June 2010

PTE

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The BIG Issue

Features

- Got (Too Much) Torque?
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All prices are U.S. published prices. AutomationDirect prices are from March 2010 Price List. Baldor prices taken from www.baldor.com 2/25/10. Dayton prices taken from www.grainger.com 2/25/10. Emerson prices taken from www.usmotors.com 2/25/10. Prices and specifications may vary by dealer and configuration. Prices subject to change without notice.

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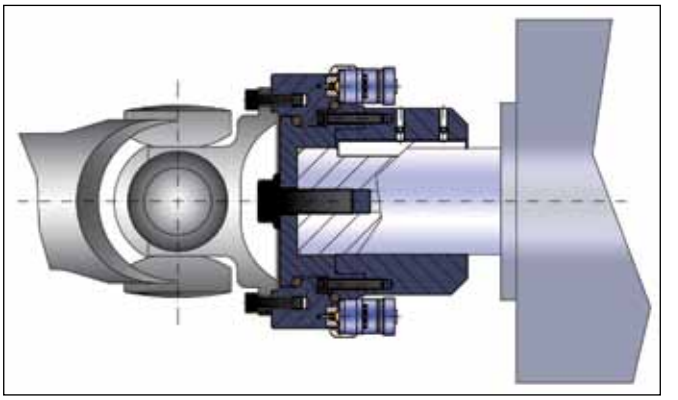

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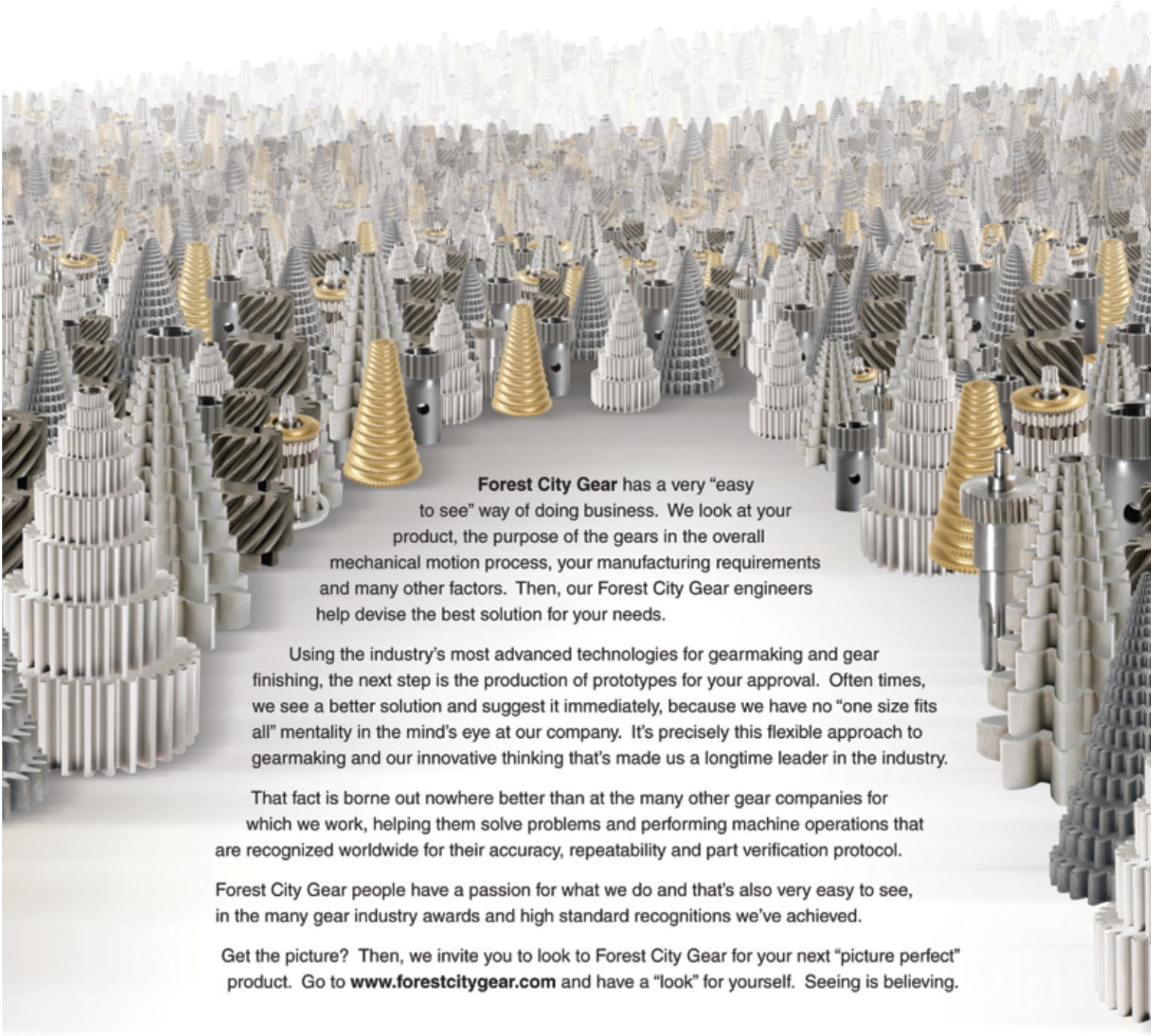
WHO SAYS YOU CAN'T SEE THE FOREST (CITY) FOR THE TREES?



Forest City Gear has a very "easy to see" way of doing business. We look at your product, the purpose of the gears in the overall mechanical motion process, your manufacturing requirements and many other factors. Then, our Forest City Gear engineers help devise the best solution for your needs.

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That fact is borne out nowhere better than at the many other gear companies for which we work, helping them solve problems and performing machine operations that are recognized worldwide for their accuracy, repeatability and part verification protocol.

Forest City Gear people have a passion for what we do and that's also very easy to see, in the many gear industry awards and high standard recognitions we've achieved.

Get the picture? Then, we invite you to look to Forest City Gear for your next "picture perfect" product. Go to **www.forestcitygear.com** and have a "look" for yourself. Seeing is believing.

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Randall Publications LLC
P.O. Box 1426
Elk Grove Village, IL 60007

Phone: (847) 437-6604
Fax: (847) 437-6618

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EDITORIAL

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

Managing Editor William R. Stott
wrs@powertransmission.com

Senior Editor Jack McGuinn
jmcguinn@powertransmission.com

Associate Editor Matthew Jaster
mjaster@powertransmission.com

Assistant Editor Lindsey Snyder
lsnyder@powertransmission.com

Editorial Consultant Paul R. Goldstein

ART

Art Director Kathleen O'Hara
kathyohara@powertransmission.com

ADVERTISING

Advertising Sales Manager Dave Friedman
dave@powertransmission.com

CIRCULATION

Circulation Manager Carol Tratar
subscribe@powertransmission.com

RANDALL PUBLICATIONS STAFF

President Michael Goldstein

Accounting Luann Harrold

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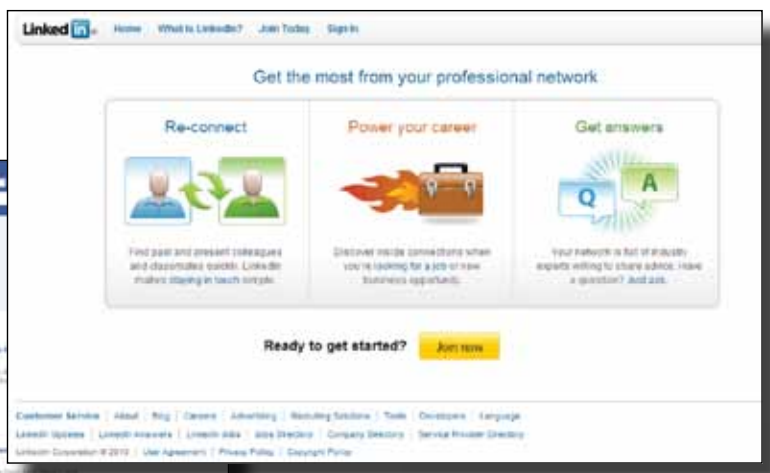

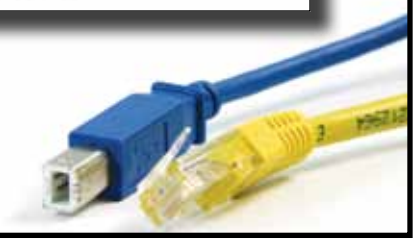

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AGMA—

AMERICAN NAME, INTERNATIONAL ASSOCIATION

The following column first appeared in the May 2010 issue of *Gear Technology*. Over the coming year, both *Gear Technology* and *Power Transmission Engineering* will be bringing you guest editorials from leaders in the industry. If you'd like to contribute a guest editorial on a topic of interest to buyers or end users of power transmission components, or designers of machinery that includes power transmission components, please e-mail *publisher@powertransmission.com.*

I'd like to thank Michael Goldstein and the staff of *Gear Technology* for offering us the space in their magazine for AGMA Voices. I am confident this forum will serve the industry well as the *Gear Technology* editors communicate with the gear industry leaders on the many great programs, activities and resources made available through the American Gear Manufacturers Association. I thought it would be appropriate to give an overview of the association, as well as some information about the association's global reach.

In the first quarter of 2010, individuals from 118 countries clicked onto the AGMA website. Fifty-seven percent were from the United States, leaving 43 percent from the rest of the world. This level of international activity is astounding and clearly reflects the recognition around the globe that AGMA is the association for the international gear and mechanical power transmission industries.

Founded in 1916, the American Gear Manufacturers Association had nine members that first year. In 1973, the Board of Directors authorized a membership category for international gear manufacturers—those with no manufacturing in the United States. And today, we have a total of 427 members in 34 countries; 110 of AGMA's members are outside of the United States.

We commonly hear that the world is smaller today. True, we can communicate by phone and e-mail at the speed of light. Air travel, for all the discomfort and bother, gets us face-to-face in a matter of hours no matter where we are when we start out.

But, I think the reason for AGMA's success and international success is that our industry is more complex and more demanding than it ever has been. Complex and demanding means that fewer companies have the capability to compete successfully in these products. Expertise is thinner and suppliers more difficult to find.

The solution is global manufacturing, and that means being connected to the best technical information and most knowledgeable experts. AGMA is the focal point for many of these activities.

AGMA's Gear Expo allows specialized manufacturers to come together for a few days to meet with manufacturers who need their products, services and knowledge.

AGMA's leadership in the development of technical standards complements experts in the other countries as we all work toward global solutions and global standards that become international standards under ISO's TC-60. AGMA is Secretariat to TC-60, the international committee charged with developing technical standards for the world's gear industries. (AGMA was first elected Secretariat in 1993 and has been reelected every three years since.)

AGMA's Annual Meeting of members is becoming the place for industry executives from the world's key players to come together to learn and to network with their peers.

And, AGMA's education programs, especially the newer offerings of advanced-engineering seminars, frequently draw attendees from around the world. Leading engineers do not hesitate to come from Europe, Australia and India to be part of these learning opportunities.

When we look at all of the members and participants outside of North America, does any country stand out as more active than others? Yes, India is growing rapidly in the AGMA as a source of members and of interest in AGMA programs and activities. Of our total international membership, 10 percent is located in India; internet traffic follows the same pattern, as 11 percent of visitors from outside the United States are also in India.

Interest is not restricted to a few of the large cities; internet users for the first quarter of this year came from 79 cities in India.

AGMA is planning to take a delegation of members to visit Indian manufacturers in February 2011. This May 2010, AGMA is exhibiting at the International Power Transmission Exposition (IPTEX 2010) in Mumbai.

And, the association is always available no matter where you are, at *www.agma.org*.

Sincerely,

Joe T. Franklin Jr., President
The American Gear Manufacturers Association

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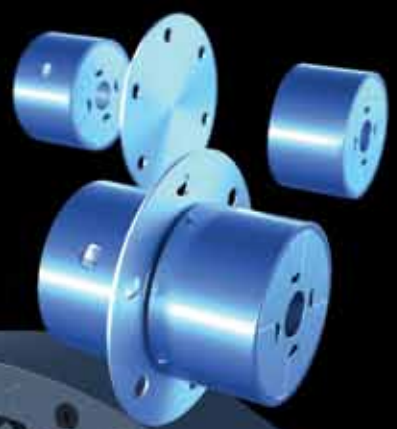

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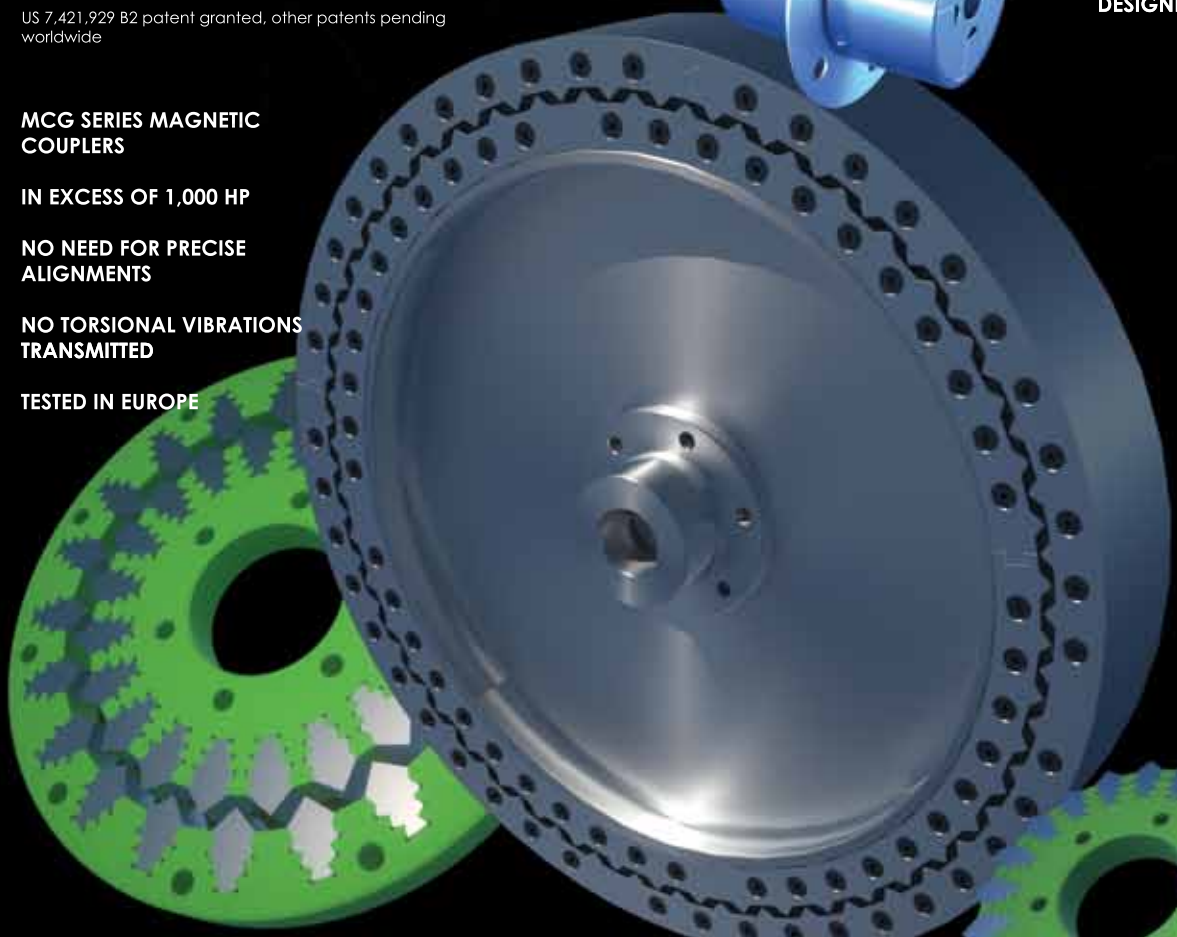

MAGNETIC GEAR COUPLERS

MAGNETIC GEARS (NON-SLIP) - GEAR TEETH NEVER TOUCH - SPACE AGE GEARING

Overhung Load Adaptors

IMPROVE PAVEMENT PLACEMENT EQUIPMENT

Overhung Load Adaptors are an off the shelf device for increasing motor durability and life.

Repaving asphalt streets and highways requires heavy equipment, including cold planers that cut eight feet wide by 12 inch deep swaths in old asphalt surfaces in order to remove them. These cold planer systems work at speeds up to four feet a minute cutting, granulating and conveying the loose asphalt into waiting trucks for recycling. By necessity, the power transmission systems in these cold planers are ruggedly designed to handle large amounts of asphalt and to operate for long periods without maintenance.

The hydraulic pump motor is connected to Zero-Max Overhung Load Adaptors.

The adaptors used in the Roadtec system have a special oil drain port to facilitate lubrication.

Roadtec, an Astec Company, has manufactured pavement placement equipment for over 30 years. Its cold planers are used for asphalt removal and are designed to provide the optimum balance between horsepower, production and maneuverability. These versatile machines are capable of cutting depths to 30 cm and widths of two meters to over 2.5 meters. They also provide side-cutting operations and have bi-directional operation capabilities to achieve down cutting in the reverse direction of travel.

Roadtec's largest cold planer, the RX 50B, operates on three D-4 size tracks, providing a 2.5 meter cutting radius with crab steer, front-track steer and rear-track steer. It has a two-stage covered 86.4 cm wide front load-out conveyor with 50-degree swing to either side, for a high volume loading capacity.

Power from the main shaft of the 600 horsepower Caterpillar diesel engine travels into a hydraulic clutch and then to the grinding drum by a belt drive. A second pump on the same shaft provides the hydraulics for propulsion.

To ensure smooth operation of the auxiliary hydraulic systems in these cold planers, two Overhung Load Adaptors (OHLA) from Zero-Max are used, one mounted on each side of the engine. The larger OHLA (800 series) drives the pump that provides hydraulic pressure to operate the components that move the ground asphalt to the conveyor. The smaller OHLA (600 series) drives a pump that provides hydraulic pressure for other system operations, such as steering and discharge conveyors.

"Without the Overhung Load Adaptors, too much stress was transmitted to the pump's bearings, which could result in premature and costly pump failure," says Chris McSharry, design engineer for Roadtec. "We'd heard about the Overhung Load Adaptors and did a bearing life scenario for our system using Zero-Max's estimated working life formula from their online catalog. These numbers looked good; plus we liked the idea of using a proven off-the-shelf module rather than trying to design a bearing support setup or our own from scratch, which would have been more expensive and time consuming."

The drive setup that McSharry and the Roadtec engineers devised positions the OHLA units at 180 degrees from each other. This balances the force applied to the front of the engine's crankshaft. The model 600 has two V-belts on one pulley connecting it from the engine while the model 800 has three V-belts on one pulley connecting it to the engine.

The OHLA 600 used in Roadtec's system has an SAE-B face mount and weighs 30 pounds, and the 800 has an SAE-C face mount and weighs 55 pounds. Both sizes feature rugged housings made from 25,000 psi tensile cast iron with shafts of 130,000 psi stress-proof steel. Both have heavy-duty tapered roller bearings and operate the Roadtec system at a 1:1 ratio at speeds up to 2,100 rpm.

"The OHLAs give us a solid,

permanent mounting surface, which aids in the overall stability of the system," McSharry says. "By eliminating the stress and overhung loading, both the pump motor and bearings perform nicely without any threat of failure for either. The entire drive system runs freer with the OHLAs and with less power utilized. These cold planers put out a lot of power, so the added stability from the OHLAs really promotes a smoother operating system."

For more information:
Zero-Max
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Smart Ethernet Drives

ADD FLEXIBILITY TO ADVANCED MOTION CONTROL SYSTEM BUILDING

The latest generation of smart drives from Baldor Electric Company offers economic and space-saving solutions for many common single-axis automation requirements. They feature an Ethernet interface compatible with Powerlink, the deterministic Ethernet-compatible motion control standard.

Mint Lite, the new programming capability, can be fitted free of charge on all Baldor MicroFlex e100 and MotiFlex e100 single- and three-phase drive ranges. The drives come in a range of power ratings up to 33.5 A, with higher ratings planned for the near future. Applications for the drives include controlling rotary and linear servo motors, linear motors, closed-loop vector motors and in V/Hz control modes.

A range of basic motion programming requirements are supported by the embedded *Mint Lite*, including performing relative and absolute moves, S-ramp profiles, jog and homing movements, changing target positions on the fly, registration moves and reacting to real-time trigger events. The programming facility enables standalone drives to provide solutions for common automation and machinery tasks, such as cutting or feeding to length, indexing axes, simple pick and place motion and machine adjustments like changing guides or backstops to reconfigure machinery for new batches. These capabilities are requirements in various manufacturing and processing sectors, including food and beverage, packaging, pharmaceutical, electrical and electronic equipment, printing and wood/metalworking.

continued

The drives allow more flexibility in PLC interfacing. Since Baldor's drives are programmable, the standard drive profile can be adapted, which can simplify the communications process or optimize drive behavior for specific applications. The TCP/IP-compatible Ethernet interface makes it simple to link into Ethernet factory networks to change product recipes, report production metrics or other uses.

Baldor's MicroFlex e100 and MotiFlex e100 drives come standard with built-in I/O—including fast latch inputs for registration applications—as well as CANopen manager capability for supporting distributed I/O expansion and HMI interfacing. The MotiFlex e100 drives feature card slots for more local I/O expansion and fieldbus connectivity. The fieldbus modules extend connectivity options to external PLCs, supporting interfaces such as Ethernet/IP, Profinet-IO, Profibus and DeviceNet. These features allow the drives to be configured cost effectively for single-box solutions in automation applications.

The local intelligence provides flexible system building capabilities when used in a Powerlink system. Critical events can be acted on directly, which does away with the impact of network and controller scan time latencies, while quicker response of critical axes can be translated directly into higher throughput. Baldor fits *Mint Lite* programming capability as standard, providing a more economical solution for machine builders who configure systems with high numbers of motion axes.

Baldor's development environment, *Mint WorkBench*, includes development and configuration tools for the drives at no additional cost.

These smart drives complement Baldor's existing Powerlink network control possibilities, which include a traditional central controller available for varying numbers of motion axes and a plug-in controller for drives called *Mint Machine Module* that control either two or five axes. The plug-in control card provides full access to the capabilities of the *Mint* language, and it can be programmed to perform sophisticated motion functions, like gearing and cams.

View more production information at *www.baldormotion.com/products/servodrives/overview.asp*

For more information:
Baldor Electric Company
P.O. Box 2400
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Phone: (479) 646-4711
Fax: (479) 648-5792
sales.us@baldor.com
www.baldor.com

Cleveland Gear

BROADENS PRODUCT OFFERINGS

A line of shaft mount reducers and accessories is available now from Cleveland Gear Company, including tapered bushing kits, belt guards, torque arms, motor mounts and backstop assemblies.

These drives are suitable for various material handling applications. They come in eight CGSM sizes, 2–9, input horsepower from 1/3 to 125 and output rpm from 4–6 up to 118–125. The shaft mount reducers meet AGMA Class I, II or III service for motor horsepowers up to 125, with standard ratios of 15:1 and 25:1.

Twin tapered bushing kits are sized for CGSM reducers and other manufacturers' shaft mount drives, with bore diameters from 1 5/16 inches to 4 15/16 inches. The kits install quickly and support both sides of the reducer. All tapered bushing kits come with fastening bolts and a full-length key.

For more information:
Cleveland Gear Company, Inc.
3249 East 80th Street
Cleveland, OH 44104
Phone: (800) 423-3169
www.clevelandgear.com

Bison

REDUCES
MOTOR'S VOLUME 30 PERCENT

In response to trends for smaller OEM equipment with higher power output, the 100 mm AC motor line from Bison Gear and Engineering Corp. offers 1/8 horsepower in 30 percent less volume than previously available. The four inch diameter single phase motors have been mated to Bison's 750 Series right angle gearing to offer up to 104 inch-pounds (11.8 N-m) of continuous torque in a compact package with three-wire reversible hookup and a range of mechanical options.

The 100 mm AC Right Angle Gearmotors are powered by 115 volt, 60 Hz single-phase TEFC permanent split capacitor motors and offered in six standard versions with gear ratios from 5.2:1 to 50:1 and fixed output speeds from 327 to 28 rpm, respectively. Continuous output torques range from 12 to 104 inch-pounds (1.4 to 11.8 N-m). The gearmotors are available in a 3/4 inch (19 mm) hollow shaft configuration that is easy to mount. Another option is replaceable single- or double-output stub shafts that can either be foot or face mounted. A rear motor shaft extension can be fitted with an optional power-off brake.

These motors are appropriate for use in packaging equipment, conveyor systems, food service and stationary agricultural equipment, as well as other specialty machinery applications.

"We believe these compact, high output AC motor designs will find many new applications where space is at a premium, but where motor power cannot be sacrificed," says Robert Lewton, electrical design engineer at Bison Gear. "This right angle gearmotor offering is the second family of Bison products to benefit from the new 100 mm AC motors. This being Bison's 50th anniversary year, we will continue to expand this innovative new 100 mm AC product line, and we will follow that up as well with other exciting new products from Bison this year."

For more information:
Bison Gear and Engineering Corp.
3850 Ohio Ave.
St. Charles, IL 60174
www.bisongear.com

Proximity Sensor

MEASURES
WITHOUT TOUCHING TARGET

The KD-2446 high-precision proximity sensor system from Kaman Precision Products offers lead-free RoHS compliance in a compact DIN package that is simple to install. Featuring a 10 KHz analog output and threshold-adjustable 3.3 KHz switched output, the KD-2446 is a flexible solution for high-speed automated manufacturing and process control applications.

The KD-2446 performs with 0.0008 percent FS resolution and 0.56 percent FS switch point hysteresis. With CE and RoHS compliance, the system is appropriate for OEM applications with worldwide distribution, including displacement, vibration, sorting and event capture.

Using inductive, eddy current technology that measures without touching the target, the sensor system also offers high performance with both ferrous and non-ferrous targets. It consists of two sub-assemblies: the sensor with integral cable and the signal conditioning or electronics module. Input voltage is variable from 12 to 24 volts DC, and gain is adjustable for up to 22 volts output, with 24 volt DC input.

The Kaman KD-2446 system comes standard with one of two production sensor configurations, 9C or 5CM. Both sensors are rated for continuous operation up to 400 degrees Fahrenheit.

For more information:
Kaman Precision Products
Phone: (800) 552-6267
www.kamansensors.com

Software Upgrade

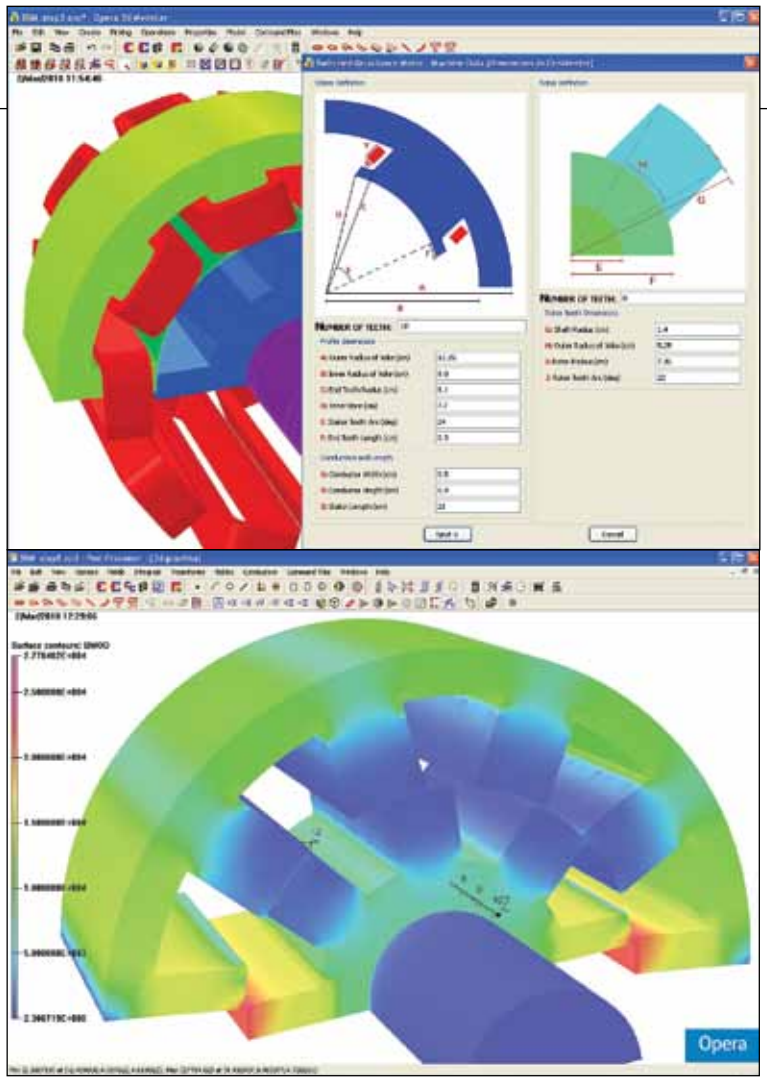
CREATES 3-D MODELS IN MINUTES

Cobham Technical Services launched a 3-D version of its rapid electromagnetic design tool for rotating electrical machines, the *Advanced Machines Environment*, that combines finite element analysis (FEA) simulation with a design entry system that creates full 3-D models of electric motors or generators in less than five minutes. The software is an application-specific toolbox of Cobham's *Opera* electromagnetic simulator.

FEA techniques allow users to simulate design concepts with accuracy, but it can take hours to build a 3-D model of a complex product like a motor. The 3-D *Advanced Machines Environment* provides a front-end to the electromagnetic simulator that speeds design entry by "fill in the blanks" dialog boxes. Users choose the form of motor or generator they want to design from a list of all common types and variants. By entering a list of 10 parameters or so to define mechanical geometry, material properties and electrical data, the 3-D models are then automatically created. The complete design entry process can be completed in less than five minutes.

Cobham Technical Services has offered this software tool in a 2-D format for several years, and the extension to 3-D allows developers to model an entire machine, which provides a comprehensive simulation that takes marginal factors, like end winding and fringe effects, into account.

The 3-D *Advanced Machines Environment* comes with design templates for common rotating machinery, including AC induction, brushless, permanent magnet and switched reluctance, plus synchronous motors or generators. The 3-D version also introduces support for axial flux electrical machines, which use a geometry that can't be represented in 2-D. Users can also choose numerous design variants for different machine types, like choice of rotor styles.



3-D finite element models of generators and motors can be produced in minutes using a new design tool from Cobham Technical Services.

Users also have open access to the scripting codes that generate the models and can modify them at will to create a proprietary automated design process. A material properties library is included in the software for speed.

The *Advanced Machines Environment* provides users with post-processing capabilities to simplify the analysis of results. Commonly required manipulations of simulation data are provided as standard, including the torque produced as a function of position. Design ideas can be tested and optimized easily by varying the values of model parameters. Cobham offers the software with an optimization tool that will automatically select and manage multiple goal seeking algorithms to find the best solution to a design problem.

Cobham sees this introduction as significant in the current motor and generator market that is actively engaged in pushing the energy efficiency of designs as far as possible. "This application-specific 3-D finite element tool provides a simple means of enhancing and speeding the design process, and is particularly relevant at a time when the market is demanding technological innovation," says Alex Michaelides, of Cobham Technical Services.

For more information:
Cobham Technical Services
1700 N. Farnsworth Ave
Aurora, IL 60505
Phone: (630) 851-1734
Fax: (630) 851-2106
Vectorfields.info@cobham.com
www.cobham.com/technicalservices

Rotary Encoder

OPERATES AT HIGH SPEEDS

The MSR 40 is a modular steel tape rotary encoder from RSF Elektronik that measures applications with diameters of six inches (150 mm) to six feet (about 2 m). Available in North America through Heidenhain Corporation, applications for this ring encoder include rotary tables, telescopes and medical instrumentation.

The steel tape of the MSR 40 uses the single-field scanning principle with 200 µm grating pitch and high achievable angular resolution for simpler mounting. The system has ± 30 µm/m accuracy with operating temperature 0 degrees Celsius to + 50 degrees Celsius. The encoder operates at high speeds, especially in large measurement applications.

The MSR 40 encoder links the ends of steel tape together with one or two joining mechanisms, depending on the application. Measurement through a full 360 degrees is possible. An MOR version uses a steel ring tensioning cleat for encoders mounted to a steel surface, which allows for thermal expansion. An MER version uses a rubber gasket with a low-profile tensioning cleat for other mounting surfaces.

Depending on the shaft diameter, up to 20,000 line counts are available on the MSR 40. Each version offers quasi-absolute positioning via distance-coded reference marks or homing via a single reference mark. The encoder is available in standard and custom sizes.

For more information:
Heidenhain Corporation
333 E. State Parkway
Schaumburg, IL 60173
kkaufenberg@heidenhain.com
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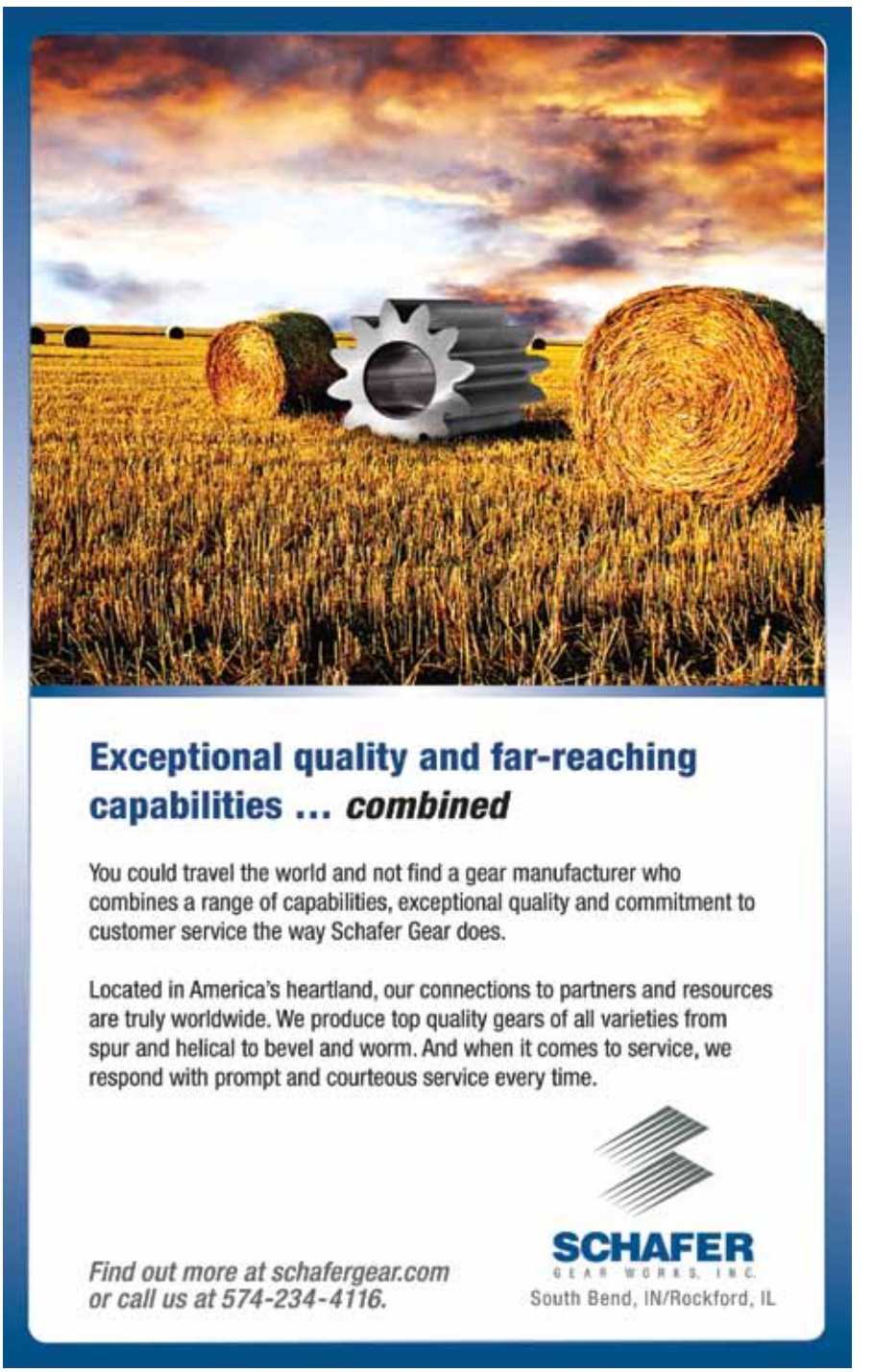

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For more information:
R+W America L.P.
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Haydon Products Division
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Commercial Elevator Double Brake Developed

In response to new safety measures that require passenger elevators to have double redundant braking systems, Ogura Industrial Corp. has developed the double MNB brake for commercial elevators.

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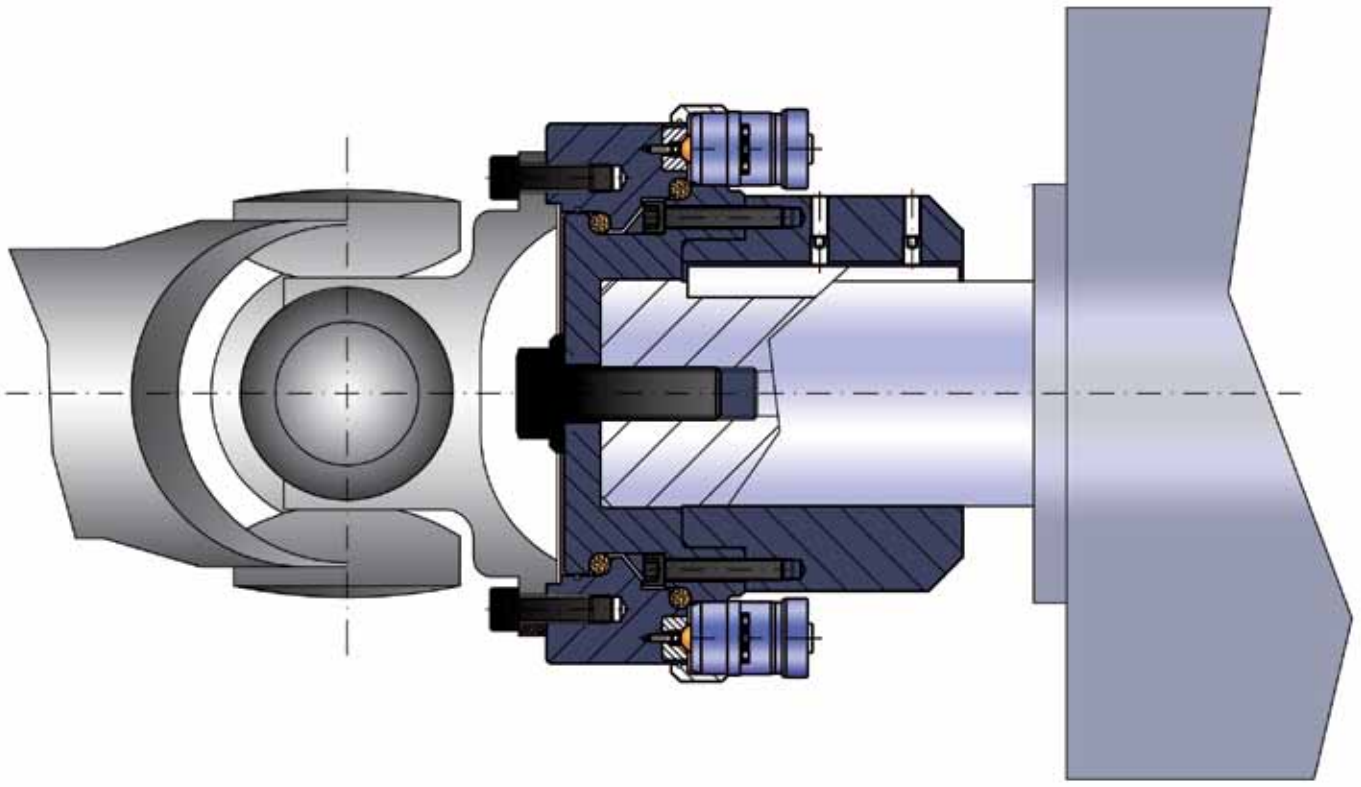


SAFETY ELEMENTS FOR

Mechanical Torque Limiters

DESIGN CONSIDERATIONS FOR HEAVY EQUIPMENT

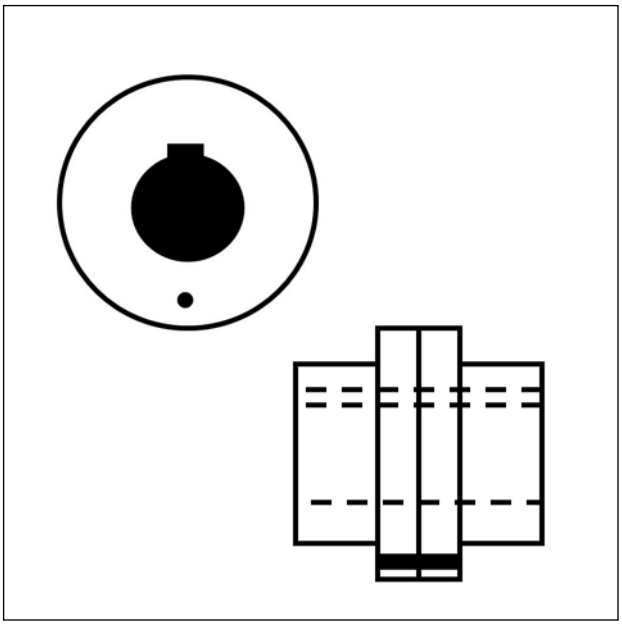
Andrew Lechner, R+W America

The world of high horsepower drives often calls for mechanical design to be approached from different perspectives. As motors, gearboxes and machines increase in size, power density can become disproportionate from one driveline component to the next, emphasizing the need for more rugged, robust and compact equipment. Precision mechanical components used in the packaging and light manufacturing automation industries, for example, can lack adequate scalability, becoming outsized quickly as drive requirements reach into the thousands of horsepower. This disparity is clearly evidenced when examining the design of modern torque overload release devices, the majority of which has focused on torque release values inappropriately low for use on large recycling equipment, gas turbines, windmill test stands, industrial crushers, and other heavy equipment requiring operation and disconnect at torque levels beyond 10 KNm. While market demand may be greater for smaller torque limiters, the availability of such devices becomes ever

more critical as mass, inertia and destructive forces increase in high powered machinery.

One exception to the rule of disproportionate size increase is perhaps the oldest and most rudimentary form of torque overload release device; the shear pin coupling. In this case, two rotating bodies are linked by one or more pins with known yield strength, located at a pre-defined radius from the center of the rotational axis. At some torque level near the calculated maximum, the pin(s) will break, allowing for a complete separation of the driving and driven shafts, and a failure to transmit the excessive torque.

While shear pins have been protecting rotating equipment for centuries, they have become outdated to a large extent, as they lack accuracy and can require a great deal of time to repair after overload. In the interest of maximizing plant uptime and improving the accuracy of release torque, a variety of torque overload release devices has been developed with integral bearings and simplified mechanical reset features, of which a limited number have been reconfigured for high horsepower.



Two rotating bodies are linked by one or more pins with known yield strength, located at a pre-defined radius from the center of the rotational axis (courtesy of R+W).

The first widely used modern overload release devices came about in the 1930s, for use in the steel industry, where downtime can be severely expensive, and replacement of shear pins time consuming and dangerous. Utilizing the same fundamental principle of a set release force located at a specific center distance, it was for these cases that the spring tensioned, form fit torque limiter was developed. In spring tensioned torque limiters, ball or roller bearings are precisely loaded into detents machined into an output flange, which is made to break away quickly and accurately at a predefined torque level. This type of torque limiter can be designed to either ratchet or free wheel during and after overload, depending on size considerations and the rotational speed of the axis.

In general this design of overload release device is desirable since it normally allows for simple torque adjustment through the turning of a single screw or spanner nut. Available ratcheting features also represent a very fast and convenient means of recovery from overload since all they require is either low-speed operation or manual back driving of the axis after the blockage has been cleared. Since their initial development, many hundreds of designs of "ball-detent" and "pawl-detent" mechanical torque limiters have been introduced, with a variety of adaptations made for high speed, high accuracy, light weight and backlash-free operation.

However convenient, these torque limiter designs tend to fall off at torque levels greater than a few thousand Nm. The basic problem is that overload breakaway devices rely almost exclusively on torque as a measurable component of power. Practical implementation of high horsepower drive systems normally involves a slow, steady increase in the rotational speed of an axis, where the torque required for instantaneous acceleration would be overwhelming. Drive shafts and gearboxes therefore are not typically required to handle the severe peak torques associated with precipitous acceleration and deceleration of the load inertia, as might be found in lighter manufacturing systems. As a result they tend not to be as large as a proportionate size increase might require in terms of pure torque capacity. This poses a torque density problem for mechanical overload devices.

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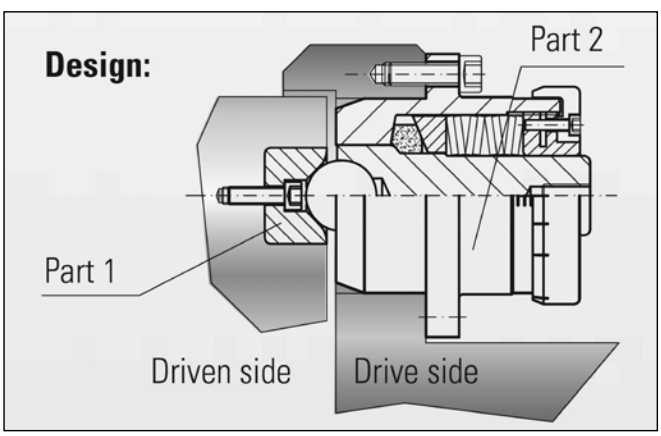
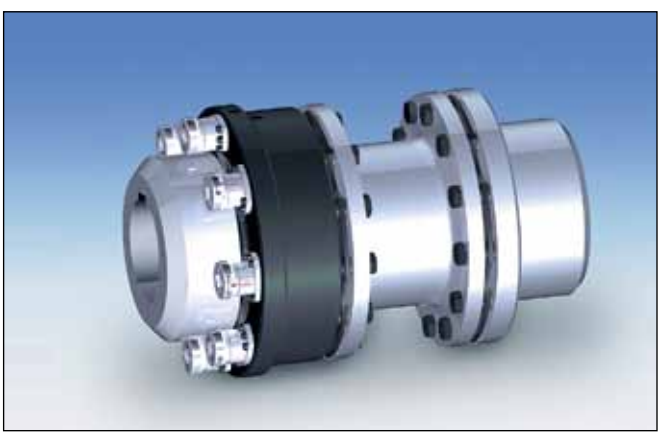


Part 1 is the engagement receptacle and Part 2 is the module with self contained, spring loaded plunger (courtesy of R+W).



Mechanical torque limiter design remains a dynamic field where safety and space considerations are always a factor (courtesy of R+W).

Beyond 10 KNm, common overload release designs become impractically large in outside diameter; the limiting factor being primarily the spring set used to load the components together. Since industrial gearboxes, motors and pumps tend to grow in diameter at a much slower rate than these types of torque limiters, as power increases there comes a certain point at which a traditional single-spring, form-fit torque limiter makes no sense at all, and it would tower over the equipment it was designed to protect. Clearly the lever arm component of the torque limiter design must be addressed, and the simple answer is to substantially increase the force by which the individual transmission elements are loaded into the output.

There are two widely accepted approaches to overload release devices for torque in excess of 10 KNm, both of which seek to increase force over a reduced lever arm distance. One is a compact, simple design involving hydraulic pressure applied between the two otherwise free-spinning surfaces. The other is based on a modified spring tensioned device similar to those previously addressed. Each has its advantages depending on the desired result.

Some manufacturers are increasingly providing these torque limiters as fully integrated flexible safety couplings, such as jaw, gear and disc pack types to name a few (courtesy of R+W).

Hydraulic torque limiters basically involve the application of hydraulic pressure between the two otherwise freely spinning surfaces. One or more chambers are inflated by hand to the desired pressure level, calculated as a function of release torque and based on charts provided in the manufacturer documentation. Special fluids are used to guarantee a constant coefficient of friction throughout various operating conditions. These chambers allow for a high level of force to be applied over a very small surface area. When the desired release torque is reached, the output will begin to slip against the input, causing the hydraulic valves to be sheared off, purging the fluid and fully releasing the input and output components of the torque limiter. An integral bearing allows for the load inertia to coast to a stop without further damage to the machine components or the torque limiter itself. Reconnection of the torque limiter involves replacing the valves, refilling the chambers and resetting the pressure.

Compared with shear pins, hydraulic torque limiters allow the user to maintain strict control over the disengagement torque setting, which can be unpredictable in the case of shear pins. They otherwise represent a compact solution for accurate torque overload release at tremendously high torque values, handling as much as 10,000 KNm. What they do not offer is a major reduction in the time required to recover from an overload event.

For maximization of plant uptime, a slightly more sophisticated form of the ball-detent design still offers the fastest means of re-engagement after overload release. Several decades ago, torque limiter manufacturers began to develop self-contained tangential force modules, based on a plunger design. The torque density problems associated with traditional ball-detent torque limiters are then addressed through the use of one or more of these individually spring-tensioned elements, across which very large tangential forces can be tolerated.

Since the individual torque transmission elements are required to provide their own back stop for the spring tension, these devices incorporate an array of small blocks, which are forced outward to clear the way for the plunger core to retract into the housing after sufficient tangential force has been applied to actuate the system. The result is a "snap action," which causes a prompt retraction of the plunger into the housing within a few milliseconds of overload. Once again, an integral bearing allows for the load inertia to coast to a stop without further damage to the machine components or the torque limiter itself.

The key advantage to this design is the quick reloading of the individual elements into the output flange with either a gentle blow from a mallet or light pressure from a pry bar. Once the driving and driven components of the torque limiter are rotated back into the necessary orientation, re-engagement of the torque limiter takes place quickly and easily. Depending on practical considerations, pneumatic actuation systems can occasionally be incorporated to facilitate automated re-

engagement, though future designs are likely to incorporate a more widely applicable, self-contained and fully mechanical reset function.

As with traditional ball-detent torque limiters, spring tension can be adjusted through the rotation of a nut, only in this case the elements are individually adjusted to the desired tangential force value, and a torque calculation is made based on the number of elements and their distance from the center of the rotational axis. While the earlier designs of safety element torque limiters involved special datasheets to be used in conjunction with measurements taken from the spring height, increasingly, manufacturers indicate the correct nut location with a marked scale. Coarse adjustment is then accomplished through the addition or removal of safety elements, which is made increasingly more plausible by torque limiter designs with the maximum number of receptacles pre-machined into the base element, and with simple covers installed to guard them from contamination. This eliminates the need to ship the torque limiter back to the manufacturer for rebuilding in the case of gross miscalculation of the torque requirement.

Because of the modularity of the design, safety element type torque limiters can be used for virtually infinite torque release values, depending on the size and number of elements used, and limited by the maximum diameter allowed by adjacent equipment. For this reason, individual safety elements are normally made available for incorporation into existing machinery designs or completely customized coupling systems, including some used for linear force limitation.

For the most part, safety element torque limiters are supplied as a pre-set and self-contained package for integration into timing sprockets, sheaves and cardan shafts. Some manufacturers are increasingly providing them as fully integrated flexible safety couplings, such as jaw, gear and disc pack types to name a few. Increasing levels of customization are known to include special materials, integral brake discs, high temperature felt seals, and added bearing support. As is the case in any field of design, manufacturers are driven to improve reliability and ease of use, while simultaneously reducing weight and space requirements for installation.

While the basic principles are highly similar to those that have been known since some of the first machines were ever built, mechanical torque limiter design remains a dynamic field. Functionality, space restrictions, safety considerations and a continuously changing machinery design environment drive the need for even the most minor components to evolve. Mechanical torque limiters are no exception.

For more information:

R+W America, Inc.
1120 Tower Lane
Bensenville, IL 60106
Phone: (630) 521-9911
Fax: (630) 521-0366
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Andrew Lechner *has been product manager at R+W since 2001. He has written articles on thermoplastics in coupling design and proper selection of bellow couplings for previous issues of* PTE *magazine.*

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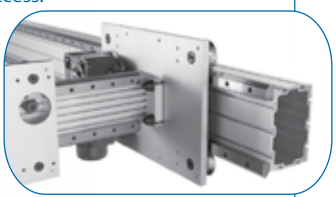

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The final mounting and horizontal preheat of a large bearing for a New York bridge application (courtesy of SKF).

A Recipe For QUALITY BIG BEARINGS

Matthew Jaster, Associate Editor

Slewing or swing bearings are used for heavy industrial projects in construction, mining, marine and defense. They have been utilized in space observatories and giant shovels. Spherical roller thrust bearings are fairly common in turning bridges (SKF has installed one on the 3rd Avenue Bridge in New York City). Both spherical roller bearings and swing bearings are key components in windmills. If the project involves heavy machinery, you can bet the components usually match both the size and scope of the operation.

"In newer windmill designs, the shaft support function is integrated into the gearbox; these bearings are large 'unitized' taper roller bearings," says Victoria Wikstrom, marketing manager general industry at SKF. "Large bearings are also used in the power transmission and wheel reduction gears of huge mining trucks."

Customers purchasing bearings look at application data including loads, speeds, orientations, and the component's intended environment before selecting the right type. In the case of big bearings, other factors might include delivery, installation, lubrication, inspection and re-manufacture. With large manufacturing projects come bigger costs; executives tend to feel better about purchase decisions if service life, safety, maintenance and engineering aspects are top of the line.

A rumored big bearing boom could be in the works if global infrastructure projects and alternative energy advancements continue to make noise in the industrial market. SKF Worldwide, NTN Bearing Corporation of America and Kaydon Bearing are three companies that handle the demands of these heavy industrial applications.

Design and Engineering Considerations

Many power transmission components require a certain level of customization for each individual project. The big bearing market is no exception. Construction, mining, steel, marine and wind applications aren't exactly areas where customers buy bearings in bulk.

"These bearings are an integral part of the structure, and therefore they are selected—a better word is 'designed'—simultaneously with the entire project," Wikstrom says. "Looking up a giant bearing in a catalogue and finding the right designation is not possible—the work is done in close cooperation between the bearing company and the design firm/contractor/machine builder."

This may be the most significant difference between the small bearings typically found in general industrial applications and the big bearings used in heavy equipment. These are custom-made pieces that have to follow strict design, safety and maintenance regulations in order to provide the proper service life for multi-million dollar operations.

"The smaller applications don't have as much visibility from the higher-ups," says Todd Franiuk, market specialist at NTN Bearing. "These heavy-duty

continued

applications rely on higher standards, more personnel and a lot more investment. They tend to get the most interest from management for obvious reasons."

Chris McGovern, a market analyst in the construction segment at NTN, adds that big bearings use more complex materials and require much more design and engineering. "These bearings typically need special materials and service treatments that you don't find in the smaller sizes."

The extra attention given to design is due to the unique set of parameters for each individual market segment.

"For marine applications, you're dealing with a salt spray environment. With steel applications, you have to have special design capabilities to handle the heat," says Rick Shaw, business manager for heavy equipment at Kaydon. "Mining is all about cleanliness. How can we keep these components clean and working properly? It's an interesting dilemma for each market. Experience helps."

Small or large, quality is an important consideration in custom bearings. "Material specifications and initial quality control are crucial," Wikstrom says. "So are a highly skilled workforce, production equipment, process control and the inspection of the final product to specification."

But safety tops the list when an engineering team sets out to design a new bearing. "When you're dealing with critical applications—whether it's a wind tower hundreds of feet up in the air or a mining facility underground—the focal point is always safety," Franiuk says.

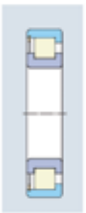
"Our engineering review team is very conservative whenever we look at applications with a human operator," Shaw says. "This is the most significant concern for the heavy industrial market. It's a premium at Kaydon."

The safety of shovel operators or engineers replacing components in a wind turbine is always discussed with large bearing manufacturers during the design phase. They also come up with some form of a maintenance strategy.

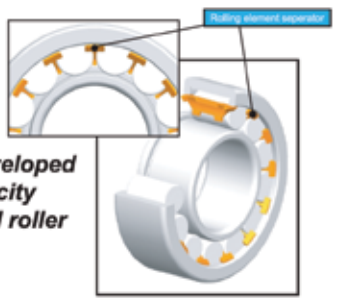
"Because these bearings are unique, there's usually not a spare. One exception would be bridges. If, worst case, a ship would hit the bridge pivot pillar, road authorities cannot afford to reroute traffic until a new bearing has been produced. Therefore, there is normally a spare bearing nearby the turning bridge," says Johan Ander, product manager for spherical roller bearings at SKF. "For wind energy, the number of mills is growing rapidly, implying that the production of large bearings will grow, too. Some users might find it attractive to keep bearings on stock. Still, replacing the nacelle bearing, for example, is a big project, and designers make sure service life is not the limiting factor."

One key to service life is the remanufacturing process where companies like Kaydon assess the remanufacturing potential of bearings between 10 to 240 inches in outside diameter (OD). "We get first-hand knowledge of what is and what isn't working in the field as these bearings come back to us," Shaw says. "Improvements can immediately

Cylindrical Roller Bearings



In addition to standard cylindrical roller bearings, NTN has developed technology that combines the high load capacity of a full complement bearing with the high rotational speed capabilities of a caged design. Placing the rolling element separator between the rollers, the high capacity cylindrical roller bearing attained a rated life 1.5 times longer than a conventional bearing.



Newly developed high capacity cylindrical roller bearing

Cylindrical Roller Bearing Comparison

	Standard Bearing	Full Complement Bearing	High Capacity Bearing
High Speed Capability	✓		✓
High Load Capability			

be made once we examine the working conditions the component has been through."

It's also an added benefit when dealing with the costly components found in the larger market. "For the more expensive bearings, remanufacturing is a viable alternative. You might need a $250,000 bearing that we can remanufacture for $100,000 with warranties equal to a brand new bearing," Shaw says. "We have dedicated personnel and equipment specifically for this process."

Kaydon works with construction manufacturers, the U.S. Navy and the U.S. Air Force on a regular basis to remanufacture bearings. "We have programs in place with several organizations for remanufacturing, particularly those that need a spare bearing on the shelf," Shaw says.

NTN Bearing provides bearing inspection and engineering field support that also assists with design and maintenance issues. "We inspect every single aspect of the product," Franiuk says. "If something goes wrong, our engineering team can go back and identify the problem, offer solutions and use this knowledge in the future."

Adds McGovern at NTN, "For construction and steel applications, the right design decisions can make sure an entire production line doesn't shut down."

Delivery, Installation and Lubrication

When discussing what separates big bearings from their smaller counterparts, delivery, installation and lubrication present a series of challenges.

"We have bearings between 60 and 220 inches for the marine industry, 120 to 240 inches in steel and 200 inch bearings in above-ground mining applications," Shaw says. "You'll find them in off-shore cranes, mooring systems on large ships and in ladle turrets and large pails."

The delivery of equipment this size can be a problem if the company is not equipped with the necessary resources for the global bearing market.

"We're finding, particularly in wind, that everyone wants local delivery right now, which presents a challenge for us," Franiuk says. "We have to expand local production to ensure that our global customers are taken care of."

"Even though Kaydon has four different production facilities and a great deal of flexibility, you'll still find customers that needed the bearing two weeks ago," Shaw adds. "Customers will always want the product sooner than later. It's just a part of the business."

Mounting and lubrication of large bearings offer additional obstacles.

"Installation is a very difficult and time-consuming process, particularly for steel mill and mining operations," McGovern at NTN says.

Wikstrom at SKF adds, "Since the bearing is a key part of the entire structure, mounting is very important and difficult due to the size. Also, achieving proper sealing can also be a challenge—because of high circumferential speed of the large shaft—as well as ensuring constant and well controlled lubrication. This is usually done on these large structures through a central lubrication system that pumps grease or oil to the locations where it is needed."

SKF strongly relies on experience and testing for lubricant models, and by nature, this experience is greater in smaller applications since there are more of them.

"With continuously improved understanding and computer modeling of lubricant behavior inside a bearing, the need for lengthy testing in one-off or few-off projects will reduce further, and our ability to predict service life with greater precision will increase," Wikstrom says.

Franiuk thinks the industry might be able to solve lubrication issues with more communication between bearing manufacturers.

"Communication in this industry seems to hold everyone back. Nobody really shares any information on individual experiences. If companies started talking to each other about the variety of lubrication problems they've encountered and how they've handled them, a lot of these problems could be avoided in the future."

Recent advancements in material science have allowed bearings to last longer and perform better thanks to special coatings and materials. The Bearing Specialist Association (BSA) provides a wealth of information and literature online (*www.bsahome.org*) regarding corrosion, wear, friction and

Kaydon offers a variety of bearings for heavy industrial applications including the geared, non-geared and catalog items pictured above (courtesy of Kaydon).

skidding protection.

The Big Bearing Boom

Though plenty of analysts wax poetic about economic relief, the truth is nobody knows what's really going to happen in the future. There are plenty of infrastructure projects in development, especially overseas. Wind is still an area of great growth and potential, but it's not happening as fast as many people in the market initially hoped. The alternative energy market, in general, might yet play a role in the resurgence of the heavy industrial segment.

"Most industrial markets are not growing right now and wind is, but it's not as enormous as people thought it would be," Franiuk says. "With the right incentives, we're still going to eventually see the boom they've been talking about."

"Wind energy, together with general investments in heavy industry, has slowed down as a result of the economic downturn, but it is coming back strong. Government stimulus packages combined with legislation have supported the rapid comeback. Ocean energy (wave and tidal) is emerging and is expected to become an interesting business in a couple of years," Wikstrom says.

"NTN is absolutely ready for these markets as they continue to gain some ground, especially ocean tide and direct drive wind," Franiuk says. "We're also getting more work in the solar market."

NTN is also seeing some improvements in construction. "Our construction customers have posted some good numbers in the last quarter," McGovern says. "A lot of that has to do with the work being done in the Chinese, Indian and Russian markets."

Shaw also sees some growth potential in China and India that Kaydon will be keeping a close eye on. "One area in particular is tunnel boring. There's a demand in China and India right now for water treatment, water supply and transportation hubs. Most of this activity is going to be done underground, and we see it as a potential long-term growth market."

"All over the world, the growing population is driving infrastructure and energy projects like wind power, hydro-

Product Spotlight

Unique SKF solutions in wind turbines

Increasing the functional safety of wind turbines has typically required design decisions that add weight—and cost—to the nacelle. For owners and operators, this added weight increases total load on the tower, resulting in safety and insurance issues. The SKF Nautilus bearing is a large-diameter, double-row taper roller bearing unit developed to directly support the wind turbine hub as a compact unit taking all the external loads. This so-called "moment bearing" design concept results in reduced drivetrain weight and length, and a high torsional stiffness of the drivetrain. The Nautilus bearing is designed to operate under preload conditions. "The SKF self-aligning bearing solution (CARB and spherical roller bearing) for wind turbine main shafts gives turbine designers an effective alternative that reduces nacelle weight and production costs while improving both functional and operational safety," says Johan Ander, product manager, SKF Self Aligning Bearings, Sweden.

High capacity cylindrical roller bearings from SKF

Applications like industrial gearboxes, gearboxes in wind turbines or machines for mining applications require components that can provide high operational reliability and long service life. In these applications, load carrying capacity is particularly important, which is why full complement bearings are frequently used. Full complement bearings do not have a cage separating the rollers, enabling them to accommodate much heavier loads than same-sized bearings with a cage. However, direct roller-to-roller contact in a full complement bearing increases friction, heat generation and the risk for wear. Consequently, the permissible speed is reduced. To achieve the maximum load carrying capacity of a full complement bearing and the robust performance of a bearing with a cage, SKF developed high-capacity cylindrical roller bearings. These bearings combine the advantages of both bearing types.

Traditionally, higher load carrying capacities have been achieved by incorporating larger rollers. However, to do this within the ISO standardized boundary dimensions requires thinner rings. Thinner rings increase the risk of ring creep, ring or flange cracks, and fretting corrosion. Also, larger rollers are more prone to smearing due to increased inertial forces. The new SKF high-capacity cylindrical roller bearings, which contain more rollers than EC design cylindrical roller bearings, not only maintain the original ISO boundary dimensions, they also maintain the internal geometry of the EC design. The result: increased dynamic and static load carrying capacities and consequently longer bearing service life. For more information, visit *www.skf.com*.

power, tunnels, bridges and roads," Ander says. "With this come large bearings in the constructions themselves and in the machinery required to build them. In turn, this drives growth in steel production and mining, two other areas where large bearings are used. We believe that the integration of our five platforms (bearings, seals, mechatronics, lubrication and services) will be our major driver for growth."

But if there is a manufacturing boom in heavy industries, Shaw says it won't be here as quick as some market analysts think.

"We're noticing pockets of recovery in some segments of the industry while other segments remain pretty flat. I believe it's going to stay this way for some time."

For more information:

Bearing Specialist Association
800 Roosevelt Rd.
Building C, Suite 312
Glen Ellyn, IL 60137
Phone: (630) 858-3838
Fax: (630) 790-3095
www.bsahome.org

Kaydon Bearings Division
2860 McCracken Street
PO Box 688
Muskegon, MI 49443
Phone: (231)755-3747
Fax: (231)759-4106
www.kaydonbearings.com

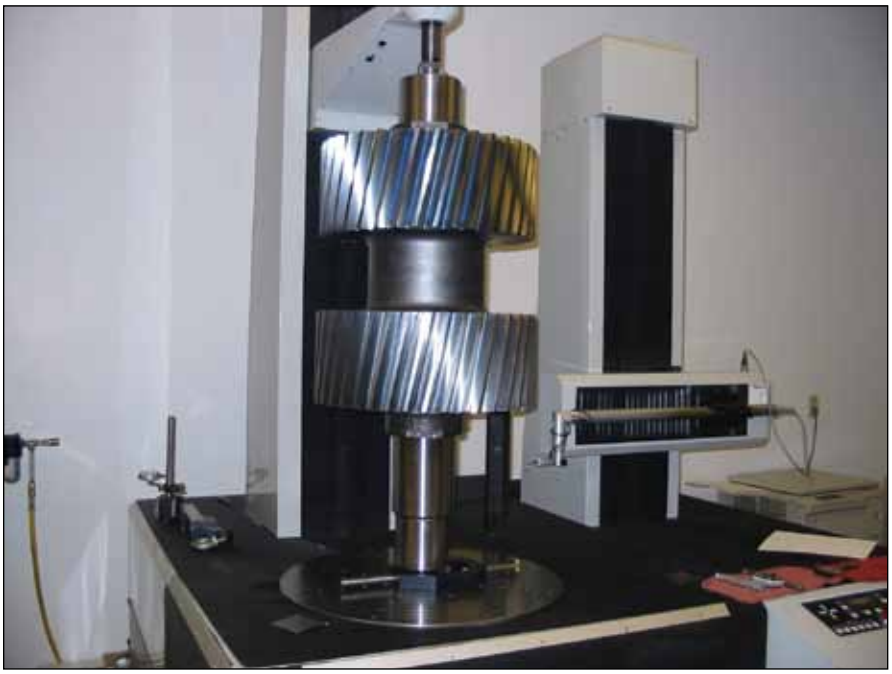
NTN Bearing Corporation of America
1600 E. Bishop Court
P.O. Box 7604
Mount Prospect, IL 60056
Phone: (847) 298-7500
Fax: (847) 699-9744
www.ntnamerica.com

SKF USA Inc.
890 Forty Foot Rd, Box 332
Kulpsville, PA 19443
Phone: (267) 436-6723
skfusainfo@skf.com
www.skf.com

Considerations for Gearmaking

IN WIND TURBINE APPLICATIONS

A Q & A with N.K. Chinnusamy, president of Excel Gear, Inc., Roscoe, IL



CMM inspection of the complete gear and spindle must be done to achieve the proper parallelism. (All photos courtesy Excel Gear, Inc.)

What are the challenges when machining gears for wind turbines?

Gears for wind turbine applications are typically large in diameter and have wide face widths, requiring very exacting material composition and heat treatment processing. The gear design must be optimized to ensure low rolling resistance and long life—owing to the extreme costs of maintenance, down time and repair of the gearbox assemblies—once they have been commissioned in the field. Every step in the manufacturing phase of these gears must be carefully processed, documented and controlled to achieve the high quality, consistency, accuracy and reliability that are demanded for operation in these environments.

The use of carburized steel for these gears is common, and the associated heat treatments and stress relief operations have to be exacting to minimize part distortion and growth, as well as to achieve the proper metallurgical properties required. Oftentimes, a preheat treatment of the forging or bar stock is necessitated on these large gears to minimize part distortion. In addition, one of the seemingly small but critical techniques to minimize distortion on gears is the vertical insertion of the gear into the quench tank during the hardening phase.

Heat treatment can cause cracks as well, so careful processing with predetermination of stock allowance for grinding and final case depth must be considered. Inspection for cracks with magnetic particle inspection and for grinding burns utilizing nital etching is an important inspection tool.

Finally, off-center crown grinding of the tooth geometry may be needed to properly distribute the load on the gear teeth.

Given the precision required for large-gear applications, and the sophistication of the equipment required in making them, is there ever a problem in hiring and retaining workers with sufficient skill sets?

Yes. Finding experienced people with sufficient skills and good work ethics is definitely a problem. We cross train our employees on a variety of machines and use the best ones for grinding operations. When hiring, we place a great deal of importance on a potential employee's attitude and willingness to learn. Fortunately, we do not have any problem in retaining skilled and productive employees, as the local area of Rockford, IL abounds in machining talent.

What modifications, if any, are needed in the tooling or the machine tool, to make gears for this application?

Rigid, heavy-duty hobbing machines are needed for the coarse-pitch gears, using roughing hobs or gear milling (gashing) cutters. Likewise, coarse-pitch diamond dressing rolls and special grinding wheel abrasives are required for the large, high-accuracy gear grinders to produce efficient, accurate results and to prevent grinding burns and cracks.

The cutting fluids used must have the proper viscosity, the right amount of extreme pressure additives and must be directed to the exact location of the

workpiece and cutting tool interface to maximize results. These fluids have to be routinely sampled and adjusted for optimum results.

Likewise, in building the gearbox, what special considerations must be taken into account?

Establishing the correct bearing clearances/preloads is critical to long life and proper gearbox operating temperature. Only sophisticated measuring techniques with bearing inspection gages can ensure these results. The type and method of lubrication and proper sealing weighs heavily on the performance of a gearbox. The verification of gearbox performance through computerized analysis and testing is a crucial step to ensuring long life.

What are some of the ancillary requirements in gear prep for wind turbines?

Special workholding and fixturing is an obvious consideration to bear the weight and to reduce the vibration and movement of the gear blank while hobbing or roughing. Careful and uniform torquing of the clamping fasteners during these operations prevents workpiece movement and distortion of the gear blank during the roughing operation. The gear blank must have accurate mounting and indicating surfaces to control the pitch line runout to critical features (bearing journals, splines, etc.) and for minimal lead error.

Have there been advances in workholding technology/equipment that facilitate the manufacture of large gears?

Nothing unusual, really. Workholding techniques are an important part in the manufacturing process for all large gears. We design and build our own special fixtures for most of our larger gears, and we constantly update our fixturing to be able to handle the larger parts, such as those found on wind turbines and the gearboxes in them.

Gear grinding using special fixturing to support weight and torque.

How does moving into the large-gear market impact a shop's QA department, in terms of added responsibilities and skill levels?

We already make very large gears for battleship gun turrets and cranes, and we have people with sufficient skill level and responsibility to handle all QA functions on small, as well as large gears. Grinding and inspection of larger gears require patience and special care in handling parts from one work center to another, without damaging the product.

Is meeting increasingly robust standards for large-gear applications something you write off as simply the cost of doing business?

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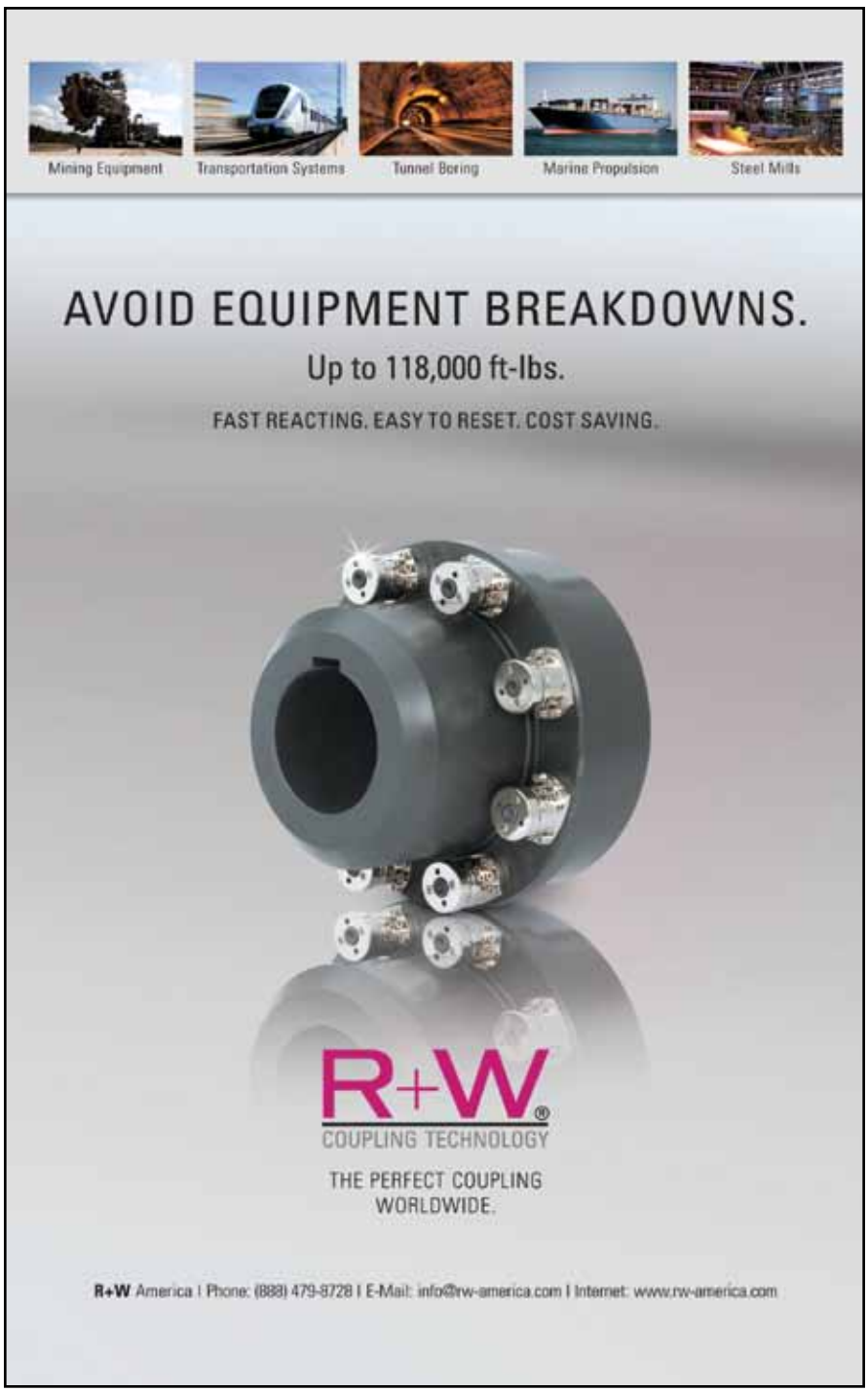

Not really. The prices of gears are dictated by size, material and heat treat specifications, as well as the applicable quality requirements. We must remain competitive but also very technology-oriented to stay in the big gear business, so some of that internal cost must be written off as the cost of doing business in this arena.

Do supply chain issues (quality steel) continue to hamper large gear production?

Not at this time. Aircraft quality and VAR (vacuum arc remelting) steels are readily available. Ultrasonic testing of forgings and bar stocks is an added requirement for any critical applications. Qualities of steels that are available now are much better than what were available 15 or 20 years ago. We work with several suppliers who have proven track records for quality, delivery and performance requirements.

Last thoughts?

The critical factor here, as with all similar power transmission applications, is that the gears are properly designed and manufactured. The other mechanical components that make up the assembly, along with the gearing, must be applied/designed so the overall system performance does not have any shortcomings that could affect the performance and life of the unit. If the sub-assembly/assembly is carried out with real precision and care, a favorable outcome is sure to follow.

Helical gear grinding of large wind turbine gearbox components often requires off-center crowning to center load the gear in operation.

For more information:
N.K. Chinnusamy, president
Excel Gear, Inc.
11865 Main Street
Roscoe, IL 61073
Phone: (815) 623-3414
Fax: (815) 623-3314
sales@excelgear.com
www.excelgear.com

N.K. Chinnusamy, Excel Gear president.

Energy Strategy Makes a Difference

HOW TO OPTIMIZE PERFORMANCE AND SUSTAINABLE PRODUCTION THROUGH STRATEGIC PLANNING, INFORMED ANALYSIS AND AUTOMATION AND CONTROL TECHNOLOGY.

Marcia Walker and Phil Kaufman, Rockwell Automation

Forecasts show world electricity demand growing 3.2 percent annually from 2006 to 2015, with U.S. manufacturers alone spending more than $33 billion per year on electricity. Similar demand exists for oil, natural gas and other energy sources. In response to these burgeoning demands, local and federal governments and utilities are promoting initiatives to reduce energy consumption. Plans are moving forward for new power generation sources to resolve instability and bottlenecks in the nation's power grid. Nevertheless, near-term supply issues remain, and that means manufacturers must take energy efficiency measures to reduce consumption and lessen demands on the grid.

This also means reducing operating costs and adding dollars to the bottom line.

Indeed, it's becoming socially responsible and financially essential for manufacturers to identify energy-efficient solutions for their plants. However, identifying these potential savings can be daunting. Manufacturing processes are interlinked, and plant floor layouts have grown larger and more complex to meet changing market demands. This is where energy management solutions and services for assessing, monitoring, reporting and optimizing energy can help manufacturers structure and manage an effective energy savings program.

This approach helps make operations cleaner, more energy efficient and more competitive.

Traditionally, industrial energy consumption has been seen one dimensionally as an unavoidable, unmanageable cost of doing business. However, the most effective energy management strategy is one that adopts a three-dimensional approach—using less energy, more cost-effective energy and a more optimized approach to consumption and supply.

The core of this strategy is to understand where, when and how much energy is being consumed across the enterprise, and then using this knowledge to create long-term savings.

Using Less Energy

While many companies collect and profile energy data, they often use manual processes that are unreliable and time consuming. Smart, automated devices can give users better data and, in turn, better power management. This can include devices installed in the power flow at the point in which that power is converted to mechanical energy.

continued

Before implementing the required energy management technology and underlying infrastructure, companies can benefit from an assessment of overall consumption to identify potential savings. This analysis allows companies to monitor and review all incoming energy sources. General benchmarks can help, but local conditions—size of the plant, degree of automation and climatic conditions—are essential to understand a plant's specific potential.

One key area of focus for reducing energy consumption is electric motors, because they drive most production output and consume the most electricity. This is where advanced motor management solutions can deliver huge results. For example, power optimization tools—variable-frequency drives (VFD), energy-efficient motors and gears, motor controllers and software—all can deliver immediate, measurable bottom line savings.

In any manufacturing process that requires less than 100 percent of designed speed, manufacturers should consider integrating VFDs for both low- and medium-voltage applications. They can help significantly reduce energy costs, and when properly applied, help eliminate valves, increase pump seal life, reduce power surges during start-up and contribute to a more flexible operation.

Cheaper Energy

Companies also can use cheaper energy by managing where, how and when energy is used. They can harness it when it's least expensive, such as during off-peak times.

By developing an integrated energy management program based on accurate consumption and spending patterns and demand profiles, companies can calculate power consumption costs among various production lines. Armed with more accurate information about actual production costs, managers can make better business decisions.

A monitoring program is essential. It can include a network of digital power monitoring devices that capture and communicate power consumption information. The devices measure electrical parameters associated with a specific bus in a facility's electrical distribution system. Plant managers can gather information on power consumption in different areas of their plants, on specific machines (such as refrigeration compressors) and even on individual product lines.

Each department is seldom aware of its consumption on a daily, weekly or even monthly basis. By simply metering consumption, manufacturers can identify small opportunities for improvement to provide a significant impact on energy usage, resulting in immediate financial savings. In addition to usage data, managers have access to power and quality information that can improve productivity and lengthen equipment life, further enhancing profits and efficiency.

A major advantage of a power monitoring system is its ability to capture and log real-time data and events via a high-speed control or information network over long time periods. If managers detect consistent differences in energy usage across departments, among shifts or between plants with the same product lines, they can analyze the operation to see how lower energy usage might be achieved.

A revenue-accurate power monitor also is useful as a backup system to verify billing statements issued by electric utilities. Energy management software allows companies to model their energy profiles by:

- Measuring peak demands and quality parameters
- Determining demand patterns
- Correlating energy consumption to weather patterns
- Aggregating loads
- Calculating energy costs by business group, department or site

Once managers identify and chart energy models of loads and trends, possibilities abound for manufacturers to maximize energy savings.

Case in point: a leading food-and-beverage manufacturer quickly found that negotiating the lowest electricity rate required precise information about its power usage patterns, such as peak power demand, time of peak demand and how often its plants draw power at

the maximum rate.

Armed with load profile data compiled from a power monitoring system, the company was able to renegotiate its agreement with its utility and reduce its annual energy costs by up to 10 percent.

Optimize Energy

The third dimension of an effective energy management strategy with the most financial impact is optimizing energy use. This helps achieve production goals in the least expensive, most profitable way. In other words, manufacturers can actively manage energy as one of many inputs to the overall production equation. Such a sophisticated approach is impossible if energy is viewed simply as plant overhead.

Once manufacturing energy consumption data are stored and analyzed, managers can see clear trends of how energy has been used among various historical events—a product cycle or batch, for example. Capturing such knowledge provides immediate benefit and promotes future improvement. Forward-thinking manufacturers are beginning to work toward programs to tie energy consumption requirements empirically to the production bill of materials. The goal is an increase in proactive operating decisions and to better manage energy investments to generate a greater return. For example, by knowing that certain batches require more energy, manufacturers can move those batches outside peak windows. In addition, unit-level energy consumption information becomes valuable input to a company's sustainability scorecards and other reporting mechanisms.

Once managers have insight into how much energy is required to run a specific production cycle, they can leverage production simulation software tools to analyze a range of input variables. They can assess peak and off-peak energy costs, raw material costs, labor and projected emissions. They also can pretest "what-if" scenarios to see how production outputs and costs will change as a result of modifications.

In addition, being able to "see" a problem often gives additional meaning to information derived from the data, and in turn leads to proper corrective actions. Armed with this insight, manufacturers can see how energy consumption affects production capabilities and begin to make more strategic energy management decisions.

Conclusion: Energy Costs are Controllable

While manufacturers have large energy demands, they also have large opportunities for savings. Manufacturers can take control of energy costs.

The bottom line is that energy costs are controllable.

Key to this endeavor is identifying energy management goals, developing a corresponding strategy and putting technology in place that enables manufacturers to accurately monitor, analyze and control energy consumption and quality.

For more information:

Rockwell Automation Energy Efficiency Solutions
www.rockwellautomation.com/go/tjsavings

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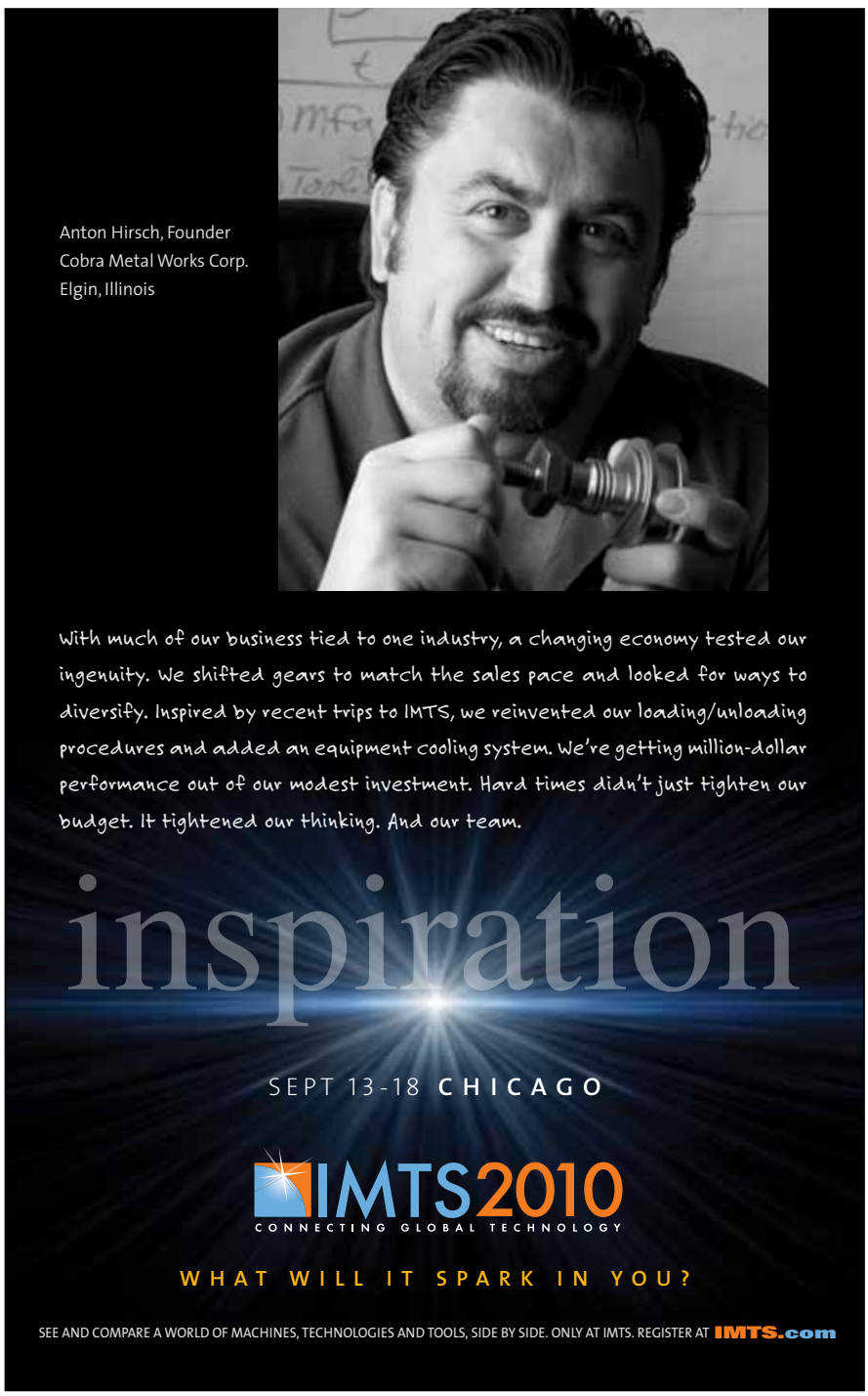
www.rockwellautomation.com/go/tjsustain



Development of an Educational Engineering Workshop

ON ELECTRIC VEHICLE AND MOTOR TECHNOLOGY

Shane Colton

(This paper was first presented at the 2009 Motor and Motion Association's [SMMA] Fall Technical Conference.)

Management Summary

This paper describes the development of an educational program centered on electric motor and electric vehicle technology at the MIT (Massachusetts Institute of Technology) Edgerton Center. The program—the Summer Engineering Workshop—has matched students from local high schools with MIT undergraduate and graduate students sharing a common interest in electric vehicles—i.e., their propulsion systems and their controls. Past projects included the creation of a "do-it-yourself," self-balancing scooter and an electric go-kart with a novel, regenerative braking system. In the summer of 2009, the Summer Engineering Workshop developed a compact, electric kick-scooter powered by two 500 W, brushless in-wheel motors. This project provided an opportunity for the group to go beyond integration of existing components and into the field of electric machine design. We developed an understanding of the theoretical and practical considerations through many avenues: research of prior art; design from first principles; integrated magnetic and mechanical computer-aided design; and ultimately, the real-world construction and testing of these motors. In the process, academic and industry professionals provided insight that benefited both the educational and the technical objectives of the project. The final product will become a valuable research and teaching tool, and the success of the program highlights certain strengths of combined technical and educational development.

Introduction

The Edgerton Center was established in memory of Professor Harold "Doc" Edgerton and is at the center of hands-on learning at MIT. Over 20 student clubs and teams—building everything from robots to solar-electric vehicles—call the Edgerton Center home (Ref. 1). The Summer Engineering Workshop, one of many outreach and engineering programs hosted by the Edgerton Center, has been offered for the past three years.

More of an ad hoc group of students with similar interests than an organized outreach program, the Summer Engineering Workshop began in 2007, before it had an official name. It is a collaboration of MIT students and students from local high schools, formed as an outlet for local FIRST Robotics (Ref. 2) teams interested in an off-season project workshop.

In other words—something to keep everyone busy when not building competition robots.

In contrast to the regulated competition structure, the workshop allows complete freedom in project selection and implementation, an engineering experience not typically seen until more advanced studies.

The group's focus on electric vehicle technologies was driven by a common passion among the founding members for "things you can ride," as well as shared experience within the field of mechatronics and robotics. In addition

to being a multidisciplinary endeavor, the vehicle projects also enable contributions at many different technical and educational levels. Each student is teaching and learning at his or her own capacity, with very little curricular overhead. This informal philosophy has allowed the group to pursue fun projects that are both technically challenging and educationally engaging.

Summer 2007: The DIY Self-Balancing Scooter

We completed our first project—a functional, self-balancing electric scooter—in the summer of 2007. The scooter, which mimics the function of the Segway Personal Transporter, is constructed mostly of off-the-shelf components from the competitive robotics market. Each wheel is driven by 350 W DC motors with planetary gear heads. A feedback control system estimates the angle of the standing platform 100 times per second based on inertial sensor measurements. It then updates commands to the motors to correct for any leaning. The scooter, shown in Figure 1 next to a real Segway, is not as easy to ride as the commercial version and does not have as many safety measures. But it is lightweight (50 lbs.) and inexpensive ($800).

The homemade, self-balancing scooter has served as an engaging demonstration of do-it-yourself engineering for students for the past two years, and in some sense demystifies an iconic piece of hardware while also revealing that there is much more that has to go into a commercial product. Since completing the self-balancing scooter, we have received over 100,000 web visits and numerous e-mails from around the world complimenting the project and requesting more information.

Summer 2008: The Cap Kart

In the summer of 2008, the workshop was awarded a $6,000 research grant to develop an electric go-kart with a novel, ultracapacitor-based regenerative braking system. A more ambitious project in scope and scale, the Cap Kart required a step up in engineering and design maturity. It was also our graduation from the world of robotic components to the world of electric vehicle components.

The kart is powered by a 10 kW, separately excited brushed DC motor made by D&D Motor Systems. The separately excited topology is featured prominently in the regenerative braking scheme, where the field winding is used to regulate regenerated current into the ultracapacitor with no high current switching. The motor also enables a fun, student-driven addition to the kart—a simulated, sequential manual transmission that manipulates the torque speed characteristic through the field controller.

Although we have not had many opportunities to drive the finished kart (Fig. 2), the few test drives we did take were useful for collecting data on its features, including the ultracapacitor "boost" mode. Flywheel testing validated more of the regenerative braking models, and the team presented the project results in Monaco at the EVER '09 conference (Ref. 3).

Summer 2009: The BWD Scooter

The technical report in this paper highlights the Summer Engineering Workshop's 2009 project—a compact, electric "kick-scooter" (similar to a Razor) with custom, brushless in-wheel motors. Without the research budget of 2008, we wanted instead to build an inexpensive, lightweight and readily portable demonstration of electric vehicle technology. After briefly considering a simpler, belt-driven rear-wheel-drive scooter conversion with a brushed DC motor, the team decided to pursue in-wheel motors for both wheels, leading to the name BWD—"Both Wheel Drive." More interesting from a technical standpoint, the in-wheel motors provided us with our first opportunity to go beyond off-the-shelf components and ask the question—"If we could have any motor we wanted, what would it be?" This design experience was very rewarding and added a new element of engineering to the workshop.

Design Process

The challenges of building in-wheel motors are many. Also called hub motors, all of the motor components exist within the volume of the wheel itself. The rim and tread are integrated with the rotor while the stator sits on the inside of the hub, held in place by a stationary shaft. While this type of motor is less mechanically complex than a brushed motor, the fabrication was more involved than any of our previous projects. The workshop has access to only basic machining equipment, though we have used rapid prototyping services in the past to make custom parts.

Figure 1—Our first project, a self-balancing electric scooter (left) built for under $1,000.

Figure 2—Our converted electric go-kart from 2008.

One of the biggest unknowns for us was whether we would be able to get adequate torque from a direct-drive motor. All of our previous experience had been with motors that require gear reduction to achieve suitable performance for vehicles. The decision to use two motors was partially driven by this uncertainty. During the course of the design, we also developed an understanding of the theoretical and practical considerations influencing the performance of the motors through several methods: research of prior art, design from first-principles, simulation and a single-iteration, prototyping strategy.

Research of Prior Art

Though there are many applications of hub motors to electric-assist or fully electric bicycles and full-sized scooters, we know of only one other example of an in-wheel motor being used in a small-diameter kick-scooter wheel. The motor, designed by MIT student

continued

Charles Guan, served as the primary inspiration and proof of feasibility for this project. (In addition to being a working example of a kick-scooter hub motor, it was also built from scratch without advanced manufacturing facilities.) The motor (Fig. 3) uses a rewound stator from a photocopier motor and a custom-built rotor with NdFeB magnets (Ref. 4).

Figure 3—A kick-scooter wheel motor built by MIT student Charles Guan.

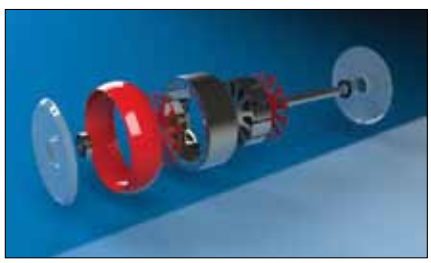


Figure 4—An exploded view of the mechanical design of our wheel motor.

Table 1—Motor Mechanical Properties.

Outer (Tread) Diameter	5.0" (127 mm)
Air Gap Diameter	3.44" (87 mm)
Total Width	2.0" (51 mm)
Stator Active Width	1.0" (25 mm)
Lamination Thickness	0/014" (0.36 mm)
Weight	6 lb (3kg)

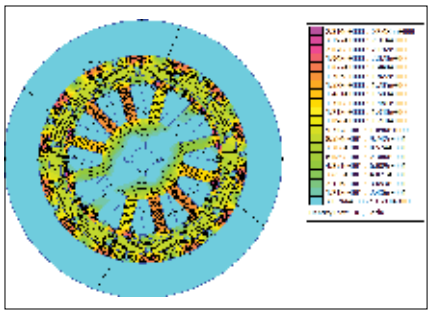


Figure 5—*FEMM* simulation output for the 60 turn-per-phase motor at 20 A.

The motor is a 12-slot, 14-pole brushless "outrunner." A high pole count creates a low-speed, high-torque motor with more windings linking flux. The fractional slot: pole ratio is advantageous for minimizing cogging torque (Ref. 5), which is especially important in a direct-drive motor. With this design, it is also possible to use an easy-to-assemble, concentrated winding scheme, winding every other tooth with more turns (Ref. 6). Early in the design, we chose to use this proven motor design as our starting point.

Motor Mechanical Design and Proto Laminations Collaboration

We were aided greatly by the support of Proto Laminations, Inc., which donated laser- cut M19 steel laminations to the project. Steve Sprague, sales manager at Proto Laminations, came to visit our workshop during the summer and gave a presentation on the many interesting aspects of motor lamination technology and manufacturing. This was the first industry guest that the workshop has hosted, and the collaboration added a new perspective to our design process.

Having used rapid-prototyping tools (abrasive water jet) for projects before, the team was excited to have the chance to design the rotor and stator from scratch. Many of the workshop students have experience with *SolidWorks* CAD software, so the mechanical design went quickly. Shown in Figure 4, our design includes features for aligning magnets as well as a pin slot for the shaft. A bolt circle with seven holes on the rotor places bolts directly behind magnets where they will interact with the least amount of flux. All of these specifically designed features would be difficult or impossible to create with basic machining processes, but are made feasible by the short turn-time laser cutting process. Table 1 lists the dimensions and mechanical properties of our wheel motor design.

Electromagnetic Design from First Principles

Although the majority of our experience is in mechanical engineering, we sought to understand the electromagnetic principles of the motors before attempting to build them. We were most concerned with the ability to produce enough torque with a direct-drive motor. Using only high school-level physics, we were able to make a first-order estimate of the motor performance. Most students see electromagnetic interaction first in the form of the Lorentz force formula:

$$\vec{F} = I\vec{L} \times \vec{B}. \quad (1)$$

From this elementary starting point, it was already clear that, in a direct-drive motor with no opportunity for gear reduction, the force at the wheel could only be increased by increasing current, field strength or active length of windings. Without analyzing the full magnetic circuit, we could still assume that the stator steel would serve the purpose of "concentrating" the total winding current into an ideal location in the air gap.

Knowing that we would need a relatively high torque and low speed for this motor size, we chose N42-grade NdFeB magnets with a remanence of 1.3 T. Since we were hand-winding the stators, anything larger than 16- or 18-gauge magnet wire would be difficult to work with. With a conductor area of approximately 1 mm^2, and a per-phase duty cycle of 67%, this set a practical current limit of about 20 A peak, 10 A continuous. The degree of freedom remaining was the number of turns, which sets the active length of wire. From a simple power conservation argument, students could see the design tradeoff: more turns would give more torque, but a higher voltage would be required to achieve the same target speed. We chose to build the first motor with 60 windings per phase. Since two phases are driven at any given time in simple square wave brushless DC controller, this gave us a peak air-gap force of:

$$F = 158N = 36\,lbf \quad (2)$$

$$F = (20A)(2)(2)(60)(0.0254m)(1.3T) \quad (3)$$

From this estimate, the torque or the force at the tread diameter could easily be calculated. The torque estimate is just the air gap force multiplied by the air gap radius, which evaluates to

6.9 N-m. We understood this to be a high estimate, assuming 1.3 T uniformly in air gap and no leakage flux. But it served as confirmation that reasonable torque could be achieved without very high winding density. By power conservation, this first-order estimate also confirmed that the desired speed was achievable with a low-voltage (33 V) supply.

Electromagnetic Design by Simulation

After doing a first-principles feasibility estimate, we sought to get a more realistic performance prediction by using finite element electromagnetic simulation software. One such 2-D simulation package—*FEMM*—is freely available and has the ability to import .dxf-format drawing files (Ref. 7). We were able to easily import our CAD files into this software and apply materials tags from the *FEMM* materials library. Figure 5 shows an example output of the *FEMM* simulation with 60 turns-per-phase and 20 A current on the correct phases to produce peak torque.

The peak torque estimate from the *FEMM* simulation was 4.2 N-m, which is significantly lower than the first-principles estimate. This was expected, since the simulation accounts for magnetic losses and leakages, as well as the non-uniform air gap field. (The simulation shows that the average flux density is closer to 1.0 T.)

The *FEMM* magnetic visualization also helped us determine ideal locations for bolt holes and other mounting features to minimize their effect on the flux paths. For example, the seven rotor bolt holes are placed directly behind magnets, where the flux density is lowest.

Single-Iteration Design Verification

In addition to providing redundancy and more combined torque, the purpose of building two motors was to allow us one chance for design revision after the first motor was built and tested. This was a very important part of our design process. Our limited knowledge of motor design and the untested geometry of our custom motor meant that all the simulations and estimates had a degree of uncertainty that we could not approach analytically. However, we were confident enough in the underlying principles to know that if we built one motor, we could learn enough from its performance to easily adjust the number of turns in the second motor to achieve a desired torque and speed. Solving experimentally for the "geometry constant" and then scaling was the key to the single-iteration strategy.

Building and Testing

We used the first motor to develop an effective winding and assembly process. After bonding the rotor laminations with a surface coating of cyanoacrylate, the magnets were dropped into their alignment slots, with careful attention paid to the magnetic orientations. Figure 6 shows the rotor and its magnet alignment features in more detail.

Winding the stator was the most challenging and time-consuming task of the project. After a test winding of the stator resulted in short circuits, we added oversized fiberglass end-laminations to insulate the corners of the stator. Three-phase windings were done on alternating teeth (A-b-C-a-B-c-) and connected in wye configuration to wires fed through the hollow 0.5" motor shaft.

Motor sides were fabricated from 0.25" polycarbonate disks. Bearings were pressed into these side plates. We chose to use semitransparent plastic sides to keep the internal construction of the motor visible for demonstrations. The use of non-ferrous side plates also had an unintentional benefit: Hall effect sensors can pick up the position of the magnets from outside the motor, simplifying the control.

With the stator and rotor subassemblies complete, the motor was assembled using a drill press and simple jig to keep the stator from moving under the force of the magnets. Once the rotor bolts engaged with the side plates, these held the stator in place and the jig could be removed for final tightening. Figure 7 shows the stator being lowered in during final assembly.

With the first motor assembled, a simple test of the no-load speed at 36 V was done to find the motor constant. The external Hall effect sensors were positioned to give the lowest stable speed. Data from this test, shown in Figure 8, placed the motor constant at 47 rpm/V, or 0.20 V/(rad/s). Assuming an equivalent torque constant—0.20 N-m/A—this put the motor peak torque at 4.0 N-m, very close to the *FEMM* estimate.

Based on the test data from the first motor, we decided to use 90 turns-per-phase on the second motor to achieve 50% more torque and a lower no-load speed. The second motor would become the rear wheel of the scooter, providing more starting torque during acceleration. The first motor would become the front wheel. The two motors, shown together in Figure 9, differ only in the number of turns-per-phase. Testing of the second motor confirmed a motor constant of 0.30 V/(rad/s), which gives a peak torque of 6.0 N-m at 20A. Table

continued

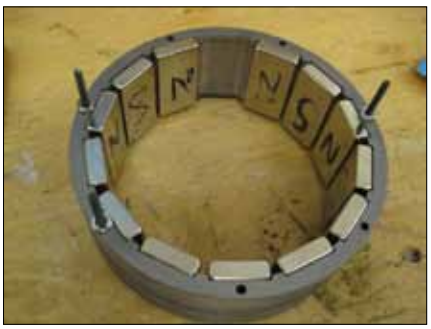


Figure 6—The rotor as it was fitted with magnets.

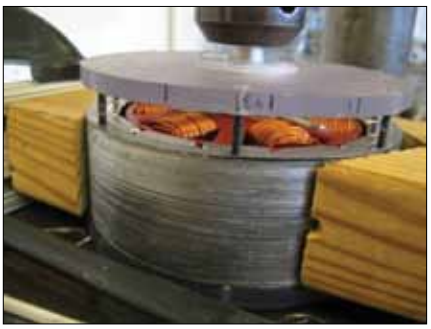


Figure 7—The stator and second side plate are dropped into the rotor with the aid of a drill press.

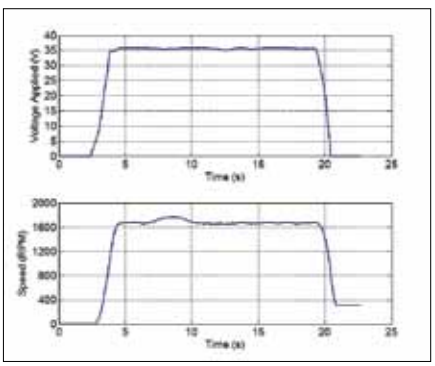


Figure 8—Test data to determine the motor constant of the first motor.

2 lists some more detailed specifications for the two motors. Each is capable of producing approximately 500 W peak.

The last step for us was integrating the motors, batteries, and controller into a custom scooter frame. The chassis is a simple sheet aluminum box with a carbon fiber deck. We used the handlebar and folding mechanism from an existing scooter. A custom 145 W-hr pack of $LiFePO_4$ batteries, fixed inside the chassis, gives the scooter a range of approximately five miles. The controller is also fixed inside the volume of the chassis. The assembled scooter is shown in Figure 10.

Conclusion and Future Work

The BWD Scooter is now a functional vehicle, with two working motors. The combined torque of the motors is more than adequate, giving impressive acceleration— even uphill. With a total weight of just over 20 lbs, the scooter is light enough to carry up stairs or through buildings. More vibration proofing and waterproofing would be required for long-distance, outdoor operation.

This project was a successful and rewarding experience for the Summer Engineering Workshop team. Starting with only a limited knowledge of brushless motor technology, we were able to step through the design process of a custom motor in a simple and quick way that matched up well with our prototyping experience. The support of Proto Laminations made the creation of these motors feasible and the collaboration contributed a new industry perspective to the workshop. The design experience and new set of knowledge and skills will certainly guide our future projects.

The workshop has, over its three years, matured in its engineering process and focus while retaining a "do-it-yourself" philosophy that puts most of the design in the hands of its students. The rich field of electric vehicles and motors provides opportunity for technical research that is interesting and relevant to today's world, but also a fun platform for education using tools that appeal to many types of students. The models and methods used are simple but can still yield accurate results that can be verified in real life with hands-on prototyping. The success of the workshop is a strong case for the combination of technical and educational development focused on current engineering challenges.

Table 2 Motor Specifications.

	Rear	Front
Turns per Phase	90	60
Motor Constant	0.30 N-m/A	0.20 N-m/A
Winding Resistance	0.333	0.221
Peak Torque (20 A)	6.0 N-m	4.0 N-n
No-Load Speed (33 V)	1,050 rpm	1,575 rpm
Peak Force at Outer	63 N	94 N
Diameter (20 A)	(14 lbf)	(21 lbf)
No-Load Linear Speed at	7.0 m/s	10.5 m/s
Outer Diameter (33 V)	(15.6 mph)	(23.4 mph)
No-Load Current (33 V)	0.85 A	1.50 A
Estimated Peak Power (20 A, 33 V)	510 W	537 W
Estimated Efficency at Peak Power (20 A, 33 V)	77%	81%

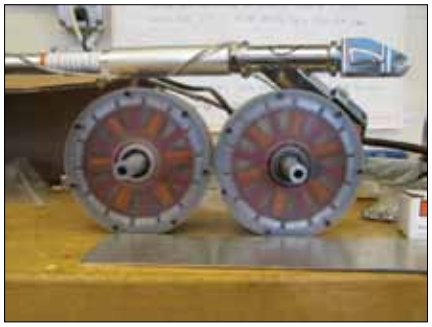


Figure 9—The rear motor (left) and front motor (right) differ only in the number of turns-per-phase.

Figure 10—The assembled scooter with two motors installed.

Acknowledgements

The author would like to thank the Electric Motor Education & Research Foundation for the invitation and opportunity to present at the SMMA 2009 Fall Technical Conference. The Summer Engineering Workshop would like to thank Proto Laminations for their sponsorship and support. We would especially like to thank Steve Sprague for his personal contributions to the project.

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Shane Colton *is a graduate student in mechanical engineering at the Massachusetts Institute of Technology.*

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Comparison of PM-HSS and Cemented Carbide Tools in High-Speed Gear Hobbing

Fritz Klocke, Philipp Kauffmann, Wolf Schalaster and Arne Stuckenberg

Management Summary

This article examines the dry hobbing capabilities of cutting tool materials—powder metallurgical high-speed steel (PM-HSS) and cemented carbide. Cutting tri-

Potentials in Hobbing 16MnCr5N

Reduction Factors
$L_{opt}/L_{analogy}$ (empirical):
PM-HSS: 50 %
HM: 33 %

Figure 1—Potentials in machining case hardening steel 16MnCr

Transmissions in Vehicles Conference

June 22–23—Friedrichshafen, Germany. Current trends and possibilities is the subject of the 10th international VDI Transmissions in Vehicles Conference, which is held by the VDI Wissensforum. VDI is the association of German engineers. Vehicle transmission developers and users gather for this event.

The conference director is Dr.-Ing. Hans-Joerg Domian, director of new products and methods, design tasks for ZF Friedrichshafen AG. Opening papers include "The Future of Driveline Development, Potential Carbon Dioxide Savings and The Role of Electricification;" "Electromobility: An Outlook for Industry;" and "Evaluation of Transmission Concepts From The Viewpoint of a Racing Driver," which is being presented by ex-racing driver Hans-Joachim Stuck, representing the Volkswagen Group's motor sports division.

In addition to future-oriented transmission components for electric and hybrid vehicles, the program also includes current developments in double-clutch and automatic transmissions, manual transmission and all-wheel drives, efficiency, components, materials and production engineering, as well as clutches and operating strategies. A machine's section is new to the program. It addresses technical trends in agricultural machines, new developments in construction machinery drives, infinitely variable power take-off drives or improvements in the ease of gear shifting.

Another new highlight is a live, hands-on transmission demonstration during paper presentations on "8HP70H: ZF's Multihybrid Transmission," and "Modular Seven-Gear Dual-Clutch Transmissions as Four-Wheel Drive Version for a Sports Car of the Highest Performance Class," where the corresponding transmissions will be in operation. Live, close-up pictures will be screened in the auditorium, so the audience can closely follow the technologies being presented.

Alongside the conference will be a technical exhibition concentrating on transmissions for commercial vehicles, buses and machines. A parallel event is the first VDI Transmissions in the Commercial Vehicle Conference. Transmission conference attendees can visit this event for free.

Registration and program information is available at *www.getriebekongress.de*, or from the VDI Wissensforum Customer Center, Postfach 10 11 39, 40002 Duesseldorf, Germany, *wissensforum@vdi.de*.

calendar

June 24–26—China (Shenzhen) International Small Motor Exhibition. Shenzhen Convention & Exhibition Centre. The eighth installment of the China International Small Motor Exhibition is co-located with several other industry events: The China International Electric Machinery Industry Exhibition 2010; The China International Magnetic Materials and Equipment Exhibition; International Electronic Equipment, Components, Photonics and Laser Exhibition; China International Power Supply Exhibition; and International Industry Control and Automation Expo for South China. The Small Motor Expo covers 7,000 square meters of exhibit space, and about 10,000 visitors are expected to be in attendance. Visitors come from all across China with 11.5 percent coming from overseas. Exhibitors include Schneider Electric, Siemens, Emerson and ABB. For more information, visit *www.motor-expo.cn*.

June 22–25—Expo Pack Mexico and Procesa. Centro Banamex, Mexico City. Expo Pack Mexico and Procesa 2010—expected to be host to 25,000 packaging and processing professionals—will promote technologies and innovations that contribute to sustainable development, through Expo Pack Verde (Expo Pack Green). Based on the Pack Expo Green program, Expo Pack Verde represents a new opportunity for business. Participating exhibitors of Expo Pack Verde will display green technologies including sustainable packaging materials and energy efficient machinery. For more information, visit *www.expopack.com.mx*.

July 6–9—World Congress on Intelligent Control and Automation. Shandong Hotel, Jinan, China. The eighth WCICA is one of the 110th anniversary celebration events of Shandong University. Visitors can attend plenary lectures given by various university scholars from all over the world. Panel sessions will be presented on how to publish papers in international journals, control science and engineering: the present and the future, and frontiers in robotics and automation. Eight free tutorial workshops are part of the schedule. The workshops topics include stability and control of time-delay systems, fractional order dynamic systems and controls, nonlinear control based on input-to-state stability and small gain, as well as deterministic learning and pattern-based intelligent control. For more information, visit *www.wcica.info*.

August 2–5—CAR Management Briefing Seminars. Grand Traverse Resort and Spa. Traverse City, MI. The Center for Automotive Research (CAR)'s Management Briefing Seminars is a traditional summer gathering for the automotive industry. Sessions on Monday will concentrate on manufacturing, especially related to tomorrow's vehicles, and on deploying connected vehicles. Tuesday's concurrent sessions will focus on powertrain developments, supplier prospects in China, the financial outlook and the intersection of electric vehicles and technology, communications, the infrastructure and the public sector. Senior level OEM and supplier executives and government officials will headline Wednesday and Thursday sessions, addressing the broader issues associated with the emerging industry and restructuring. For more information, visit *mbs.cargroup.org/2010*.

September 6–8—International Conference on Electrical Machines. Crowne Plaza Rome-St. Peter's Hotel, Rome. The ICEM is a biannual event in its 19th edition that is entirely devoted to electrical machines. A community of specialists discusses the progress achieved and the future developments in technologies, analysis, design, testing, operations, practical applications, maintenance and teaching in the field of electrical machines. Conference topics have been divided by tracks, each of which has two co-chairs or more for reviewing. Topics include conventional machines; non-conventional machines; electrical drives; materials; theory, modeling and design; measurement, testing, losses and efficiency education; embedded applications; and grid-connected and emergency applications. For more information, visit *www.icem2010.it*.

September 21–23—Atlantic Manufacturing Technology Show. Exhibition Park, Halifax, Novia Scotia. The Atlantic Manufacturing Technology Show (AMTS) brings manufacturers together to connect on new technology and new products. The Atlantic Canada region is home to more than 2,600 manufacturing companies employing nearly 24,000 workers. AMTS will bring together diverse industries such as aerospace, defense, heavy equipment, mining, energy, wood products, machinery and metal fabrication. For more information, visit *www.sme.org/amts*.

September 9–10—International AVL Engine and Environment Conference. Helmut-List-Halle, Graz, Austria. This conference, held by Austrian powertrain developer AVL, looks at the innovative internal combustion (IC) engine in the context of powertrain electrification as a major key to long-term carbon dioxide reduction. Exploration of the potential of IC engine powertrains is a major topic, as well as developments necessary to enable current niche solutions to enter the high-volume market will be discussed. The following issues will also be looked at: IC engine innovations; optimization of the IC engine as the strategy of major OEMs for the next 20 years; ecology and economics of different technologies; the battery as an obstacle or chance on the way to the high-volume electric drive; electric vehicles with and without range extenders; software; and the transmission as a system enabler. For more information, visit *www.avl.com/engine_environment*.

SKF

OPENS FACILITIES IN HOUSTON, INDIA, SHANGHAI

Several new facilities have been opened by SKF so far this year; A Solution Factory opened in Houston in March, two factories were opened in India and a wind industry service center was opened in Shanghai, in April.

The 25,000-square foot Solution Factory in Houston is the first in the United States, and it joins a network of eight others worldwide. "The new facility can equip customers with value-added solutions and industry knowledge to optimize their machinery performance and maximize operating efficiencies," says Poul Jeppesen, president and CEO of SKF USA Inc. "The facility further provides us with an unprecedented venue to advance our dialogue with customers in a working partnership to help solve their challenges."

The Solution Factory is a "multi-million dollar long-term investment," according to Bart Bartholomew, vice president of business integration and Solution Factories. Currently, there are 27 employees, and SKF intends to employ 50 at full capacity. The facility houses applications engineering, spindle and ball screw repair, bearing application expertise, sealing solutions, lubrication system expertise, mechanical equipment services (including mounting, alignment and balancing), remote condition monitoring and diagnostics, engineering consultancy services and operator and worker training.

"All these resources under one roof allow us to deliver customized and timely product and service packages tailored for particular operations," Jeppesen says. "We expect that this Solution Factory will quickly become a key destination for customers striving to increase overall asset efficiency, reliability and productivity."

The facilities in India and China support growing demand in that area of the world. One of the factories was built in the Indian city Haridwar, which will serve the two-wheeler manufacturers in the Uttarakhand state, an emerging industrial hub, and contribute to the growing vehicle aftermarket in India. The total investment amounts to about $35 million (USD), and the factory will employ around 200 people.

The other Indian factory was opened in Ahmedabad, the largest city in the Gujarat state. Medium to large size bearings of various types will be manufactured at this site for customers in railway, wind and other heavy industry sectors. SKF invested about $63 million into this facility, which will employ around 300 people at full capacity.

"SKF has been present in India for more than 85 years, and it is a very important market for us, both in terms of business and for the development of products," says Tom Johnstone, president and CEO of SKF Group. "The opening of these new factories, which means that we now have five factories in India, shows our strong commitment to supporting our growth in India and Asia."

The SKF Solution Factory in Houston (top) and the new factory in Haridwar, India (bottom) are two of several SKF facilities opened this year.

SKF, in its commitment to reducing the carbon dioxide emissions from its factories, built the Haridwar factory according to the Indian Green Building Council (IGBC) green factory recommendations, and the Ahmedabad factory was built according to the Leadership in Energy and Environmental Design (LEED) standard.

The SKF Asia Pacific wind industry service center was built at the SKF Solution Factory in Shanghai. It is the third SKF facility of its kind, tailored to the wind industry, joining centers in Hamburg, Germany and Houston.

This center was established to meet market demand for maintenance technology in the wind industry and to provide one-stop solutions in the market of wind farm operation and maintenance in the Asia Pacific region, particularly in China. According to Vartan Vartanian, president SKF Service Division, "The establishment of the wind industry service center in Shanghai demonstrates SKF's strong commitment to provide extensive technical support and services to the wind industry and the wind farm operation and maintenance market in Asia Pacific."

Rexroth, Dana

FORM JOINT VENTURE

Bosch Rexroth AG and Dana Holding Corporation announced that they expect to form a 50-50 joint venture to co-develop and manufacture advanced drive transmissions for the off-highway market. The two companies signed a memorandum of understanding to this effect.

The planned joint-venture company is expected to operate in Arco, Italy. It will manufacture, engineer and market hydro-mechanical variable power split transmission systems (HVT) for the global off-highway markets. The transmission systems will focus on meeting customer needs for improved fuel economy, productivity, emissions and maneuverability. Both Bosch Rexroth and Dana will contribute staff, intellectual property and capital to the joint-venture company.

We are excited about the opportunities that this combination of two respected global off-highway transmission manufacturers presents," says George Constand, chief technical officer of Dana. "Together, Dana and Bosch Rexroth offer a broad range of complementary skill sets, which will enable the joint venture to deliver a unique array of advanced transmission solutions to the off-highway marketplace."

The planned joint venture will capitalize on Dana's experience in off-highway transmission engineering and manufacturing, as well as Bosch Rexroth's experience in hydraulics and systems. The two companies are currently involved in a joint project to develop power split transmissions for construction machines.

"The smart interaction of hydraulics and mechanics will be the driving factor for future innovation in drive transmissions," says Reiner Leipold-Buettner, executive vice president of engineering and manufacturing for Bosch Rexroth. "Only those with the best knowledge in both fields will master the growing market demands. Dana and Bosch Rexroth ideally combine both fields."

Sauer-Danfoss

APPOINTS
EXECUTIVE VICE PRESIDENT AND CMO

Marc Weston was appointed executive vice president and chief marketing officer of Sauer-Danfoss, effective April 5. He will be based out of the Ames, IA location and is replacing Tim Hanson upon his retirement from the position.

continued

Marc Weston, Sauer-Danfoss.

Weston previously served as vice president, strategic planning with The Timken Company.

Weston brings more than 18 years of experience in a range of key leadership positions in marketing, operations and strategic management within The Timken Company in the United States, Europe and Asia. He also served as vice president automotive Asia and president Japan/Korea in Tokyo.

"I am pleased to welcome Marc to Sauer-Danfoss," says Sven Ruder, Sauer-Danfoss president and CEO. "In his new role, Marc will be a member of the Sauer-Danfoss leadership team and will have overall responsibility for the Sauer-Danfoss sales and marketing organization, as well as quality and advanced systems engineering. Some of Marc's main tasks will be to orchestrate an aligned sales approach to customers across the company and ensure heightened focus on achieving our quality goals."

Emerson

AWARDED EDUCATION FOUNDATION OUTSTANDING PARTNER

The Society of Manufacturing Engineers (SME) Education Foundation presented the 2010 Outstanding Partner Award to Emerson at the foundation's Board of Directors Dinner in St. Louis in April.

Robert M. Cox, Jr., Emerson senior vice president, was on hand to receive the award for Emerson. The annual financial support from Emerson to the SME Education Foundation assisted Gateway Academies at Hazelwood North Middle School, Florissant, St. Louis; Thomas Worthington High School, Worthington OH; and Strom Thurmond High School and Career Center, Johnson, SC. Emerson funding has also supported the Science, Technology and Engineering Preview Summer (STEPS) Camp for seventh and eighth grade students near Emerson facilities.

"Emerson is an extraordinary organization. They have been a supporter of our Foundation and our youth programs for a very long time, and they are truly outstanding partners," says Bart A. Aslin, director of the SME Education Foundation. "Their consistently generous funding of more than $600,000 since 2001 has truly allowed us to enrich the lives of young people and setting them on a career path offering innovative tech-based education. We're grateful for their support."

Kollmorgen

ESTABLISHES AFTERMARKET SERVICE AGREEMENT

Kollmorgen drives are exclusively being remanufactured by Flight Systems Industrial Products for the North American electric fork lift truck market, in accordance with an Aftermarket Service Agreement between the two companies.

Flight Systems Industrial Products (FSIP), a provider of remanufacturing services for electric vehicle control systems, and Kollmorgen have signed an Aftermarket Service Agreement. Under terms of the agreement, FSIP will be the exclusive remanufacturer of Kollmorgen drives and controls for the North American electric fork lift truck market.

Kollmorgen is recognized under the company's previous branding of Danaher Motion, and is a supplier of drives and control to OEMs of electric fork lift trucks. "Partnering with FSIP helps us better support and bring additional value to our OEM customers' aftermarket businesses in North America," says Brian Lubin, business unit director, Kollmorgen Electric Vehicle Systems. "These customers will have ready access to a lower-cost, high-quality remanufactured drive and control solution through FSIP, and directly supported by Kollmorgen through revision control and testing. Additionally, the agreement will extend the availability of legacy Kollmorgen drive and control products."

According to Barry Bowman, president of FSIP, "This agreement aligns with our strategic focus of nurturing

alliances with industry-leading manufacturers of electric vehicle components and systems, and doing so allows us to provide our customers with the most recent upgrades to the control hardware and software. As the intellectual property of today's electric vehicle controls become more complex, these alliances enable us to truly remanufacture the control and not just 'repair it' or 'swap it out,' as may be the case with other repair facilities. It also provides the market with an alternative to 'new,' while maintaining the integrity of the control as a remanufactured product."

NSK

WINS QUALITY AWARD FROM PSA GROUP

PSA Peugeot Citroen, the second largest automotive manufacturer in Europe, awarded NSK for outstanding performance in quality at the group's suppliers' day event, which brought together 300 of its leading suppliers.

The award is the result of a strong relationship developed over the years between PSA and NSK, and it recognizes NSK's efforts in achieving the high quality standards that PSA sets. In this relationship, NSK attributes its performance to a close coordination with the manufacturing location in Peterlee, England, for wheel hub units and in Saitama, Japan for tapered roller bearings for transmission applications.

NSK European Automotive Business Unit started working with PSA in 1998. The first major project came in 2000, with mass production deliveries in 2003. NSK supplies bearings for chassis and drivetrains for various PSA car models and light commercial vehicles. NSK is also involved in developing future vehicles.

During the ceremony, Jean-Christophe Quémard, PSA executive vice president and purchasing manager, commented, "[NSK's] quality record is exceptional since its first part supplied: less than 1 ppm for six consecutive years. Whether in development or production, NSK performance is remarkable and recognized as a technical benchmark."

BEI Merges Divisions

Industrial rotary encoders and accessories from the BEI Industrial Encoders division are now available under the BEI Sensors brand name, along with the product portfolios of BEI Duncan Electronics and BEI Ideaco.

BEI Industrial Encoders, BEI Duncan Electronics and BEI Ideacod have combined to form BEI Sensors. The merger brings a broad product portfolio and a combined 100 years of experience in engineering development to better serve motion control solutions in the industrial, military/aerospace and transportation markets. BEI Sensors is headquartered in Goleta, CA.

The BEI Sensors product line includes rotary and linear position sensors, potentiometers, Hall Effect sensors, absolute and incremental encoders, panel controls, electronic interface modules and various accessories. More information is available at *www.beisensors.com*.

Habasit

APPOINTS PRESIDENT OF GEARMOTOR DIVISION


George Rizza

George Rizza joins Habasit America as president of the Gearmotor Division. Rizza previously served as vice president of sales at Nord Gear for 12 years. He earned a bachelor's degree in electrical engineering technology from Bradley University, and he is fluent in Italian. Rizza will be responsible for all Rossi Gearmotor product lines in the form of assembly, sales, marketing, customer service and engineering in North America, Mexico and Brazil, as well as acting liaison with Rossi Modena Italy.

Habasit produces transmission belts, conveyors and gearmotors. Habasit America is a subsidiary of The Habasit Group, Reinach, Switzerland.

PMMI

LAUNCHES MECHATRONICS CERTIFICATE TEST


Maria Ferrante

The "Introduction to Industrial Electricity" mechatronics certificate test—the first in a series—has been launched by PMMI in cooperation with the Mid-Atlantic Mechatronics Advisory Council, partner schools and industry professionals.

"Mechatronics brings a range of engineering disciplines together," says Maria Ferrante, PMMI's vice president of education and workforce development. "PMMI developed this mechatronics certificate program to set a standard for the industry and to encourage schools to provide the training students need to get started on this complex and exciting career path."

The certificate program is based on the mechatronics standards PMMI has developed. In partnership with educators and the industry, PMMI has identified 24 skill areas required for mechatronics professionals working in the packaging industry. PMMI and its partners are in the process of outlining the competencies required for each skill area.

"These competencies form the backbone of the test development," Ferrante says. "For this initial test, 'Introduction to Industrial Electricity,' we identified and validated the competencies which are published on our website and developed the assessment to test for skills and knowledge in these areas. We hope that curriculum developers around the country will adopt these standards to provide the consistent and rigorous training that the packaging industry needs from its young and growing class of inventors."

PMMI is a trade association of companies that manufacture packaging, processing and related converting machinery, components, containers and materials in the United States. The association worked with the U.S. Department of Labor to develop a packaging oriented mechatronics competency model. To earn the certificate, candidates need to achieve a passing score on the online assessment test. For the complete list of competencies covered in PMMI U's "Introduction to Industrial Electricity," visit *www.pmmi.org/pmmiu*.

"This certificate will enable students to better prepare for a career in packaging as well as establish professional, nationally recognized credentials," Ferrante says. "It will also enable the existing workforce to identify areas of opportunity to enhance knowledge and skills and prepare for additional job responsibilities. For managers, this certificate will demonstrate independent validation of a technician's knowledge and skills as well as establish documentable hiring and promotion criteria."

Bison Gear

SIGNS NATIONAL DISTRIBUTION AGREEMENT

Following a successful two-year period of regional authorized distribution, gearmotor manufacturer Bison Gear and Engineering Corp. has entered into a North American distribution agreement with Kaman Industrial Technolgies, a distributor of power transmission and motion control products. Kaman will distribute Bison's full product offering of gearmotors through Kaman's 200 customer service centers in the United States, Canada, Mexico and Puerto Rico.

"In our 50th anniversary year, Bison is especially pleased to have entered into this expanded distribution partnership with Kaman," says Todd Lucich, vice president of sales for Bison Gear and Engineering. "Kaman's reputation as a solution provider for its customers aligns well with Bison's consultative approach to engaging end users from the design to installation phase of the product development lifecycle to ensure that the product we provide meets our promise of engineering excellence."

The addition of the Bison lines is designed to enhance Kaman's ability to serve the electrical needs of customers looking for solutions that require reduced dimensions in a powerful, compact package.

"Bison's technological leadership is recognized throughout the industry and aligns well with Kaman's goal of providing high technology product solutions to our customers," says David Mayer, vice president of marketing for Kaman Industrial Technologies. "With Bison's reputation for innovative engineering and Kaman's focus on application-based selling solutions, this partnership has the potential to provide unique solutions to the challenges faced by our customers."

CSIA

ANNOUNCES RECERTIFIED MEMBERS, NEW ASSOCIATE AND PARTNER MEMBERS

The Control System Integrators Association (CSIA) recently recertified Automation Horizons, of Des Plaines, IL, and Integrity Integration Resources, of Plano, TX.

CSIA welcomed several new associate members: Cimation-Houston, of Houston; PACIV, of Indianapolis; PCI, LLC, of Detroit; Prolucid Technologies, Inc., of Mississauga, Ontario; and Shafer, Kline and Warren, Inc., of North Kansas City, MO.

Newly joined partner members are Electrochem Solutions, Inc., of Clarence, NY; QSI Corporation, of Salt Lake City; and VIPA USA, Inc., of Alpharetta, GA.

In order to become a CSIA Certified Member, member companies must pass an intensive audit process that includes stringent performance standards in nine categories: general management, project management, quality management, technical management, human resources management and marketing, business development and sales management.

Certified Members are re-audited every three years and recertified if they meet the required performance standards.

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CORRECTION

There was an inaccuracy in the April Power Transmission Engineering *story,* "Bogus Bearings Beat Price and Lead Time—But at What Cost?"—*regarding the economic scope and impact of counterfeit bearings. The figures reported—gleaned from the Bearing Specialists Association (BSA) website—refer to economic losses caused by counterfeiting in* general, *and are* not *specific to the bearing industry alone, which the story reported. Apologies to our readers and to the BSA for misstating the information.*

—Jack Mc Guinn, Senior Editor

ad index

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The Ultimate Control

We all dream of being our own boss, but living that dream is a rare reality. Not so for employees at Isthmus Engineering and Manufacturing, an entirely worker-owned cooperative, where each member has a vote in every aspect of the business. "We have complete say over what we do here," says Ole Olson, a controls engineer and owner/member of Isthmus.

Sounds more like an anarchic free-for-all that would have the likes of Rush Limbaugh clutching his chest and going numb in the left arm than a custom automated machinery designer and manufacturer.

The cooperative business model has been popping up more increasingly within the "green" movement in the United States, but we're more used to seeing it at our local grocers or farmer's market than in the business world. As far as industrial cooperatives go, the folks at Isthmus don't know any others like this in the country, although they may be more common in Europe.

Employees at Isthmus Engineering and Manufacturing own part of the business and have equal say in everything the company does.

John Kessler, a mechanical engineer and founding member of the Isthmus Engineering cooperative, explains the basic organizational structure: "We have 28 members, and every other Monday night we have a board meeting. We sit down and discuss major issues affecting spending money, hiring, firing [etc.]. We have a committee system within that that takes care of the computer system or the building itself or co-op issues. We have about nine different permanent committees; we have a general manager whose job is to keep an eye on things and to do what the board tells him to do."

Most of the work Isthmus performs is project based, meaning, when a contract order comes in, a team is assigned with project leaders, and that team is managed by the people on it.

Hiring for Isthmus is done from the general marketplace, and a new employee is not eligible to become part of the co-op for two years. They then need to apply and be approved by the board in order to join. Once voted to become a member of the co-op, an employee takes on certain risks that non-members do not assume. These include the responsibilities of being a member of management, as well as their health insurance and vacation time. "You can think of it as becoming self employed," Olson says. "You get the profit at the end of the year, but you have to supply your own benefits."

In return, the members work for a portion of the Isthmus profits and enjoy corporate autonomy.

"Every year, the board votes on what every member should make per hour," Kessler says.

"Hourly wage is based on what we're worth to the outside world. It's an average of what everyone on the board thinks," Olson says.

At Isthmus, the cooperative structure reinforces employees' work ethic. They are more compelled to share equal responsibility for their work.

Chris Kernkamp is currently undergoing the process of applying to be a member. Having previously worked for a company with traditional business practices, he views a positive difference in employee attitude due to the cooperative structure. "In the day-to-day work and the jobs—because they are project/team based—that team is in charge, and it is not a hierarchy structure," he says. "There's a lot more discussion involving all parties. Because of that, people are a lot more energized about the projects they are working on."

Olson also supports the co-op structure as a more positive one for workers. "I've been here 18 years, and for ten years before, I worked for a large machine tool manufacturer. It was a large company with several divisions. In the time I was there, the management turned over completely several times. They were bought and sold. We did what we were told.

"[At Isthmus] We get to decide how our company runs, what we build, what we don't build," he says. "We all have a say in that. We're not controlled by a company [that is] possibly in a foreign land. We operate autonomously."

Naturally, the members of Isthmus Engineering and Manufacturing experience disagreements, and everyone is entitled to speak up on, well, everything. "The small issues are the ones that everyone has an opinion on," Kessler says. "We made a decision to spend five million to build a new building, and it took a half hour meeting to decide. We probably argued all night about painting the mailbox."

Isthmus members view their business model as one where everyone benefits, including the community, which they make charitable contributions to, and their customers who see the value in the egalitarian employee work ethic.

At the end of the day, Isthmus Engineering and Manufacturing exudes great pride for the cooperative business model and how it differentiates them from other manufacturers.

"From a [human resources] perspective, a lot of what I read and hear about in management magazines or trade publications are the different processes companies use to try to empower employees to give them a false sense that they have a say in what they're doing," Kessler says. "We don't have to play those tricks; in reality, they do have complete control.

"When someone points out that something isn't fair or isn't working right, we work toward a better solution."

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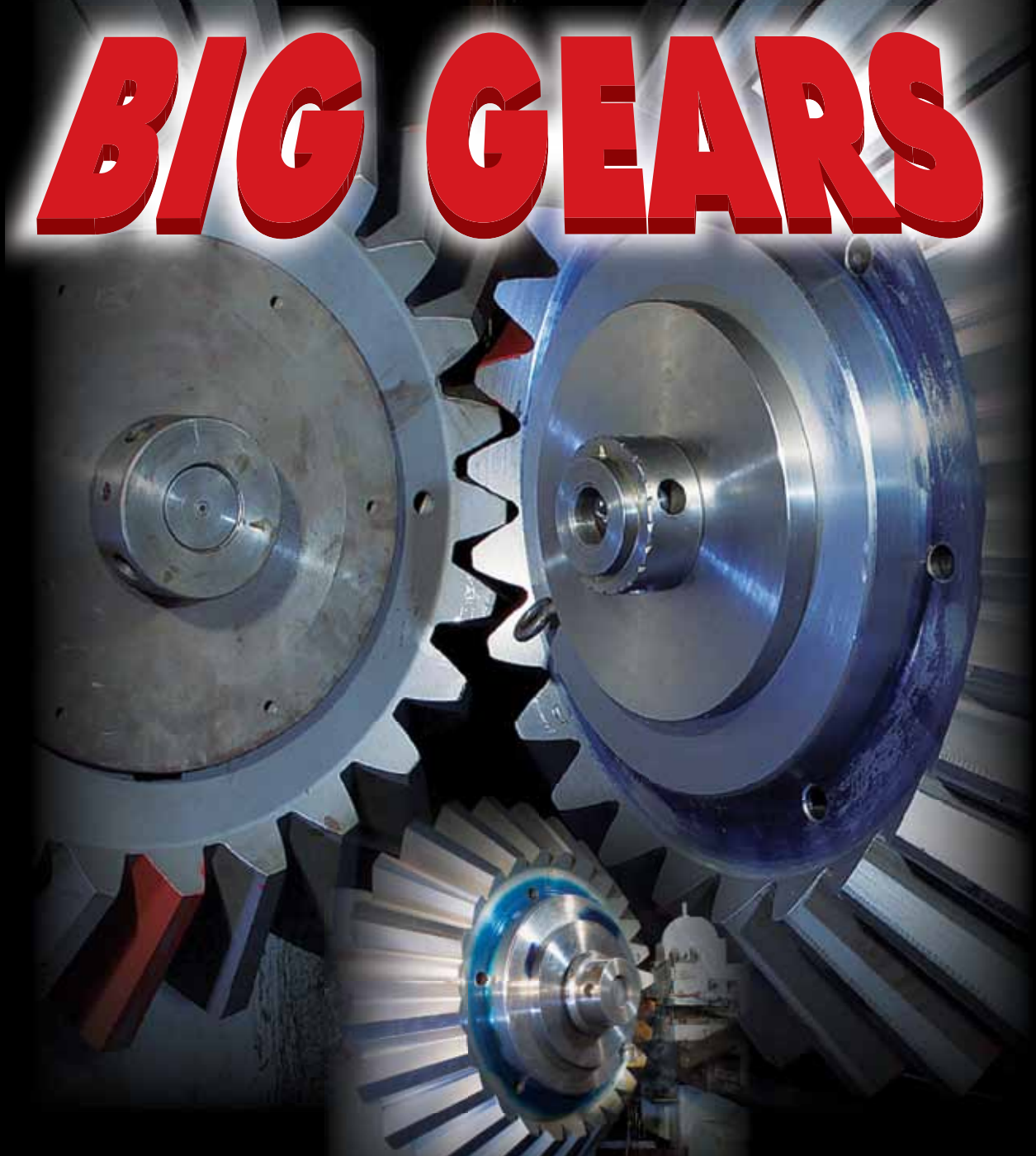

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