where he served as general manager. Troyan has more than 29 years of operations experience in manufacturing. Prior to joining Schafer Industries, Troyan was senior operations manager for Dana Holding Corporation, where he was responsible for five North American facilities. Troyan has also served as general manager of F&P Georgia Inc., where he was instrumental in the program launch of several North American Honda vehicle platforms. He also served as plant manager for Metaldyne, a manufacturer of precision machined components for the automotive compressor market and spent 13 years with Allison Transmission, serving in various roles in engineering and operations. Troyan has a B.S. in industrial management and engineering from Purdue University and an M.B.A in operations from Butler University. He is a previous member of the Society of Automotive Engineers as well as the Society of Manufacturing Engineers.

## SKF

ACQUIRES KAYDON CORPORATION

SKF and Kaydon Corporation have agreed that SKF will acquire Kaydon in an all-cash transaction valued at approximately USD 1.25 billion, including USD 95 million of net debt. The transaction will be paid through existing cash and credit lines and will be accretive to SKF earnings in year one. Tom Johnstone, SKF president and CEO, explains, "We have followed the development of Kaydon for a long time. They have a strong product portfolio, strong management and a solid financial performance and I am delighted that they will soon be part of the SKF Group. The complementary nature of their products and technologies, their geographical and customer presence and their manufacturing footprint will enable us to even better serve our customers and distributors in the industrial market worldwide. In particular this acquisition, combined with our other activities, investments and acquisitions in the last few years, shows our strong commitment to the North American market."

Kaydon is a diversified industrial manufacturer with three distinct business areas: friction control products (bearings), velocity control products and specialty products, including environmental services. Kaydon has a global footprint with 62 percent of its sales generated in North America, 24 percent in Europe, 12 percent in Asia Pacific and 2 percent in the rest of the world. In 2012, the company had sales of USD 475 million, with an adjusted operating profit of around 16 percent and has over 2,100 employees. James O'Leary, chairman and CEO of Kaydon Corporation commented, "Our board believes that the proposed transaction represents a compelling value for our shareholders. We believe that this

transaction represents an excellent strategic fit for Kaydon that will allow our market leading businesses to accelerate their growth strategies by joining forces with SKF, a global industry leader."

## David Brown

WINS ROYAL NAVY CONTRACT

David Brown has been awarded one of the first design contracts for key elements of the U.K. Royal Navy's Type 26 Global Combat Ship by BAE Systems. Under the Design Development Agreement (DDA) David Brown will create detailed designs and progress plans for the gearbox of the Type 26 Global Combat Ship, while working in partnership with the joint BAE Systems and Ministry of Defense project team.

The Type 26 Global Combat Ship will replace and enhance the capabilities presently being delivered by the Type 23



Frigates in the Royal Navy's current fleet. Geoff Searle, Type 26 global combat ship project director for BAE Systems said: "The ship design and program has progressed so well, that we are now at a stage where we are able to work very closely with our suppliers to identify the best quality products and technology for the ship that are already proven and ensure the highest level of service and capability."

Steve Watson, managing director Europe at David Brown said: "This is great news for David Brown. We have a strong track record in mission-critical gearing and we've worked hard to remain at the very forefront of technological innovation - maintaining our capability and expertise to support the U.K. defense sector from our U.K. headquarters in Huddersfield."

Jason McCartney, member of parliament for Colne Valley, said: "I am delighted that David Brown has been awarded this contract. They are a world-class engineering firm that makes a huge economic and social contribution to Colne Valley and Huddersfield, employing a lot of people and running a fantastic apprenticeship scheme. Following a week of positive economic news for our country it's great to see that local companies and people are set to reap the benefits. This contract is a welcome reminder that things are getting better for our part of Yorkshire."

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## GAM Gear

MERGES INTO GAM ENTERPRISES

GAM, a leading manufacturer of precision gear reducers, servo couplings, linear mounting kits, and other innovative products used in automation technology announces the merger of GAM Gear, LLC into GAM Enterprises, Inc. GAM Enterprises, Inc. was founded in 1990 when Gary Michalek introduced a line of servo bellows couplings to the North American machine tool market. In 1998, GAM Gear, LLC, was started in order to bring to market a complementary range of servo gearboxes. At the time, GAM Gear was launched as a separate entity from GAM Enterprises, Inc. for legal and financial reasons. "We chose to adopt the legal name GAM Enterprises, Inc. because it reflects our overall range of product types as well as it leaves open the possibility for future product expansion," stated Gary Michalek, CEO of GAM. "The name GAM Gear will be kept as a brand name under GAM Enterprises, Inc."

The most significant outcome of the merger was the consolidation of two ERP systems into one. Having a single database will drastically improve the processing and reporting capabilities in GAM's accounting, production, and sales functions. The process of merging companies was a large undertaking that required an elevated level of teamwork between GAM and external consultants. "I would like to compliment you on having formed the team at GAM that showed the patience and perseverance required to achieve a very difficult goal," said Dan Johnson, independent IT advisor who lead the technical aspects of the merger, "You may take my word for the fact that I know of no other company that could accomplish a month end, quarter end and major business software environment change in one working day".

Customer service at GAM will also see a substantial improvement as order processing times will decrease. Customers will now also be able to order gearboxes, couplings, or any other GAM products on the same purchase order. "We are excited about this change as it will streamline many of our processes and open the opportunity for gains in efficiency," said Craig Van den Avont, president of GAM. "Having all products within one company will also make it easier for our customers and our channel partners to do business with us."

## Lafert NA

HIRES PROJECT MANAGER

**Fahad Haq**, has joined Lafert NA, as the new project manager. Haq brings with him years of experience in industrial supply, motor distribution, and project management. This newly created position will enhance the company's ability to support small and large customers alike at Lafert NA. Lafert NA offers a complete range of metric motors, pumps and gearboxes with extensive inventories throughout North America.



## Arrow Gear

ANNOUNCES NEW CHIEF FINANCIAL OFFICER

Arrow Gear is pleased to announce the appointment of **Andrew Mazzarella**

as the company's new chief financial officer (CFO). Mazzarella joined Arrow Gear in mid-August. He has an extensive background in executive level finance for the manufacturing sector. A graduate of the University of Illinois in accounting, Mazzarella began



his career working for a Fortune 200 company in the automotive replacement parts industry; eventually achieving the position of CFO. After moving on to CFO positions at several middle-market companies, he later became part of an ownership team that operated a manufacturing company which supplied products to the automotive industry. Here he performed the dual role of CFO and vice president of manufacturing; heading up the company's main manufacturing facility in Carson City, Nevada. Mazzarella's diverse experience in the financial requirements of manufacturing is a valued addition to the Arrow Gear executive team.

## Oerlikon Graziano

DISCUSSES MEASUREMENT OF FRICTION COEFFICIENT

High-performance transmission specialist Oerlikon Graziano shared its extensive knowledge and innovative research techniques at the World Tribology Congress 2013, in Turin, from September 8-13, stand 56. The event, organized by the Italian Tribology Association (AIT), occurs every four years and provides a unique opportunity for discussion of recent developments in tribology and to strengthen the link between research organizations and industry.

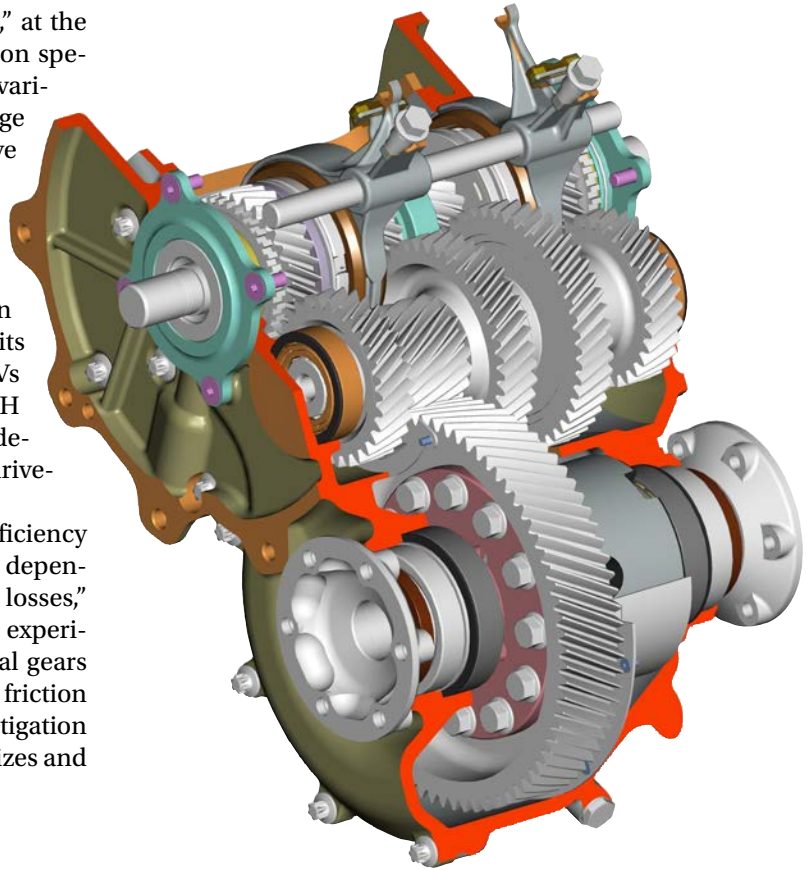
"Creating low friction surfaces is a crucial factor in Oerlikon Graziano's development of market-leading transmission systems, and we intend to share our methods for measurement of the friction coefficient involved in cylindrical gear teeth meshing," says Oerlikon Graziano Chairman and Managing Director, Paolo Ramadori. "The effects of gear mesh on transmission efficiency have been estimated with an analytical approach that requires a suitable corrective coefficient calibration: using prototype development, intensive testing and statistical approach — DOE methodology — we are able to deliver a more accurate, proven efficiency model to predict the power losses of transmission systems."

Vincenzo Solimine, Oerlikon Graziano virtual validation engineer and Davide Crivello, Oerlikon Graziano testing engineer, delivered a speech on "Measurement of friction co-

efficient involved in cylindrical gear teeth meshing,” at the Congress, which offered diverse scientific sessions on specific tribology-related topics, a broad exhibition and various collateral events. It is seen as a crucial knowledge sharing tool that continues to promote collaborative opportunities for the ongoing development of technologies.

Eco-tribology and sustainability were the primary focus in this year’s Congress, and Oerlikon Graziano’s study of friction, wear and lubrication in cylindrical gear teeth meshing has been crucial to its development of gearboxes and drive systems for EVs and HEVs. Due to efficiency requirements and NVH expectations, this emerging market is the most demanding in terms of maximizing the operation of drive-line components.

“Oerlikon Graziano’s calculation code for the efficiency model is all-encompassing and considers both load dependent and load-independent contributions to power losses,” explains Solimine. The activity is focused on the experimental evaluation of power losses due to cylindrical gears meshing to obtain a mathematical expression of the friction coefficient. In particular, the parameters under investigation are oil viscosity, the most important gear geometry sizes and working conditions.”



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# Power Transmission Engineering

SPONSORS GEAR AND GEAR DRIVE MARKETING

*Power Transmission Engineering* sponsored a free breakfast seminar on Wednesday September 18<sup>th</sup> during Gear Expo 2013. Dave Friedman, associate publisher and advertising



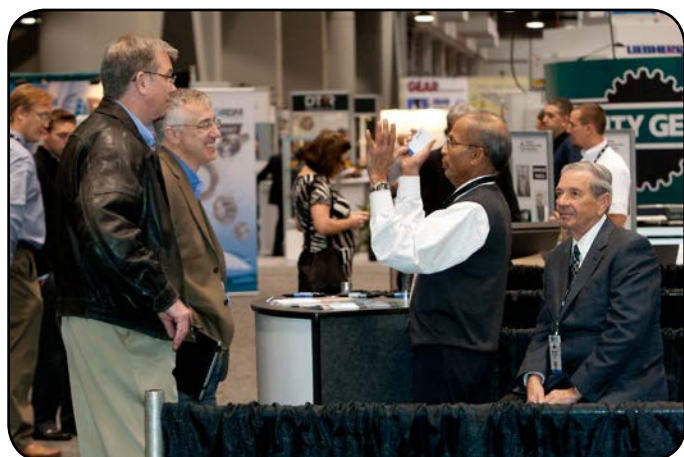
sales manager, discussed how to build brand identity, print vs. online advertising and how to best use the tools *Power Transmission Engineering* has to offer the industrial marketplace. Randall Publications would like to thank the 50+ attendees who joined us for the breakfast seminar.

## NTP

RELEASES GEAR EXPO NUMBERS

National Trade Productions, Inc. (NTP), recently announced notable show growth metrics for its client, the American Gear Manufacturers Association (AGMA). The association's biennial Gear Expo, held September 17-19, 2013 at the Indiana Convention Center in Indianapolis, sold out the exhibition floor by attracting 219 exhibiting companies across 52,500 net square feet of exhibit space. This milestone represents a 26 percent increase in exhibiting companies and a 29 percent increase in exhibit space over 2011.

The event also united more than 3,400 industry professionals in 2013 (an 11.8 percent increase in attendance over



2011) and earned an 82 percent rebook rate during 2015 exhibit space selection.

"Gear Expo is a high-quality event focused on precision, power and partnerships," said Andrew Ortale, executive vice president. "For more than two decades, gear professionals have relied on the event—and its exhibitors—to provide the latest industry information, technology, products and services to help expand and streamline their businesses. The event continues to deliver real strategic value as demonstrated by its significant achievements and expansion, and we anticipate even greater success in 2015 as we celebrate AGMA's 100-year anniversary."

Gear Expo is the world's only conference and expo designed exclusively for the gear industry. For three days, gear buyers and manufacturers meet face-to-face to discuss industry trends, demo the latest technologies and to network and build relationships that benefit their respective companies. NTP facilitates and manages the operations and exhibit sales for the event. Gear Expo 2015 will take place October 20-22 2015 at the Cobo Center in Detroit, Michigan.

## ABB

SIGNS AGREEMENT WITH GENERAC

ABB recently announced it has signed an agreement to sell all assets of Baldor's generator-set business to Generac Holdings Inc. Generac is a producer of generators and other engine powered products, headquartered in Waukesha, Wisconsin. The sale is expected to close in the fourth quarter of 2013. The terms of the transaction were not disclosed. ABB is divesting the generator-set business because of limited synergies with ABB's core portfolio and because Generac is in a better position to create additional value from the business. The business was acquired as part of ABB's acquisition of Baldor Electric in 2011, and accounts for about three percent of Baldor's total sales. Baldor's generator-set business produces in its facility in Oshkosh, Wisconsin, a broad line of portable, standby, prime power and peak-shaving generators from 3 - 2,500 kW in LP, natural gas or diesel for every power requirement. "The divestment is in line with our strategy to continuously optimize our portfolio and to focus our efforts on driving profitable growth in our core automation and power businesses," said ABB CEO, Ulrich Spiesshof. "Overall, the fit between ABB and Baldor is excellent, as we are seeing from the value that has already been created." Baldor CEO, Ronald Tucker, added that the transaction would benefit both firms' employees and customers. "This sale will allow Baldor to focus on industrial electric motors and mechanical power transmission products in line with ABB's core portfolio, while enabling the generator-set business to become part of a company solely focused on the manufacturing, distribution and sales of these types of products."

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How is THIS LOCATION involved with power transmission products? (Check all that apply)

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- WE SELL power transmission products (Distributors, sales reps. etc.) (14)
- WE DESIGN products with power transmission components in them. (16)
- Other (please describe) (15) \_\_\_\_\_

5

What is your primary job function responsibility? (Check one)

- Corporate Management (1)
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- Marketing & Sales (4)
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**October 28–31—Power Transmission and Control 2013.** Shanghai New International Expo Centre, Shanghai, China. Organized by Deutsche Messe, PTC Asia is the continent's leading trade fair for electrical and mechanical power transmission, fluid power, compressed air technology, machine parts, bearings, linear motion systems, internal combustion engines and gas turbines. Sponsors include Bosch Rexroth, Emerson, DMG, Parker, Siemens, EMAG, SKF, Lenze, Tsubaki, ABB, NSK, SEW Eurodrive, Gates and others. An important part of PTC ASIA is the gathering of companies from industries including gears, chain transmission, belt transmission, couplings, brakes, electrical power transmission, fasteners, springs and powder metallurgy. It is held in combination with CEMAT Asia 2013, the international exhibition for material handling, automation technology, transport systems and logistics. For more information, visit [www.ptc-asia.com/EN/](http://www.ptc-asia.com/EN/).

**October 29–31—South-Tec 2013.** TD Convention Center, Greenville, South Carolina. South-Tec draws manufacturing suppliers, distributors and equipment builders from across North America and around the world. With hundreds of exhibitors, attendees will find all the products and services needed to streamline their various manufacturing processes. Automotive, advanced materials, energy, aerospace, biosciences plus many others are all represented. Over 34 percent of the jobs in the Greenville region are tied to manufacturing, drawing a skilled workforce that invigorates the area with new ideas and a strong entrepreneurial spirit. Panel discussions include workforce development, supply chain optimization and a brief manufacturing overview from the Department of Defense. The Additive Manufacturing/3-D Printing Resource Center will offer new technologies and designs that can help lower production expenses. For more information, visit [www.southteconline.com](http://www.southteconline.com).

**November 6–8—AWEA Wind Energy Fall Symposium.** Colorado Springs, Colorado. The administration's recent commitment to new renewable energy initiatives has arrived at the right time, as the wind energy industry is emerging from a record year in new capacity additions and is moving to design a robust strategic direction for 2014 and beyond. With that, the AWEA Wind Energy Fall Symposium returns to offer a unique platform for attendees to provide feedback and expertise to help mold this comprehensive agenda. In 2012 the AWEA Wind Energy Fall Symposium hosted hundreds of key decision makers, including over 20 CEOs, 50 vice presidents, and 55 directors. Now is the time to join fellow C-level executives from across the industry for a stimulating and thought-provoking discussion on analyzing market challenges, examining potential solutions, and steering the industry towards a new phase of growth in America's successful form of renewable energy. For more information, visit [www.awea.org](http://www.awea.org).

**November 13–14—Automation Fair 2013.** Houston, Texas. Automation Fair gives attendees an opportunity to explore smart, safe, sustainable manufacturing solutions geared toward improving profitability. Education opportunities include improving productivity throughout the lifecycle of automation investments, learning about flexible automation solutions and how sustainable practices can increase your competitiveness. Attend industry forums, user group meetings, hands-on labs, technical sessions and demonstrations to expand knowledge and use of the latest control, power and information technologies. Attendees can also take advantage of Rockwell Automation's PartnerNetwork that provides solutions from industry leaders in distribution, system

integration, machine building and complementary technologies. For more information, visit [www.rockwellautomation.com](http://www.rockwellautomation.com).

**November 15–21—ASME 2013.** San Diego, California. The annual ASME International Mechanical Engineering Congress and Exposition is a premier global conference that focuses on today's technical challenges, research updates and breakthrough innovations that are shaping the future of engineering. The congress convenes engineers, scientists and technologists of all disciplines for the purposes of exploring solutions to global challenges and for the advancement of engineering excellence worldwide. The congress will feature a technical program that promises to be the most extensive and diverse in the history of the exhibition. In line with the national strategic initiatives, ASME and the organizers of IMECE have chosen advanced manufacturing as the overall theme for 2013. Technical presentations include aerospace technology, energy, heat transfer and thermal engineering, systems/design, advanced manufacturing, education and more. For more information, visit [www.asmeconference.org](http://www.asmeconference.org).

**November 19–21—Fluid Power Systems Conference.** Doubletree Hotel, Rosemont, Illinois. Fluid power (hydraulics and pneumatics) is used in dozens of industries and hundreds of applications to precisely control the movement of machinery and material. Yet many engineers and technicians working in those industries have not been fully trained in the design concepts critical to developing efficient fluid power systems and the diagnostic and maintenance techniques essential to keep those systems operating at peak efficiency. These concepts and techniques can result in significant energy and cost savings for companies that use hydraulics or pneumatics, as well as for the customers they serve, making fluid power a more competitive and logical technology choice. This educational conference will deliver hands-on instruction into practical maintenance techniques and offer roundtable discussions with industry peers. The Innovations Showcase will focus on the newest products and technologies in hydraulics and pneumatics. It is hosted by the International Fluid Power Society, the FPDA Motion and Control Network and the National Fluid Power Association. For more information, visit [www.nfpa.com](http://www.nfpa.com).

**December 2–5—12th International CTI Symposium.** Maritim Hotel, Berlin. The 12th International CTI Symposium and its flanking specialist exhibition is aimed at people seeking the latest developments in automotive transmissions and drives for passenger and commercial vehicles. Drivetrain and transmission are important for all customer-oriented vehicle characteristics. They can particularly help to reduce energy consumption and CO<sub>2</sub> emissions considerably. Hence it is not surprising that car developers place their focus on drivetrains and transmissions in view of the tighter emissions regulations which will come into effect in 2020. This does not only apply to heavy premium cars, but also to all other vehicle segments including electric cars. The event will feature the latest drivetrain and transmission developments, concepts, components and systems. Featured speakers include experts from BMW, Siemens, Getrag, Bosch Transmission Technology, RWTH Aachen and more. Special sessions focus on CVT, commercial vehicles and functional safety. For more information, visit [www.getriebe-symposium.de](http://www.getriebe-symposium.de).





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For publication guidelines and more information, please contact Jack McGuinn at [jmcguinn@powertransmission.com](mailto:jmcguinn@powertransmission.com).

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# Ready for Some (Hyper)-Loop-De-Loop?

## High-Speed Transit System the Dreamwork of Ideators — or Idiots?

**OK** — going to Mars, it is not. But if Elon Musk has his way — and he often does — we'll be able to travel distances up to 1,000 miles, in about 90 minutes — at 800 mph.

And the Hyperloop is the magic carpet ride that will get us there.

Musk, the entrepreneurial, hi-tech wunderkind (Tesla Motors, SpaceX), presented his concept (back in the day, things like this were called “gizmos”) this summer in a 58-page proposal. Initial reaction was predictably skeptical — if not downright insulting. Essayist Tad Friend, in the *New Yorker*, referred to Musk's vacuum train as little more than a “napkin doodle.” The engineering community seemed to agree. Others highly doubt it can be built for the \$6 billion that Musk claims will be sufficient.

The proposed — beta, you might say — route for the high-speed system is Los Angeles to San Francisco. Travel time? Approximately 30 minutes. In part, the Hyperloop is Musk's response to California's proposed high-speed train, a project Musk has deemed inferior on several levels, including speed and cost. So politics — and greed (\$6 billion vs. \$70 billion) — will play a role in determining the Hyperloop's development — or lack of same.

Significantly, however, after the initial scoffers weighed in, a group of would-be angels have stepped up to help make the Hyperloop a reality. According to a Nick Statt *CNET* article last month, *JumpStartFund* (since 2002, a California-based online, crowdsourcing nexus for hi-tech entrepreneurs, rainmakers, investors and inventors; *jumpstartfund.com*) has dedicated a Hyperloop marketing/funding platform on its site in order to attract other entrepreneurs and big-brain types for investment and engineering support — and credibility.

“We want to be the ones that actually make (the Hyperloop) happen,” said Dirk Ahlborn, CEO and co-founder of *JumpStartFund*, in a recent inter-

view. “So of course we need to create a corporation. Whoever decides to dedicate more time to this than just logging onto the (site) deserves to be part of this company.” Guided by Musk's proposal, Ahlborn said his group is working towards sometime next year to have the “train” in a more complete design stage, from which a prototype will hopefully emerge.

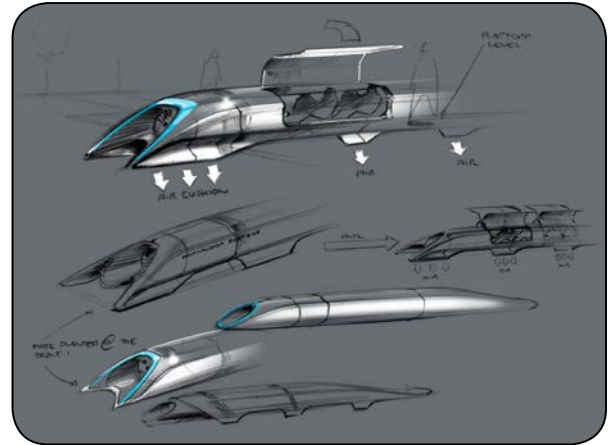
### How it works (theoretically):

According to Musk, the Hyperloop would consist of elevated (think El in Chicago's Loop) aluminum pods suspended on a thin layer of air inside two steel tubes — one running in each direction. The reduced-pressure tube would contain pressurized capsules driven within the tube by a number of linear electric motors. The design also requires a capsule that would ride on “skis” outfitted with air bearings to provide a cushion of air that is forced through multiple openings on the capsule's bottom. Green-wise, Hyperloop would deploy solar panels atop the tubes for its primary power source.

The concept received a huge boost when ANSYS, the design software supplier, conducted simulations and, according to a *Discovery News* report, announced that — with some further R&D — this thing could actually work.

Meanwhile, *JumpStartFund* says things are now at “in progress” mode. Also joining and adding luster to the work-in-progress team are engineers Marco Villa, formerly of SpaceX, and Patricia Galloway, a former U.S. National Science Board member and vice chairwoman.

According to the *CNET* report, “*JumpStartFund* is also accepting applications from members of the site to work full-time on the Hyperloop project in exchange for equity in the company. “We want to find a way to give everyone the ability to be a part of this



project,” said Ahlborn. “Everything is going to be very transparent, and we intend to reserve a percent of future (equity) revenues for people that work with us on the platform.”

In just a few days after start-up, reportedly, “more than 20,000 people” visited *JumpStartFund*'s website expressing, at minimum, curiosity — if not serious interest — in Hyperloop. One can easily imagine *Facebook* and others being only a quick click away from joining in on the fun. Indeed, Ahlborn is hoping others will jump in with — if not capital — expertise to help move the project to fruition.

For some feasibility vs. fantasy perspective, Samuel R. Staley in *CNN.com* points out that throughout history, technology advances have been considered impossible to realize — until someone went ahead and made them. Invoking the steam-powered locomotive as an example, Staley points out that while it “was considered the stuff of fancy” when William Murdoch built his engine prototype in the 1780s, a legitimate railroad industry emerged within just a few decades. And this from *Gizmodo.com*'s Joel Johnson: “We should be cheering Musk on.”

Added *JumpStartFund*'s Galloway in, perhaps, a bit of unintended irony (or hedging): “I believe this project will revolutionize how transportation will be viewed for future travel, to and from major cities — similar to the way the Concorde almost changed air travel.”

“Almost”?! **PTE**



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