February 2010

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Features

- SEW Produces Energy Efficiencies
- AGMA Onboard for DOE Energy Initiative
- Recapturing Energy Dollars

Technical Articles

- Gear Reducer Housing Design via FEA
- The Right Bearing for the Right Application
- Putting a Premium on Motor Energy Savings

Power Play

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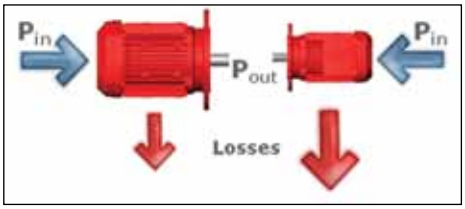

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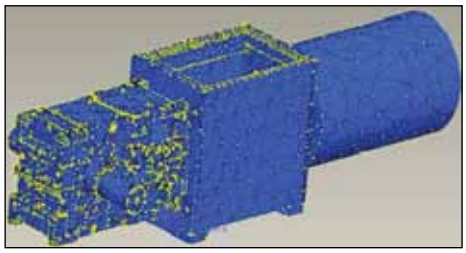

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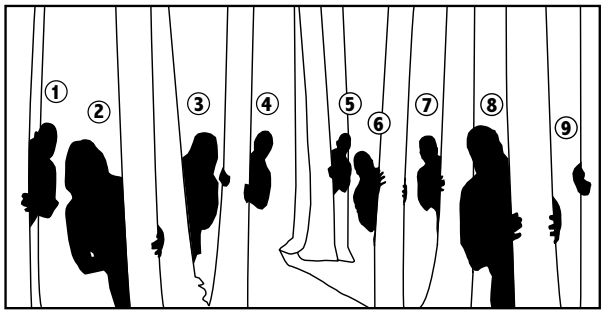
Who Says You Can't See The Forest (City) For The Trees?

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.

Using the industry's most advanced technologies for gearmaking and gear finishing, the next step is the production of prototypes for your approval. Often times, we see a better solution and suggest it immediately, because we have no "one size fits all" mentality in the mind's eye at our company. It's precisely this flexible approach to gearmaking and our innovative thinking that's made us a longtime leader in the industry. 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.



(1) Pat Keeley, (2) Wendy Young, (3) Kika Young, (4) Rustin Mikel, (5) Jared Lyford, (6) Gene Fann, (7) Tom Christenson, (8) Fred Young and the shy guy, (9) Everett Hawkins.

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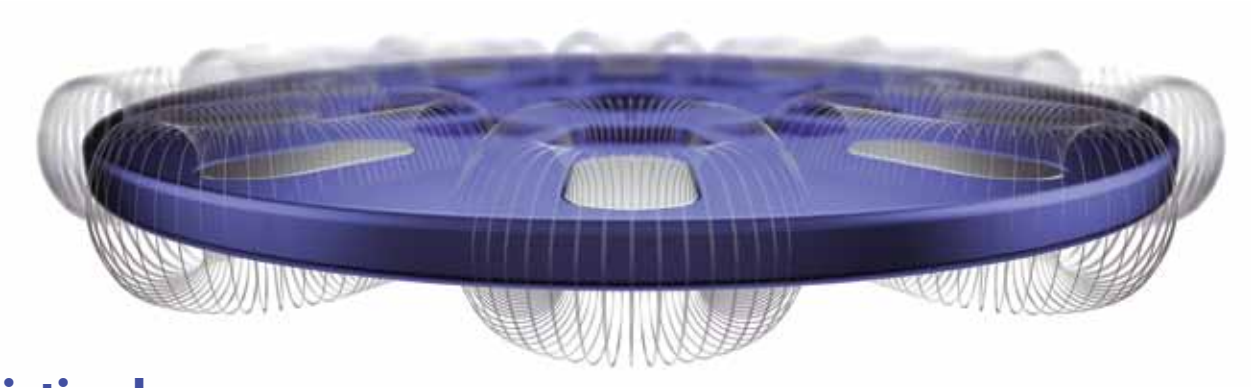
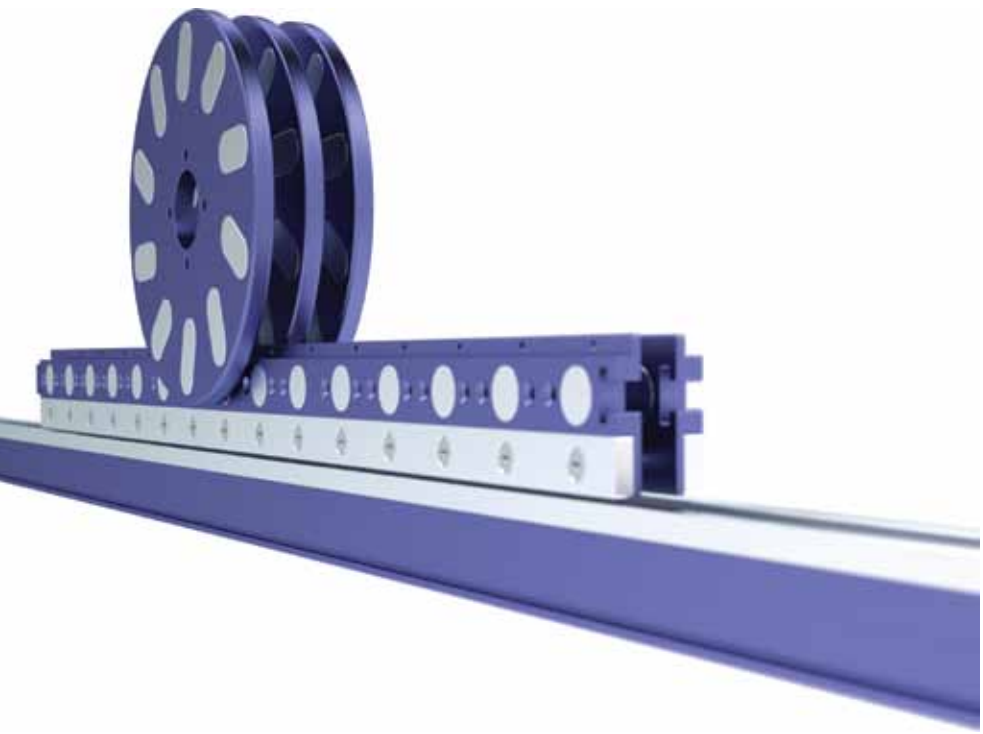


Frictionless, Magnetic Gears and Couplings

GAIN TRACTION

The Magnetic Gearing and Turbine Corp. (MGT), founded by Australian inventor Andrew French in 2000, manufactures injection molded gears and couplings based entirely on magnetic technology. The repulsive magnetic forces are used to transmit power without losing any energy, and drive shafts rotate completely independently of each other. The frictionless gearing and coupling systems operate with higher efficiency, much less maintenance and with little to no risk to the operator, French says.

Lining the circumference of each gear is a series of rare-earth, neodymium magnets, which are stronger than the standard equivalent and more heat-resistant. The gears can be stacked up to transmit large amounts of torque, like having three or four belts on one shaft. The MGT technology has made inroads in various industries including solar water pumps and agricultural machinery, but many other applications are possible.



The latest product from MGT is a DIY (do-it-yourself) range, which does not require installation by trained and authorized MGT agents and suppliers as the other industrial ranges do. This factor makes the DIY range significantly simpler than typical electromagnetic couplers. "They are only 10 mm thick, so they are not too dangerous for people to handle with no experience," French says. "They are the same gears we use on our solar pump range, and they can transmit up to 108 Nm with the 12 disks as a coupling. People can couple or use them as gearing around the farm or in the workshop. Also, a lot of OEMs can use them instead of belts or pulleys or as a coupling in the machines, vehicles, pumping systems, or anything they make."

The industrial range is 20 mm and more in thickness, so they can be dangerous if users don't know what they're handling. The only thing required to use the DIY range of gears and couplings is a basic mechanical understanding. "The DIY market is for farmers, workshops, one-off engineering jobs, water pumps, hydraulics, compressed air, robotics, small production lines and industrial applications; electric boats, electric cars and any other small applications," French says.

Five standard sizes are available, as are custom designs. The standard

magnetic wheels can be used either as gears or couplers. If the system is overloaded, it simply slips, avoiding potentially dangerous situations. Coupler faces don't touch, so no vibrations are transmitted.

The DIY range was tested to consume 22 percent less energy than a belt drive, as assessed by Sydney University and also in South Africa, by using the same MGT Solar Water Pump running with belts and pulleys against magnets. Other tests have been performed by Torque Test, in Holland, which could not define the difference between 99.9 percent and 100 percent efficiency. "This is unheard of, and most people would think it impossible," French says.

"It was believed that losses must occur, but no losses could be found."

The MGT technology has great potential for the mechanical power transmission industry and competition is steep. "We have covered and patented every possible magnetic drive, including linear drives, 90 degree bevel drives, transmitting power through walls, electro-magnetic drives and many more," French says. "We have five different patents, our first two have been granted in the U.S. and other countries, and three are still pending. We know we have companies copying our technology at present, and we intend on taking action to stop them over the next 12 months as we release our products."

MGT is pursuing other uses of the technology aggressively. Sometime this year French anticipates releasing a magnetic, frictionless gearbox for the electric car industry. MGT is also involved in plans to build an International Solar Showcase in Koh Samui, Thailand, which will demonstrate the best solar technology. Developing future transportation systems are also on MGT's radar, such as small electric taxis, like those common in Bangkok. Planetary gear drives for wind turbines are another possible use for the industrial range, since gearbox reliability issues are so critical in the industry.

In discussing the limitless nature of applications possible with magnetic gear systems, French expresses great passion for his technology and its potential. "There is so much more for mankind to explore."

For more information:
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Millenium Park
Pacific Highway
Via Karuah
NSW Australia 2324
Phone: + 61 (402) 383-352
Fax: + 61 (2) 4997-3073
sales@mgt.com.au
www.mgt.com.au

Safety-Oriented Rotary Encoders

FEATURE SMALL FOOTPRINT

Heidenhain Corporation's 1000 Series rotary encoders offer IP 64 protection, absolute position-value formation and functional safety in a 35 mm diameter housing size. These encoders are designed for single-encoder measurement feedback systems in safety-oriented applications.

The 1000 Series encoders with functional safety produce two independently formed position values by means of a serial EnDat interface. They meet EN ISO 13849, EN 61508 and EN 954-1 standards for performance level d, safety integrity level two and category three, respectively. The EnDat 2.2 version with serial data transfer provides a single-turn resolution of 23 bits and a multi-turn resolution of 12 bits. Supply voltage ranges from 3.6 to 14 volts. The 1000 Series is made up of eight rotary encoders.

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

BLDC Motors

OPERATE SMOOTHLY REGARDLESS OF SPEED RANGE

Lin Engineering has improved its NEMA 17 brushless DC motors, the BL17 line. The motors are appropriate for applications that involve high speed and high dynamic torque. The BL17 line provides quiet, smooth operation regardless of speed range. Speeds of up to 4,000 rpm are possible.

The motors are available in four body lengths: 1.7, 2.4, 3.2 and 3.9 inches. They are capable of up to 106 ounce-inches of peak torque depending on stack size. The BL17 motors are useful where velocity control with an analog input is desired, no holding torque is necessary and where there are reliability issues with existing brush DC motors. They can be ordered with custom shaft and winding variations to meet exact speed/torque/voltage points.

For more information:
Lin Engineering
Phone: (408) 919-0200
sales@linengineering.com
www.linengineering.com

Yaw Position Transducers

ENGINEERED FOR WIND APPLICATIONS

Micronor's MR200W series yaw position transducers monitor position, direction, speed and cable twist while providing feedback to the yaw directional motor drive and brake control system. The transducers were designed specifically for wind turbine applications.

The MR200W position transducer can be multifunctional and integrate any combination of geared limit switches, rotary encoders, resolvers or potentiometers. The unit can be supplied with an external anti-backlash POM (polymer) pinion gear, which optimizes coupling to a turbine's large yaw bull gear for increased accuracy and repeatability.

Engineering evaluation units can be delivered within four to eight weeks and production units within four weeks thereafter.

For more information:
Micronor Inc.
750 Mitchell Road
Newbury Park, CA 91320
www.micronor.com

J.W. WINCO

OFFERS BALL TRANSFER UNITS

Industrial machine component supplier J.W. Winco Inc. released the series GN 509 steel and stainless steel ball transfer units. The metric sized components are for use on conveyor tracks to enable linear or rotary movement of heavy loads.

Three versions are available: Type SBL, with zinc-plated housing, blue passivated sheet steel and a plain finish steel ball; Type SNI, with zinc-plated housing, blue passivated sheet steel and a stainless steel ball; and Type NNI, with both a stainless steel housing and ball. All types are RoHS compliant. The transfer units have a load capacity of 500 to 2,000 N, depending on size and type.

For more information:
J.W. Winco Inc.
Phone: (800) 877-8351
Fax: (800) 472-0670
sales@jwwinco.com
www.jwwinco.com

Electric Cylinders

PROVIDE ALTERNATIVE TO PNEUMATIC, HYDRAULIC SYSTEMS

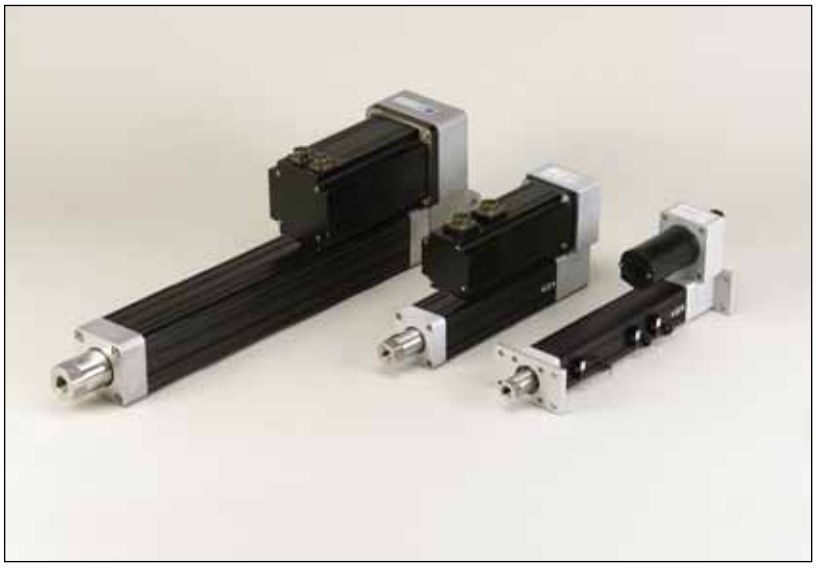
Kollmorgen's EC1 electric cylinders are a cost-effective, high-performance linear positioning alternative to pneumatic and hydraulic systems in applications that require continuous thrust of up to 150 pounds (660 N). They provide smooth, controllable speed, up to 0.325 m/s, accurate mid-stroke positioning and position holding without power (with brake option), in a compact package.

"EC1 electric cylinders fill the market need for a small-thrust electric linear positioner with a low enough price point to make it an attractive and beneficial alternative to pneumatic and hydraulic actuation," says Gene

continued

Mathews, chief application engineer for Kollmorgen. "They are more accurate, use less energy and provide true controlled motion compared with the simple 'start/stop' limit switch motion of pneumatics. They also reduce parts count and maximize machine uptime by eliminating the valves, pipes and hoses required of pneumatic and hydraulic options."

The EC1 electric cylinders deliver standard stroke lengths from 50 mm up to 200 mm; they handle maximum payload weight of 150 pounds at 100 percent duty cycle. The cylinders deliver repeatability to ± 0.001 inches with lead accuracy to ± 0.004 inches per foot with backlash of 0.015 inches. Performance combined with a compact footprint make the EC1 suitable for use in space-restricted applications, including testing systems, test sample placement in medical applications and general factory automation machines that require precise, repeatable motion.



For more information:
Kollmorgen
203A West Rock Road
Radford, VA 24141
Phone: (540) 633-3545
contactus@kollmorgen.com
www.kollmorgen.com

Right Angle EG Planetary Gearheads

FEATURE LOW-COST SOLUTIONS

A series of right angle EG planetary gearheads from Sterling Instrument, an ISO 9001:2000+AS9100B registered manufacturer, features low cost and is offered in four standard NEMA sizes: 17, 23, 34 and 42. These gearheads, identified as the S91 SREG Series, feature the planetary system, high torsional stiffness, and case-hardened spiral bevel gears, and the units are sealed to extend service life. They offer both single- and double-stage design and include a precision-balanced, clamp-on pinion. Woodruff keys number 404 and motor mounting hardware kits are supplied.

Each of the four NEMA sizes is offered in 13 gear ratios ranging from 3:1 to 100:1. Their maximum input speed is 5,000 rpm. Their radial and axial shaft loading is 400 pounds. Their single-stage and double-stage minimum efficiencies are 85 percent and 80 percent respectively. Operating temperatures range from –40 degrees Fahrenheit to +225 degrees Fahrenheit. The housings are made of gold zinc plated steel. The right-angle housing and mounting flanges are made of black anodized aluminum.

Detailed specifications are contained in Catalog D795, available free upon request from Sterling Instrument.

For more information:
Sterling Instrument
2101 Jericho Turnpike
P.O. Box 5416
New Hyde Park, NY 11042-5416
Phone: (516) 328-3300
Fax: (516) 326-8827
www.sdp-si.com

Tensioner

COMES READY TO MOUNT

Misumi USA's Tensioner is a ready-to-mount mechanism that eliminates design and assembly time and labor for end users. The Tensioner, comes fully assembled, complete with slotted holes and adjustment screws for easy mounting, installation and tension control.

The attachment plates and tension block are constructed from 1018 carbon steel, tension pins are 1045 carbon steel, and the slide plates are 1045 precision cast carbon steel.

Fully assembled Tensioner units come in various sizes and configurations with selection based on application needs, including stroke, load and tension.

For more information:
Misumi USA, Inc.
Phone: (800) 681-7475
inquire@misumiusa.com
www.misumiusa.com

Steinmeyer

INTRODUCES
ULTRA NARROW LINEAR STAGE

The PA 30x40-SM01 precision linear stage from Steinmeyer, Inc. is a single axis system for applications that require extremely narrow positioning tables. Typical applications include miniature robotics, pick and place devices, specimen handling for life sciences and scientific applications where precision positioning is required within a very narrow footprint.

The compact, fully enclosed stage measures 30 mm wide and 40 mm high. Travel ranges between 25 mm and 150 mm. Positioning repeatability is 1 micron, maximum speed is 50 mm/s, and load capacity is 100 newton. Inside the assembly is a precision preloaded 8 mm diameter Steinmeyer ball screw, miniature size 9 linear guideway, non-contact limit switches and a choice of either stepper motor or DC servo motor with encoder. A separate motion controller is an available option.

For more information:
Steinmeyer, Inc.
56 Middlesex Turnpike, Suite 200
Burlington, MA 01803
Phone: (781) 273-6220
Fax: (781) 273-6602
www.steinmeyer.com

Automation Direct

OFFERS UNIVERSAL SIGNAL CONDITIONERS

Universal signal conditioners from Automation Direct convert, isolate and transmit scale signals from a range of process sensor and controller I/O. The DIN-rail mountable models (884114 and 84116) come in plastic slim-line housings. They support scalable input signals including mA, VDC, thermocouple with internal cold junction compensation, two- to four-wire RTDs, linear resistance and potentiometer signals.

Both models feature mA and VDC outputs. The 84116 model adds two individually programmable relays for alarming and control functions. Isolated universal supply voltage input does away with the need for separate transformers or power supplies.

A menu-structured LCD programming/display module, which is sold separately, features automatic scrolling text identifying each menu item. The detachable module stores and transfers configuration parameters from one signal conditioner to another. This reduces setup time with multiple unit applications. The module supports seven programming languages and can be password protected. The display module can be used to show input signal values, engineering units, output signal and relay status when not in use for configuration.

For more information:
Automation Direct
3505 Hutchinson Road
Cummings, GA 30040
Phone: (800) 633-0405
www.automationdirect.com

PDP

REDUCES MESH BACKLASH

As the first range of Preloaded Double Pinion from Redex Andantex for high precision rack and pinion applications, the PDP is made of two ground WMH pinions connected through a patented preload system to reduce mesh backlash. The PDP is a competitive alternative to high performance ball screws.

The gear teeth mesh precisely when the coupling is engaged. In many applications, it can eliminate the need for two coupled planetary reducers. The PDP is mounted at the output flange of Redex Andantex' SRP high-tech planetary gearhead, where it demonstrates repeatability of less than 0.1 mm, high torsional rigidity, high radial rigidity and tilting moment levels. The sub-assembly SRP-PDP is between 10 and 20 percent higher in rigidity than other units.

The PDP features a high input speed up to 1,200 rpm, maximum acceleration

continued

torque and nominal torque from 1,000 to 2,840 Nm. When mounted on the SRP, other features include four different modules with straight or helical teeth, eight reduction ratios, angle drive version available in all sizes and full solutions with reducer, pinion and rack available in all sizes. The input interface is available throughout the range in an in-line flange version or with a 90 degree angle (associated with a high-quality angle drive).

For more information:
Andantex USA
1705 Valley Road
Wanamassa, NJ 07712
Phone: (800) 713-6170
Fax: (732) 493-2949
info@andantex.com

Linear Actuator

EXTENDS RELIABILITY

The Haydon Kerk Motion Solutions' G4 37000 series can-stack stepper motor linear actuator is a 36 mm version of the G4 line of products. Technical improvements made to this series include optimized stator tooth geometry, high energy neodymium magnets, an oversized output spline, custom engineered plastics and larger ball bearings for improved rotor support and high axial loading capabilities.

The new series provides a high linear force-to-size ratio. It is ideal for precise linear motion in a range of applications including medical equipment, bar code scanning devices, printing equipment, lab instrumentation and other mechanisms that require high force and durability from a small package.

For more information:
Haydon Kerk Motion Solutions, Inc.
1500 Meriden Road
Waterbury, CT 06705
Phone: (203) 756-7441
Fax: (203) 756-8724
info@haydonkerk.com
www.haydonkerk.com

Latest Mechatronics Software Version

INSTALLS SIMPLER

ITI GmbH released the latest version of *SimulationX*, its software for physical modeling of mechatronics systems. Version 3.3 provides functional enhancements and will be available with on-demand software licensing for the first time. The palette of ready-to-use, real-time capable models and physical components was expanded by ten percent. A highlight of the new release is the first independent *SimulationX Modelica* edition. The all-in-one installation package simplifies the installation process by installing all required program components via a single setup automatically according to

the user's particular needs and profile.

SimulationX 3.3 is easily adjusted to the different profiles of users and is now available in two editions, *SimulationX Professional* edition and *SimulationX Modelica* edition. With the *Modelica* edition, *Modelica* experts can now design and exchange individual models by using *Modelica* language inside *SimulationX*. Users benefit from the combination of user friendly simulation software with the flexibility and formalism of a true *Modelica* platform. Delivering this new edition quickly to the market, ITI has responded to the growing demand for an open standard for exchanging models. Manufacturers, OEMs and service providers can now design, exchange and re-use simulation models.

The program handling safeguards the overview of the complete model, even during later changes and enhancements. Thanks to manually editable connections between model components and highlights in colors for dynamic visualizations, the user can immediately detect changes in the model. Quality of models and reliability of modeling results are increased while time for validation is reduced as, for instance, deviations from admissible values are observable at a glance. Another enhancement in ergonomics is achieved by additional views. The structure view and 3-D model view are enhanced with additions of documentation and text view, enabling models to be changed and enhanced directly in the *Modelica* text format.

One of the highlights of the *SimulationX Modelica* edition is the advanced graphic editor that allows the user to set up demanding graphics in a convenient way. The improved model explorer of the *SimulationX StatechartDesigner* displays the different states as well as the transitions between them. This simplifies the navigation within complex state charts. The *SimulationX 3.3* Professional edition broadens the modeling scope with more than 20 new model types in the power transmission library, e.g. for combustion engines, clutches, transmission elements, cam disc mechanism and propellers. Other new functions and model types are also available in the libraries signal blocks, actuation, electronics and magnetic. New features in the 1-D Mechanics allows for all elastic elements such as springs and dampers to be switched to rigid. This allows the user to analyze the model's kinematic behavior in a more precise and effective way.

The use of *SimulationX* models in real-time platforms significantly expands the possibilities in design, prototyping and series launch of machines and plants. *SimulationX 3.3* contains interfaces to the NI real-time testing and simulation platforms LabVIEW and NI VeriStand as well as new solvers with constant step size. This facilitates the test and optimization of the model's real-time capabilities without biasing the model itself.

"We are proud to be able to offer our customers real functional innovation across all development areas. It's not in our development plan it's in our new release, and it's available now on schedule. Considering all enhancements connected with a 50 percent reduction in required results storage and increased solver speeds makes *SimulationX* an unbeatable modeling tool," says Thomas Neidhold, ITI manager software development. "*SimulationX 3.3* is a genuine *Modelica* platform. It represents real-time capability, total user friendliness and greatest flexibility."

For more information:
ITI GmbH
Webergasse 1
01067 Dresden
Germany
Phone: +49 (0)351-260 50-150
marketing@iti.de
www.iti.de

Maxon

RELEASES EXTREME HIGH DENSITY DRIVE

The RE 50 from Maxon motor features an ironless rotor, which results in detent-free running and minimized mass inertia. The drive combines a two-pole neodymium permanent magnet with Maxon's patented winding technology for high torque and acceleration.

The drive measures 50 mm diameter x 108 mm length and is available with four windings. It achieves a nominal torque of up to 0.38 Nm, a nominal speed of 2,800 to 5,700 rpm and efficiency of more than 90 percent. Low nominal voltage of 24.70 VDC and high power density make the RE 50 appropriate for use in battery-powered applications, including electric vehicles, transport and logistics equipment, mobile systems, robots, etc. Pre-loaded bearings contribute to low vibration, quieter running and an extended life span.

For more information:
Maxon Motor
101 Waldron Road
Fall River, MA 02720
info@maxonmotorusa.com
www.maxonmotorusa.com

Total System Efficiency

Matt Murray, SEW Eurodrive

Total cost of ownership is not just a buzz phrase; it's a philosophy for creating a sustainable business model in today's environment of shrinking resources and increasing energy costs. Based on worldwide energy usage figures (Ref. 1), humans will double their current energy consumption by the year 2035 (a mere 25 years), as shown in Figure 1. Much of the industrial energy being consumed by systems is wasted through inefficiency. For this article, a system will be defined as the following components working together: electrical input power, variable frequency drives, induction motors, gearboxes and transmission elements (chains, belts, etc.).

No single component within a system is 100 percent efficient. Converting some of the intended work output to heat is a necessary evil of any process. However, the amount of heat (wasted energy) created by a process can be minimized through thoughtful and careful selection of individual components.

Each component introduces its own inefficiency to the entire system. Each efficiency is multiplied together to obtain an overall efficiency for the system, as shown in Figure 2. One individual component with a poor efficiency rating has a multiplicative effect on the rest of the system. Look at Equation 1 for a theoretical example of an ideal system where each individual component is 99 percent efficient (η is the symbol used for efficiency).

Even using ideal values, a system with six different components results in 94.15 percent efficiency. Another way to look at this is 5.85 percent of the energy put into this system is merely converted to heat and wasted, and this is with an ideal system. Now let's examine a more realistic system using good, efficient components, as shown in Equation 2.

These good components result in a total system efficiency of 79.76 percent. A staggering 20.24 percent of the input energy is simply converted to heat and wasted. Remember, these are good components. How can we prevent this loss of energy, and where do we have the greatest potential for energy savings (Ref. 2)? The greatest potential gains in efficiency lie in the mechanical components, followed by electronic speed control and increased efficiency motors (Table 1).

Let's break this system down into its individual components and analyze where and how we can recover some of this lost energy.

Electrical Input Power

The first part of our theoretical system is the electrical input power. The majority of industrial electrical loads are inductive as opposed to being resistive or capacitive in nature. This inductive loading causes a shift in the phase relationship between voltage and current as shown in Figure 3. This phase shift results in reactive power. Reactive power is not used by the load to accomplish useful work like real power (kilowatts); it is inefficiency. The reactive power is actually the negative power shown in Figure 4. The phase shift caused by inductive loads can be corrected by introducing capacitance into the

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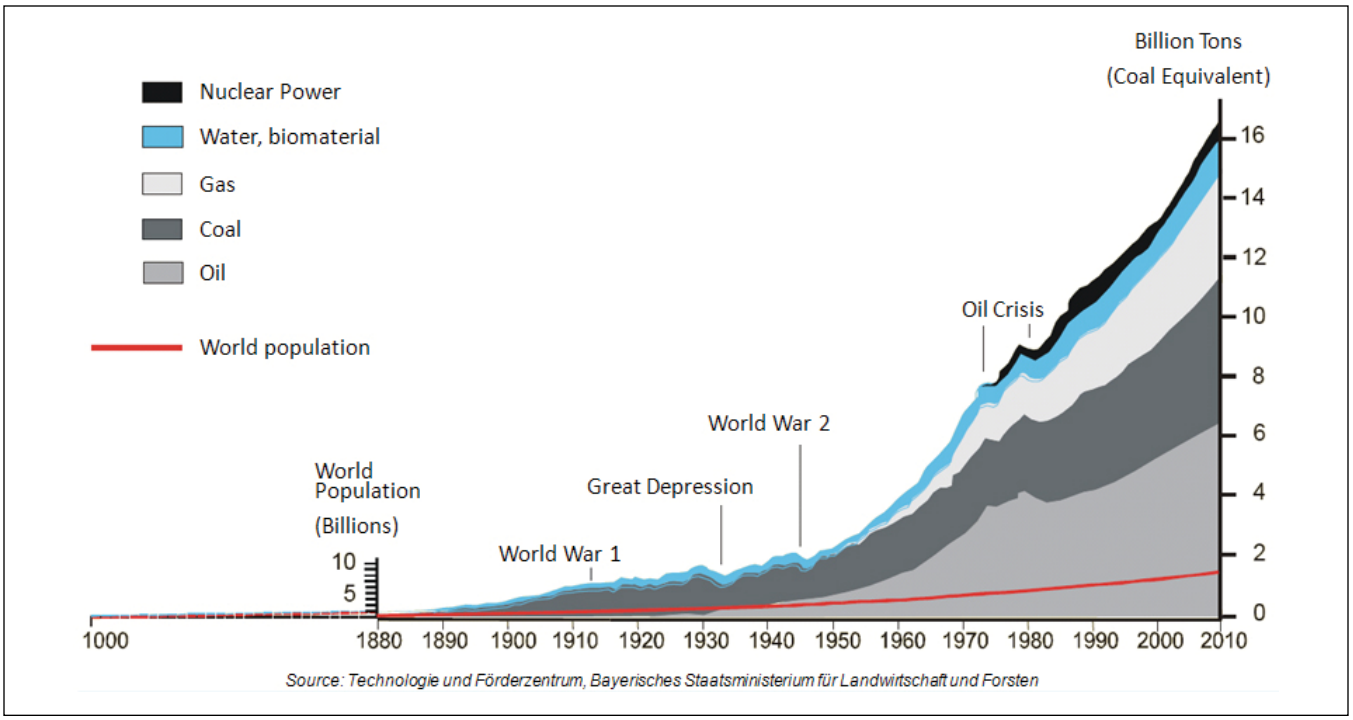

Figure 1—World energy consumption.

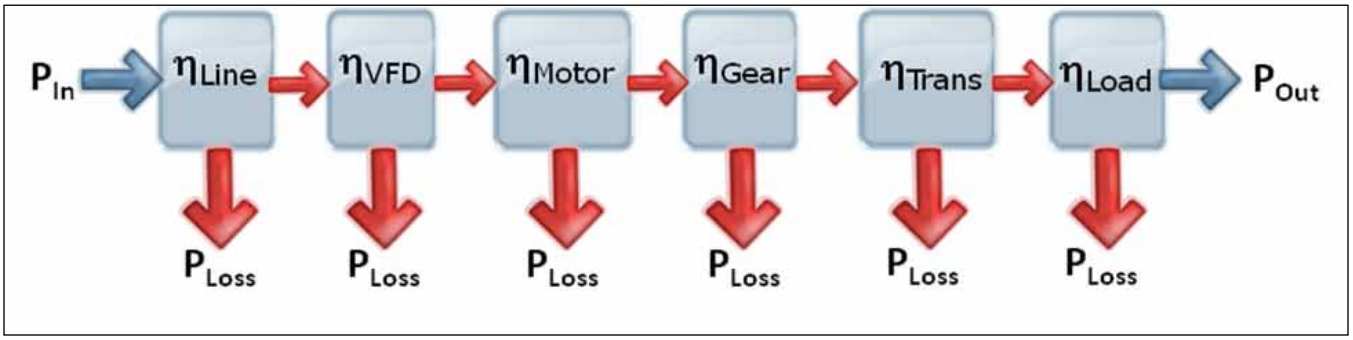

Figure 2—Total system efficiency.

$$\eta_{System} = \eta_{Line} \times \eta_{VFD} \times \eta_{Motor} \times \eta_{Gear} \times \eta_{Trans} \times \eta_{Load}$$

$$\eta_{System\ (Ideal)} = 99\% * 99\% * 99\% * 99\% * 99\% * 99\% = \mathbf{94.15\%}$$

Equation 1—Ideal system efficiency.

$$\eta_{System\ (Good)} = 98\% * 96\% * 92\% * 95\% * 99\% * 98\% = \mathbf{79.76\%}$$

Equation 2—Realistic system efficiency.

Table1—Energy Savings Potential

	Energy Savings Potential
Mechanical System Optimization	60%
Electronics Speed Control	30%
Use of Higher Efficiency Motors	10%

system. Ideally, if the capacitive properties equal the inductive properties of a circuit, then all of the electrical power is used by the load with no reactive power being created. When there is no phase shift and all of the power is being used by the load, all of the power is positive and can be measured in kilowatts as shown in Figure 5.

Electronic Speed Control Devices

Next, we have an electronic speed control device. There is an urban legend out there that adding an electronic speed control device automatically makes a system more efficient. This is not true. Think of it this way: We know that no single component is 100 percent efficient. If we change nothing in a system other than introducing an extra component, what happens to the efficiency? It goes down. While an electronic speed control device can't make a system more efficient, the proper application of such a device can. An electronic speed control device can save energy during the starting of a motor.

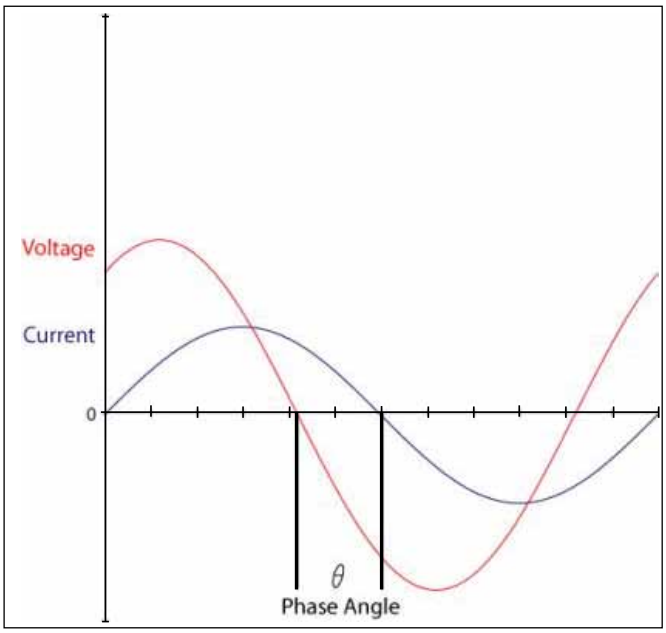

Figure 3—Electrical phase shift.

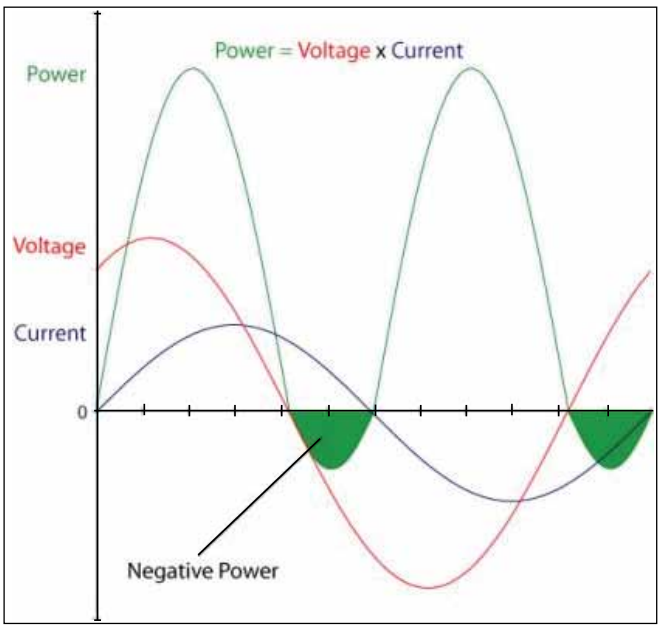

Figure 4—Reactive power.

As mentioned earlier, there is the potential for saving energy, but how? The most effective method is reducing the speed of the system. The majority of losses in any system are from mechanical components (various frictions). All friction losses are either directly proportional to or have a squared relationship to speed. Reducing the speed reduces the friction; reducing the friction reduces the losses; reducing the losses increases efficiency. Other areas of savings with electronic speed control devices are varying manners of recovering the regenerative energy created when an induction motor acts like a generator (during deceleration, overhauling load conditions and downward vertical movement, to name a few ways). One method of recovering regenerative energy is by using a regenerative power supply to recondition the regenerative energy and put it back on the main power supply. Another technique is to link the DC bus of several inverters together and share the regeneration of a decelerating drive to power a linked accelerating drive.

However, there are additional losses associated with electronic speed control devices. The easiest loss to point out is that of the electronic device itself. All of the components inside use energy-processors, resistors, inductors, capacitors, LEDs. All of these components create heat, and heat equals loss. These days, electronic speed control devices are essentially computers. Computers get hot and have losses, as do electronic speed control devices. Moreover, electronic heat loss is not the only inefficiency present in modern electronic speed control devices. Another concept that is often overlooked is that an electronic speed control device converts AC to DC and back to AC. This energy conversion process also yields losses.

A more abstract topic is that of harmonics. The pulse width modulated (PWM) output of the electronic speed control device is actually pulsed DC. The voltage signal does not look anything like the familiar sine wave to which an induction motor is accustomed. This square pulse signal creates harmonics. These harmonics induce a loss in the induction motor itself. The more pronounced the corners of the pulses, the more harmonics that are created, which in turn creates more losses. These harmonics can actually increase the motor losses up to 10 percent (Ref. 3). The increased frequency of a PWM signal also increases the losses of the supply cable running between the electronic speed control and the motor. These cable losses are typically on the magnitude of 1–4 percent. There is some good news on the cable between the source transformer and the electronic speed control device. Because the electronics contain capacitance, there is an improved power factor (compared to operating a motor directly from the mains without an electronic speed control device). This improved power factor can reduce the losses on this cable by about 20 percent.

Induction Motors

The induction motor is the next piece of the puzzle. Great strides have been taken by both standards organizations such as NEMA (*Ed's note: See sidebar page 22*) and the federal government to increase the minimum allowed efficiency of induction motors in the United States (Refs. 4–5). There are basically two ways to increase the efficiency of an induc-

tion motor: use better materials during the construction or oversize the active parts (windings, rotor cage and laminates). Both methods are equally effective. Motors may use either or both methods to increase efficiency.

Using better materials during the construction is simple enough to understand. Most rotor cages in standard-efficiency induction motors are aluminum. Aluminum (Ref. 6) is a fairly good conductor and lends itself to inexpensive manufacturing costs, but copper (Ref. 6) is an excellent conductor (approximately 35 percent better than aluminum). A better conductor creates less heat, and therefore reduces the losses (Fig. 6).

Another method to increase the efficiency of induction motors is through over-sizing the active parts of the motor. Imagine an induction motor with a nominal rated current of 1 ampere. Suppose this motor is operated with exactly 1 ampere of load and under these conditions the motor gets warm to the touch, not uncommon in typical induction motor applications. Now imagine that we replace that motor with one that has a nominal current rating of 2 amperes. Keeping the load constant at 1 ampere of current, how would one expect the temperature of the second motor to behave? You would be correct in assuming that the temperature will go down. If the motor is not creating as much heat, the losses are reduced. This is the basic concept behind over-sizing a motor to achieve an increased efficiency rating (Fig. 7).

Bear in mind that both of these situations (using copper for the rotor and over-sizing the motor) result in a few important changes to the operating characteristics. First and foremost, either method will increase the inertia of the motor. Copper is more dense than aluminum, and the shape of an object affects its inertia more than the mass. Additionally, energy-efficient motors are designed for situations where the motor is continuously energized for long periods of time, not applications with high cycling rates.

The Gearbox

Now we get to heart of the matter—the greatest potential for energy savings—mechanics. The gearbox being driven by

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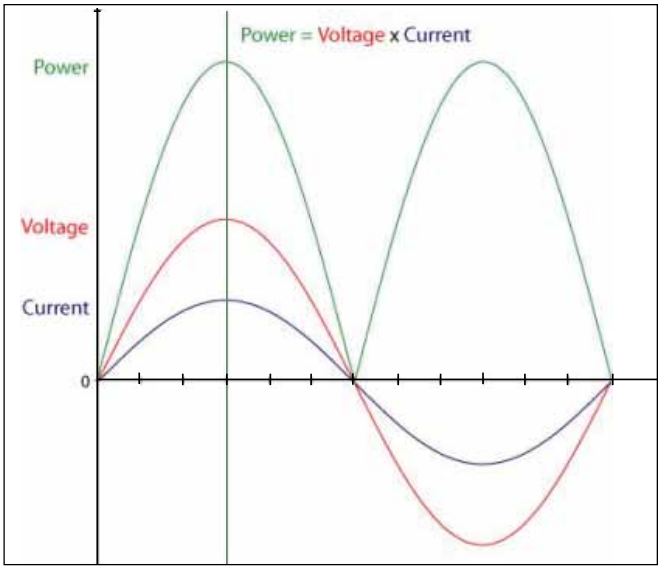

Figure 5—Ideal electrical loading conditions.

Figure 6—Copper rotor bars.

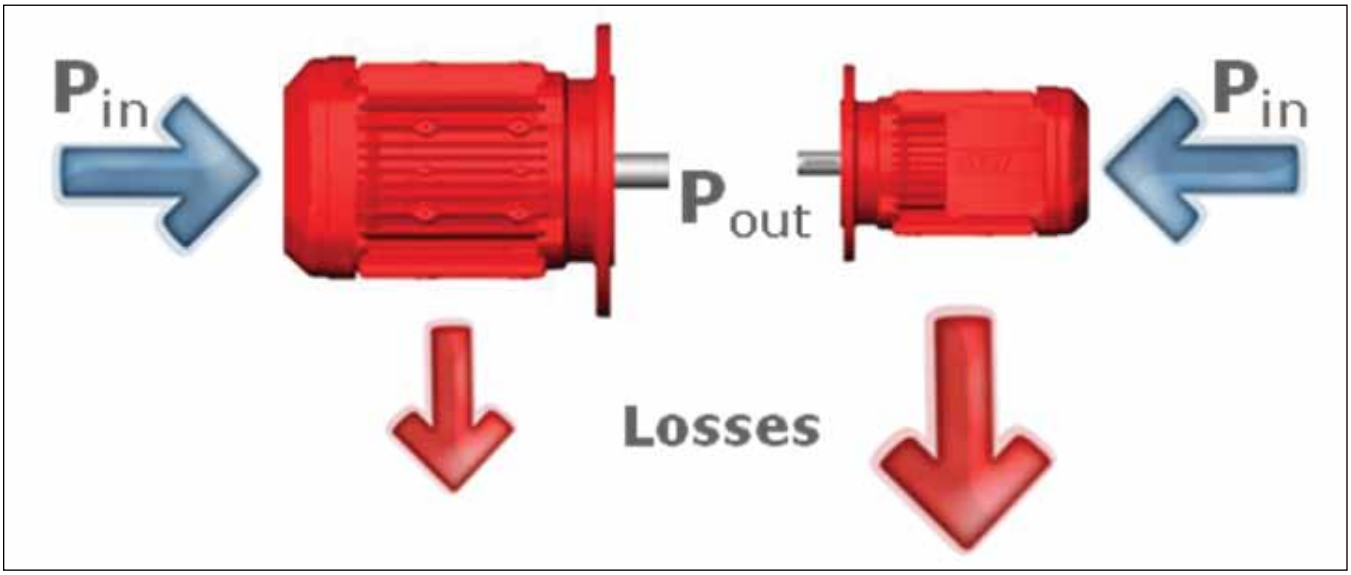

Figure 7—Over-dimensioning a motor to increase efficiency.

the induction motor can be the greatest contributor to inefficiency. There are various losses associated with any component in a system. The main contributors of gearbox losses in order of importance are:

Meshing between the teeth
Gears churning through oil (or grease)
Friction of bearings and seals

Gear Mesh Losses. Gears mesh through a combination of rolling contact and sliding contact. Spur, helical, and bevel gears are considered rolling contact gears, because the majority of the contact is of the rolling type. A typical estimate of the power loss in rolling contact gearing is 1.5 percent per stage. Worm gear sets use mostly sliding contact to transfer torque. The efficiency of a worm gear set is mainly determined by the number of threads on the driver (Fig. 8).

As you can see from the numbers in Table 2, the efficiency of a worm gear set can vary drastically. Without question, certain applications that must withstand heavy shock load or provide increased back-driving resistance may require a worm gear set. But, in comparison to the single-tooth worm gear efficiency (approx. 50 percent in some cases), there are alternatives that can improve the total cost of ownership. Wasting 50 percent of the input energy seems a bit much when the worm gear is not required by the demands of the application (which is not often). Of course, the initial cost of a helical-bevel gearbox is much higher than that of a worm gearbox, but the majority of lifetime cost will be the electricity purchased to run the system. Therefore, it makes sense to think of the total cost, not just the initial purchase price (Fig. 9).

The type of lubricant selected also contributes to the efficiency of a gearbox. Synthetic lubrication can reduce the amount of mesh loss per stage by approximately 33 percent. Using a the rule of thumb that rolling contact gears have a loss of approximately 1.5 percent per stage, using synthetic oil would reduce this loss to around 1.0 percent per stage. How much impact can 0.5 percent really make? Over the life of a

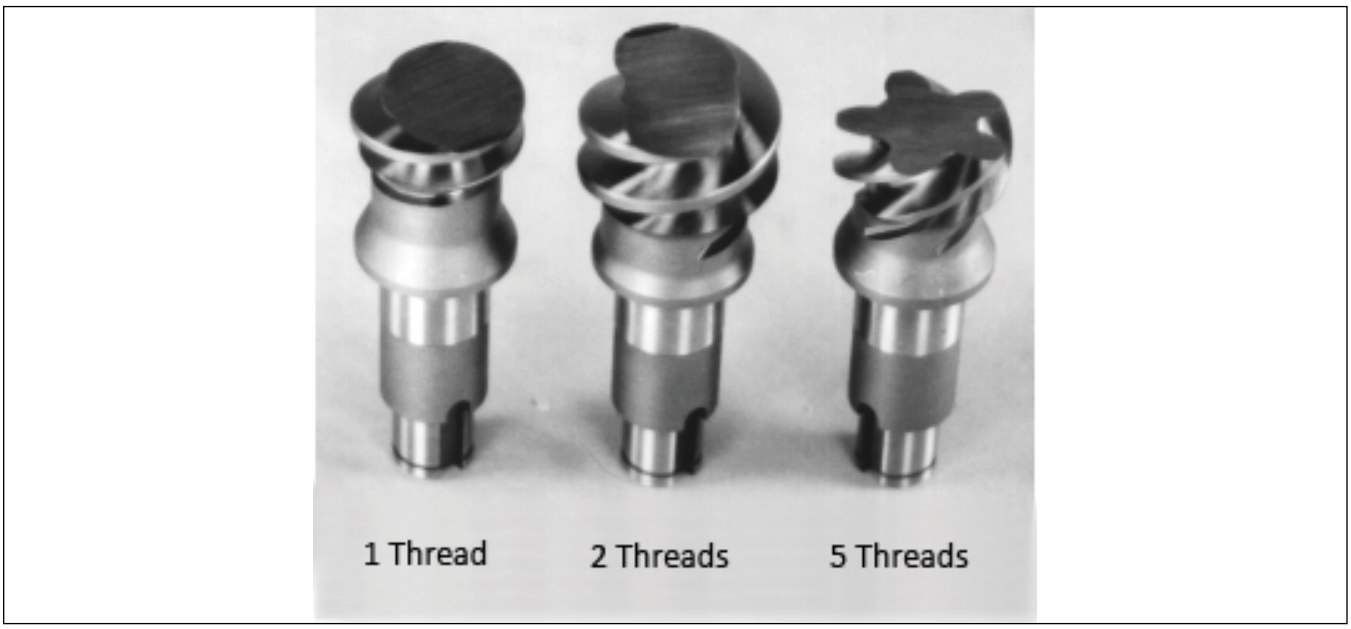

Figure 8—Cross-section view of a worm gear.

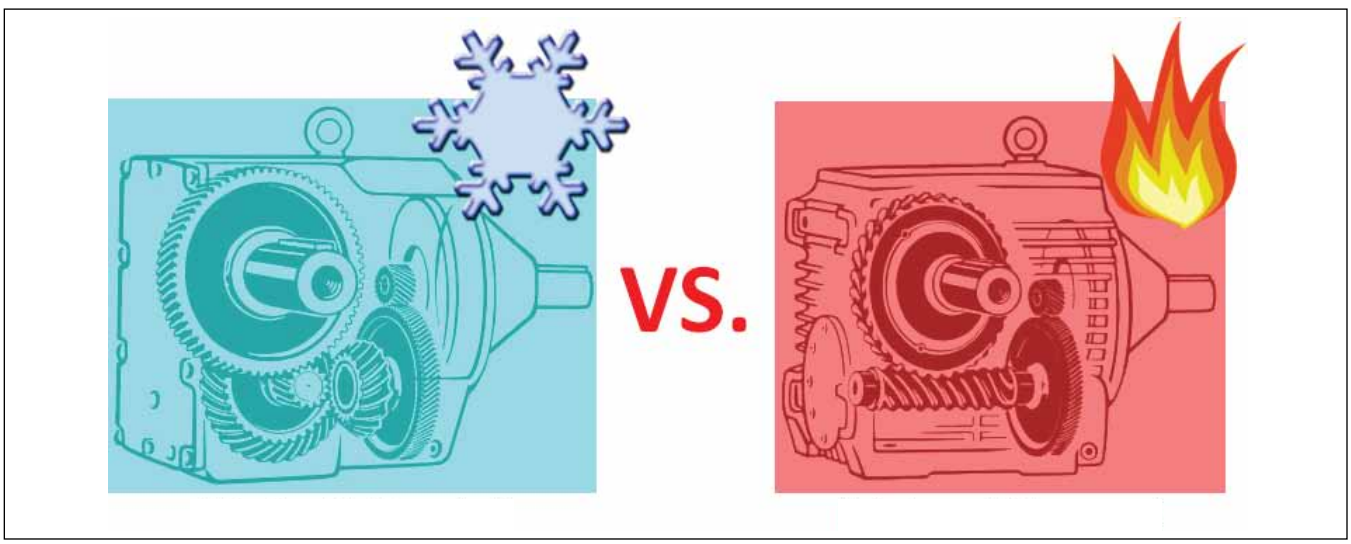

Figure 9—Helical-bevel rolling contact versus helical-worm sliding contact.

system, it can make a significant difference. Take a look at the following example of a three-stage helical-bevel gearbox with mineral oil in Equation 3.

Changing the oil (and nothing else) results in an energy savings of 1,172.5 kW hours per year. That's on one gear motor. Imagine a plant with 100 units like this. That would be an annual savings of 1.1725 MW-hours (not to mention the $11,725). Synthetic oil, shown in Equation 4, also lasts longer than mineral oil. The decreased change interval leads to more savings (not to mention lower disposal costs).

Churning Losses. The second largest loss in a gearbox deals with churning. Churning losses are caused by internal friction between the lubricant molecules. There is also friction between the lubricant and the gears themselves. The gears have to constantly "plow through" the lubricant during operation. Lubricant must be applied to all gear teeth mating surfaces during operation to prevent metal-to-metal contact. The amount of lubrication used is determined by the mounting position of the gearbox, and this determines the amount of churning losses that will be present, as shown in Figure 10. Consider the same gearbox mounted in two different positions requiring different lubrication levels. The amount of churning loss in a vertically mounted gearbox is greater than that in a horizontal one (because one gear set will always be completely submerged in lubrication). The difference in efficiency is not astronomical (on the order of a few percent), but every percentage point adds up to large energy savings over the lifetime of a system.

Bearing and Seal Friction. Bearings and seals make up a smaller percentage of the overall losses in a gearbox. Antifriction bearings can be selected to reduce their contribution

continued

Table 2—Worm Gear Efficiency Based on Teeth	
Number of Teeth on Worm Gear	**Typical Efficiency Range**
1	**≈ 50-69%**
2	**≈ 70-79%**
5	**≈ 80-88%**

EXAMPLE: High efficiency motor (10 Hp = 7.5 kW) 87.50%
3 stage helical bevel gearbox (mineral oil) 95.50%
Shaft mounted 100.00%

η_{System} = 87.50% * 95.50% * 100.00% = 83.56%

7.5kW * (24 hour/day) * (350 days/year) / (0.8356) = 75394.93 kW-hour / year

(75394.93 kW-hour / year) * (10¢ / kW-hour) = $7539.49 / year

$ 7539.49 annual operating cost with mineral oil

Equation 3—Operating cost with mineral oil.

EXAMPLE: High efficiency motor (10 Hp = 7.5 kW) 87.50%
3 stage helical bevel gearbox (synthetic oil) 97.00%
Shaft mounted 100.00%

η_{System} = 87.50% * 97.00% * 100.00% = 84.88%

7.5kW * (24 hour/day) * (350 days/year) / (0.8488) = 74222.43 kW-hour / year

(74222.43 kW-hour / year) * (10¢ / kW-hour) = $7422.24 / year

$ 7422.24 annual operating cost with synthetic oil

Equation 4—Operating cost with synthetic oil.

NEMA Waits on Washington for Energy Bill

Who has the time in Washington to discuss energy efficiency these days? Democrats and Republicans are spending so much time on health care almost everything else has been put on the back burner. That's not to say energy advocates haven't tried. Late last year, Congresswoman Tammy Baldwin (D-WI) launched a $700 million motor rebate bill for an energy-efficient motor rebate program advocated by the National Electrical Manufacturers Association (NEMA). This "crush for credit" legislative proposal was introduced in the House of Representatives as HR 4031.

Similar to a previous legislative proposal, this bill authorizes a federal rebate program for the purchase of NEMA Premium motors. The newly introduced bill, however, doubles the authorized amount from $350 million to $700 million.

"NEMA and one of its member companies in my district, Regal Beloit, have been valuable resources and allies in crafting legislation that will help create jobs and protect our environment," says Congresswoman Baldwin, a member of the House Energy and Commerce Committee. "Offering incentives to purchase energy-efficient electric motors is a smart way to reach these goals."

The $700 million legislative proposal creates a federal rebate program that will provide a $25 per horsepower rebate for the purchase of NEMA Premium energy-efficient motors. It also provides for a $5 per horsepower rebate for the proper disposal of the less efficient, non-NEMA Premium motor.

"Since the energy/climate change bill continues to be held up due to partisan bickering, I applaud Representative Baldwin for taking a leadership role to ensure that the crush-for-credit proposal remains active," said NEMA President and CEO Evan Gaddis. "Not only does this program incentivize the purchase of NEMA Premium motors, it also vastly decreases the demand on our electric grid."

Dain Hansen, NEMA government relations, stresses the importance of both the House and Senate to pass an energy bill as soon as possible.

"There are many good energy policies that are currently getting tangled up in the controversial climate change debate and this is unfortunate. We're hoping Washington can move forward on many of these energy portions separately," Hansen says.

While energy and climate change policies were passed together in the House, the issues remain separate in the Senate. Hansen is hoping the House will take action on the energy portions of the bill, including renewable energy incentives, new lighting efficiencies, tax credits for smart technologies and the rebate program for motors.

"With all the current political agendas surrounding health care, it's hard to tell when we're going to move forward on energy," Hansen adds. "In a perfect world, an energy bill will be passed early this year. Realistically, it will probably happen toward the end of 2010."

NEMA continues to remind Washington that its new Premium Efficiency Program goes into effect December 19, 2010. At this time, all motors must meet or exceed the standards presented by NEMA that were passed in the Energy Independence and Security Act 0f 2007 (EISA).

Based on U.S. Department of Energy data, it is estimated these efficiency standards will reduce CO_2 emissions by 238 million metric tons over equipment lifetimes and provide net present energy savings of $1.39 billion.

"The job and efficiency gains will be incredible," Hansen says. "If, however, companies don't have any sort of incentive to buy a new motor, they'll just repair the old ones."

Along with the motor rebate program, NEMA is working on an advanced motor systems tax credit as well as legislation for motor assessment. For more information about these programs, contact John Caskey, NEMA industry director, at *john.caskey@nema.org*.

—Matthew Jaster

to gearbox power loss. Polytetraflouroethylene (PTFE) seals can be used in some applications. PTFE seals actually lay down a sacrificial layer of material onto the shaft surface. This sacrificial layer fills in the micro-asperities of the surface, thus reducing friction. The reduced friction leads to reduced losses.

Transmission Elements

The final portion of our system is the transmission element between the gearbox and the load. Chain and sprocket, V-belt and sheave, timing belt and timing pulley—there are different methods for transmitting torque. As you can imagine, there are different efficiency levels available for each method. Of course, a transmission element that allows slip creates friction; friction creates heat, which is a loss. A positive engagement method will always be more efficient than one with slip. Even when a slip transmission element is needed for the application, increased efficiency models are available.

Summary

The big picture is that a system needs to be examined as a whole. Remember that each component's efficiency is multiplied together to obtain the entire system efficiency. A high efficiency motor is a great idea to save energy, but when it's mounted to a worm gearbox driving a V-belt, there is the potential to save more energy by being mindful of the entire system. An electronic speed controller is a great idea to save energy, but only when you take advantage of its energy saving capabilities.

Efficiency has a give-and-take relationship with performance and cost. To gain a little bit of efficiency, you have to give up some performance or maybe pay a little more for the component. Somewhere in the middle lies a level of performance, cost, and efficiency that can deliver results without excessive waste. That's a relationship we can all live with.

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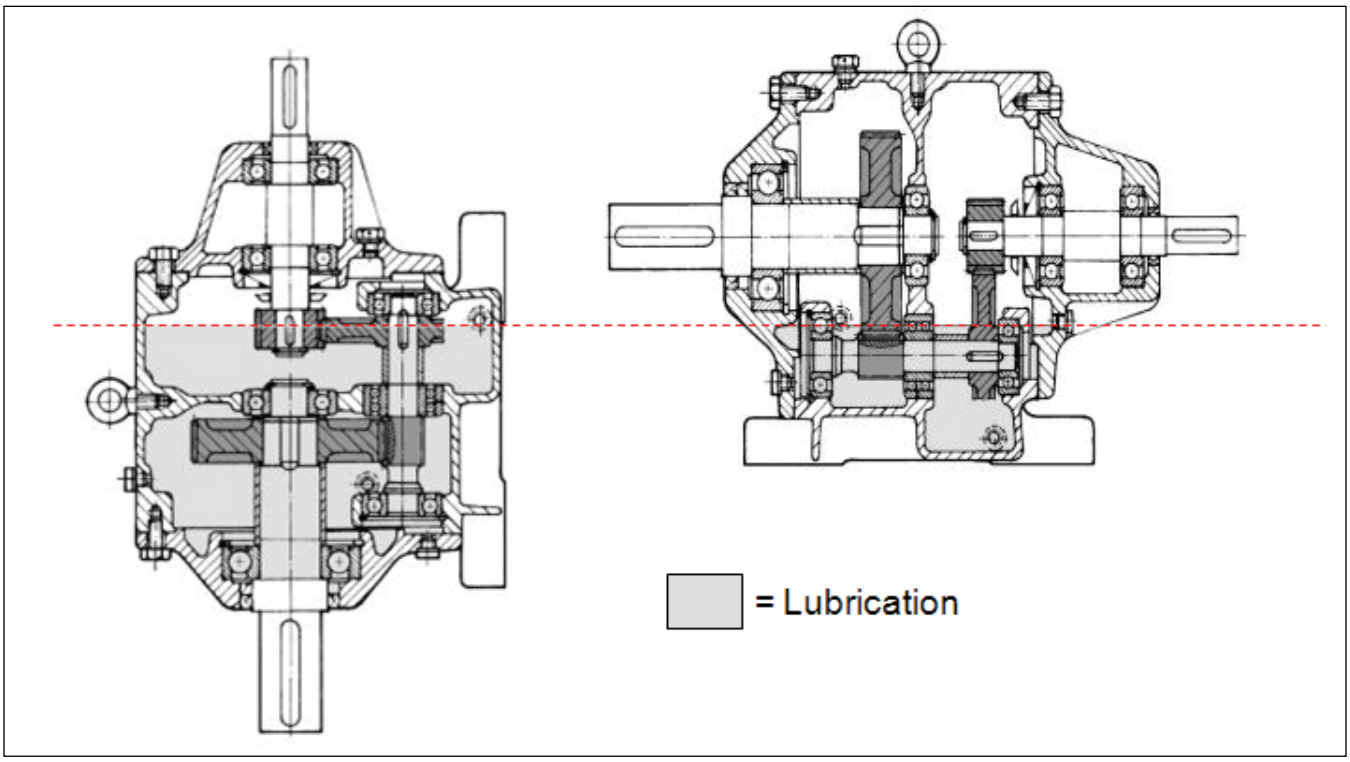

Figure 10—Oil level by mounting position.

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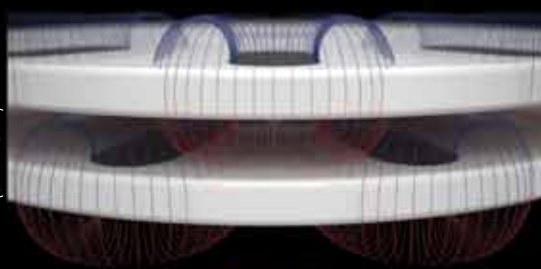
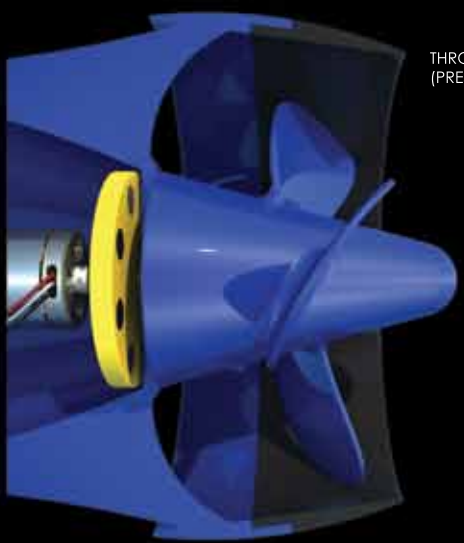


FACE COUPLERS
(SLIP MODE)



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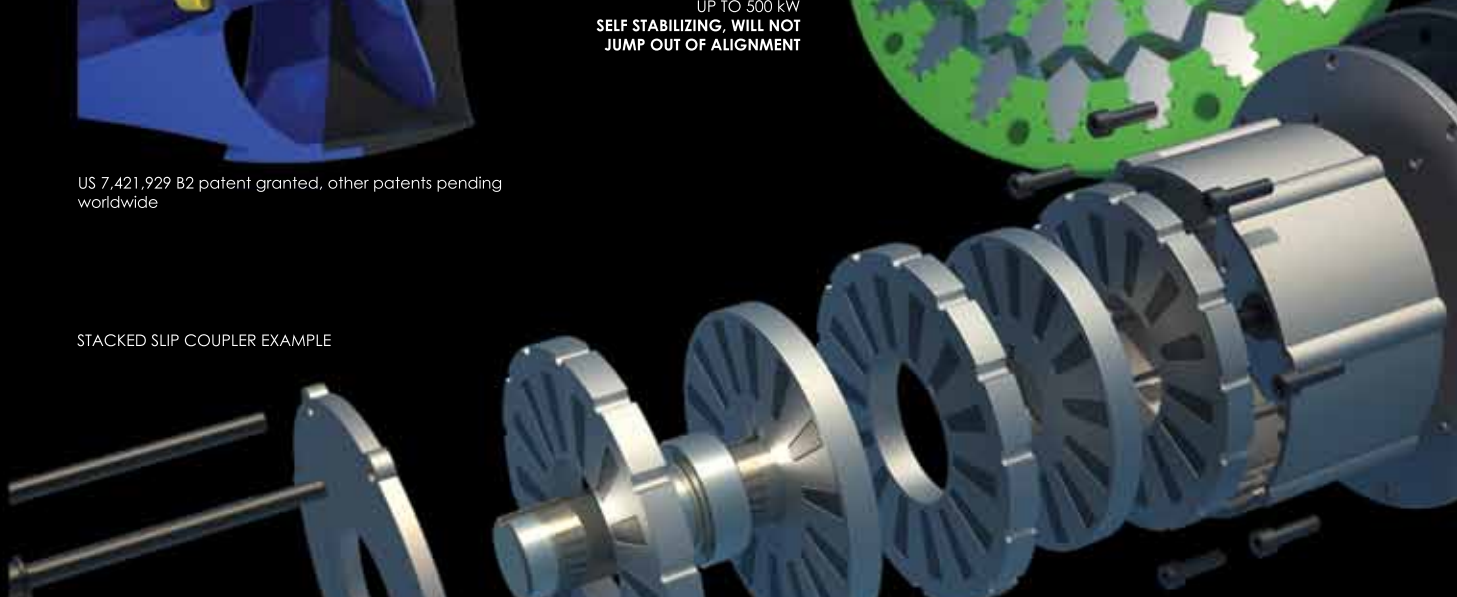


AGMA

IN FULL SUPPORT OF ENERGY EFFICIENCY INITIATIVE

Jack McGuinn, Senior Editor

Our politicians in Washington continue dithering over the Obama administration energy bill aimed at developing alternative, green sources of energy production. As a result, when this country will have a viable energy program in place is anyone's guess, given the usual D.C. gridlock. And yet, Americans can take more than cold comfort in the fact that at least some government agencies—U.S. Department of Energy (DOE)—and the private sector—some major manufacturers—are doing more than their share of work in trying to harness our existing, fossil-based energy sources in such a way that they are used to their best efficiencies.

Momentum for this effort began building last November with the announcement by Energy Secretary Steven Chu that his department was awarding "more than $155 million in funding," under the American Recovery and Reinvestment Act, for 41 industrial energy efficiency projects across the country. The funds will be directed toward industrial combined heat and power systems, district energy systems and grants to support technical and financial assistance to local industry.

And while none of the above applies to gear manufacturing, per se, the American Gear Manufacturers Association (AGMA) is wasting no time in getting with the government program, officially known as the Energy Efficiency Initiative Project (EEIP).

Implementing the project for AGMA is Amir Aboutaleb, AGMA staff engineer.

continued

"AGMA held exploratory meetings with various AGMA members who are major suppliers of complete drive systems and who work closely with end users," he says. "Encouraged by these discussions, we convened a general meeting and, again, found very positive responses from members. This is clearly an area ripe for industry action. And, as noted above, companies that supply full systems and that work with end users (rather than sell to other suppliers) are the core of this initiative."

Credited with spearheading the AGMA buy-in is Dave Ballard, current AGMA chairman and corporate manager of engineering and marketing for SEW Eurodrive.

Another governmental group, the U.S. Council for Energy-Efficient Manufacturing, states as its goal "to achieve global leadership in energy efficiency and greenhouse gas emissions reduction." The council is supported by such corporate giants as 3M, Dow Chemical, Ford Motor Company, PPG and other major players.

While AGMA's ambitions may not be as far reaching, it is certainly jumping into the fray with both feet. As the saying goes, it's better to have a seat at the table than it is to be on the menu.

"Most of the Department of Energy's work has been at a more aggregated level," says Aboutaleb, "developing certification programs, supporting the development of the anticipated ISO 50001 Energy Efficiency Management Standard, etc. AGMA's role through the formation of the new committee on energy efficiency will be to work on tools and guidelines to assist component makers and users become more aware of their energy usage and also help them identify ways of improving their efficiencies. At this point, we think that it is unlikely that DOE would take up gearing and mechanical power systems as a major focus. AGMA clearly will."

As for any of you naysayers still remaining out there, Aboutaleb stresses the need for such a program.

"The vast majority of AGMA's programs come from our members," he says. "This program is the most recent example. Companies who question new approaches have a responsibility to their stakeholders to question it, to examine it and to ask how this affects (their customers). But, we know this is an important issue because of the support we have from a broad base of members.

"Energy efficiency is an increasingly important issue, and we can either embrace it by actively taking part and doing our share, or we can wait until it is regulated and we are forced to comply with it."

The AGMA EEIP next committee meeting will take place via web-ex on March 5. (For info: *aboutaleb@agma.org* or *www.agma.org*.)

The strategic goals of the AGMA energy efficiency initiative, as stated by the aforementioned energy-efficient council last June, are ones that any manufacturing sector will acknowledge as central to the energy performance and efficiency:

- Foster an organizational culture of continuous improvement in energy efficiency;
- Develop a transparent system to validate energy intensity improve ments and management practices;
- Create a verified record of energy source fuel savings and carbon emission reductions with potential market value that could be widely recognized both nationally and internationally.

Inherent in these goals is the development of ISO and ANSI standards, including those addressing energy management, system assessment and measurement and verification protocol.

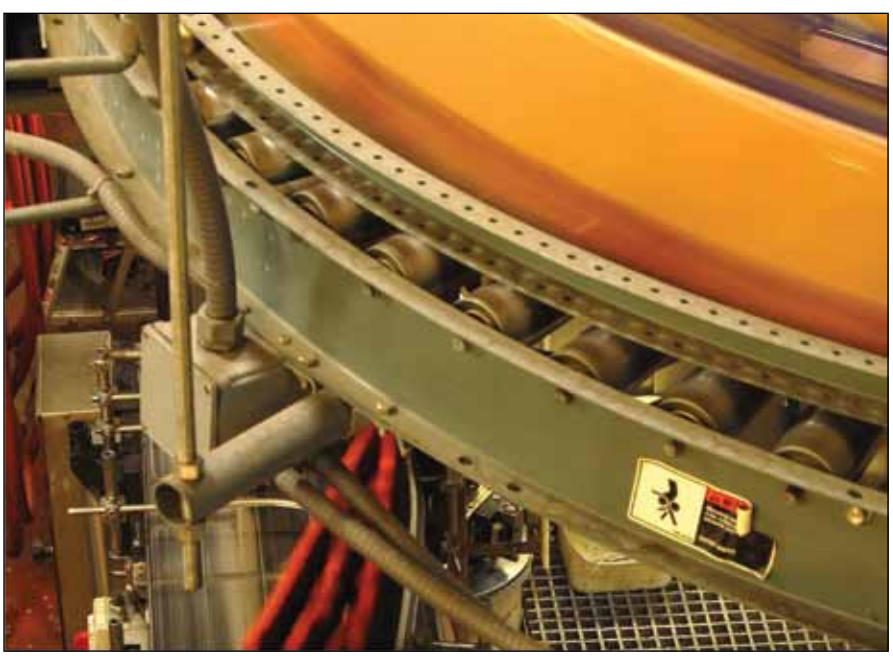
Given its import, Aboutaleb foresees the EEIP initiative having a role of sorts at the next Gear Expo.

"This is an important business issue, both from a position of good stewardship of resources and from a cost saving process," he says. "Suppliers will likely discuss their capabilities as part of their exhibit at the show, and there are a few papers on energy efficiency related issues submitted for this year's Fall Technical Meeting (2010 FTM)."

No one doubts that the road to energy efficiency and, ultimately, independence, will be a long, hard slog.

To that end, Aboutaleb was asked to state the benefits for AGMA members who embrace the energy initiative.

"In short, it will help members and others in the industry better meet the needs of their customers. In doing so they will improve their bottom line, remain competitive and save existing jobs, if not create new ones."



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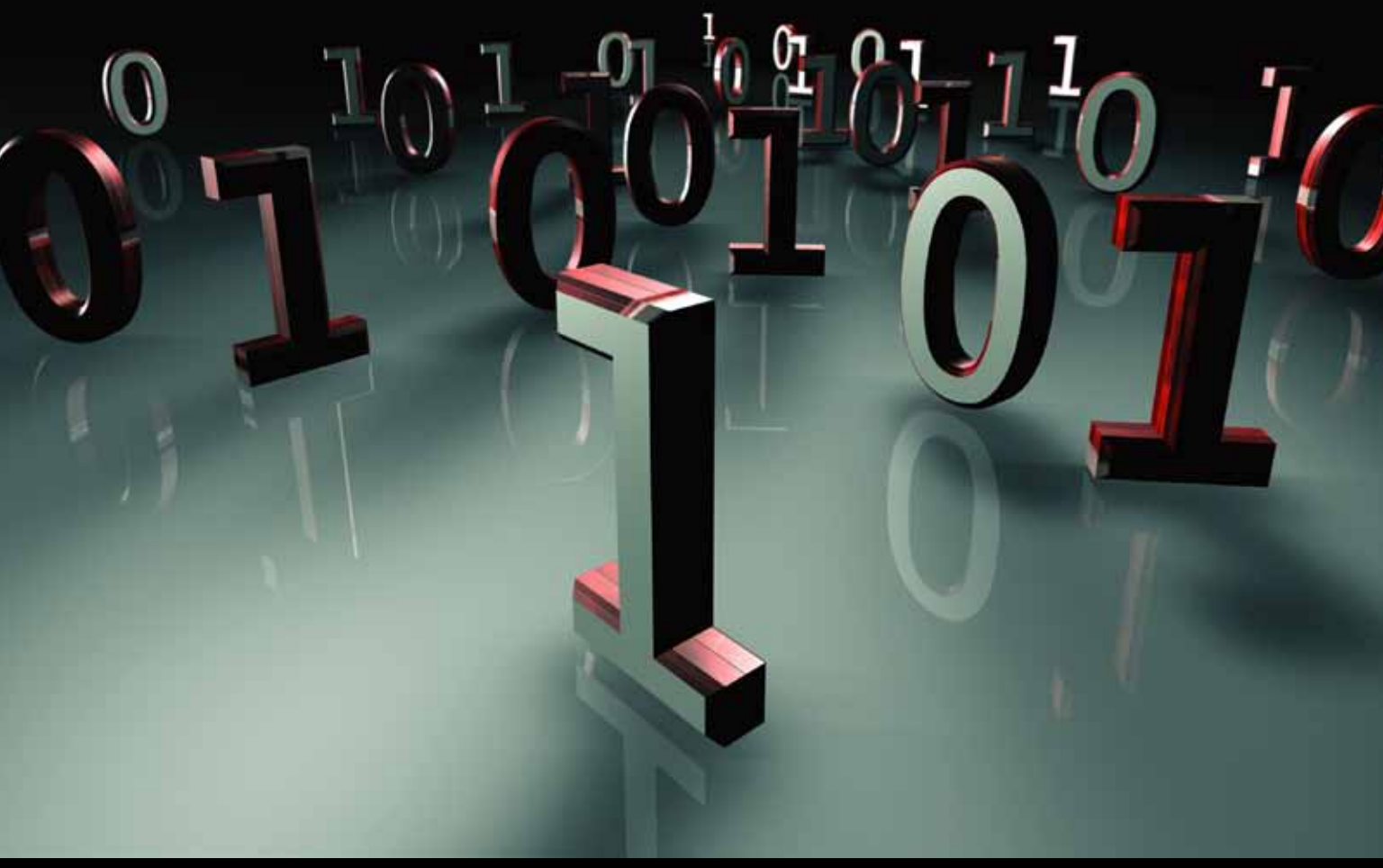


Somewhere in Cyberspace

The Web Master and Binary Experts are gathering together, to discuss New Designs for *geartechnology.com* and *powertransmission.com*. The Hot Topics are, "New Features," "Cleaner Navigation" and "Greater Interactivity."

See you then

2 0 1 0

Selecting the Right

Precision Ball Material

FOR AGGRESSIVE ENVIRONMENTS

Jim Peta

Balls are a common mechanical component used in nearly all complex—and many simple—mechanical products. The critical nature of balls is illustrated by the fact that ball bearing factories were one of the primary targets for Allied bombers seeking to disrupt the German war industry during World War II. While the vast majority of balls are made of some type of steel, steel's relatively weak resistance to chemical attack means that applications involving aggressive environments generally require a more exotic material. This article will examine the major materials used to enhance balls to resist aggressive environments and help in selecting the right one.

Brass Balls

Brass balls provide excellent resistance to corrosion by water, including seawater, and also resist the corrosive effects of fuel oil, gasoline, butane, dry carbon oxide, benzene and similar chemical agents. However, it should be noted that brass can be unstable in the presence of acids and bases.

Another key advantage of brass balls is their cost, which is substantially lower than other corrosion-resisting balls. Brass balls have a Rockwell B hardness of 75 to 87, which makes them suitable for applications where the balls are only required to withstand a medium load. Brass provides excellent electrical conductivity, so it is well suited for many electrical applications. A silver coating is sometimes applied to brass balls to improve their electrical conductivity and corrosion resistance to even higher levels.

Brass balls' combination of resistance to corrosion from water and high hardness make them suitable for water valves, including high-pressure applications. Brass valves are even used in fire nozzles where they must withstand high

continued

Corrosion Resistance Properties

BALL MATERIALS	Industrial Atmosphere	Hydraulic Oils (Petroleum)	Fresh Water	Salt Water	Food Products	Fruit & Veg. Juices	Milk	Alcohol	HCl-40%	Sulfuric Acid-40%	Phosphoric Acid-40%	Nitric Acid-50%	Citric Acid	Ammonia Liquids
52100 CHROME	C	A	D	D	–	–	–	C	–	–	–	–	C	B
440C STAINLESS	B	A	C	C	B	–	A	A	D	D	A	A	A	A
302 STAINLESS	B	A	B	B	A	–	A	–	–	–	A	–	–	–
316 STAINLESS	B	A	A	A	A	A	A	A	D	D	A	A	A	A
BRASS	C	B	C	C	D	–	C	C	–	D	D	–	D	–
MONEL	C	A	A	B	D	C	C	A	D	–	C	–	–	A
NYLON	A	A	A	A	–	A	A	A	D	D	D	D	C	–
VITON®	A	A	A	A	A	A	A	A	A	A	A	A	A	D
CERAMIC	A	A	A	A	A	A	A	A	C	D	C	A	A	A
TITANIUM	–	–	–	–	–	–	–	A	C	C	–	A	A	–

Numbers indicating order of preference

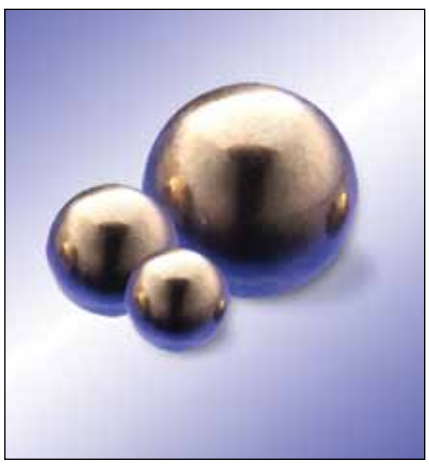
A = excellent B = good C = fair D = poor – = test data not available

pressures and flow rates. Brass balls are frequently used in electrical equipment, most often in the role of connectors that make an electrical circuit. For example, brass balls are used in wireless power devices, data storage equipment, heating units and kitchen applications. Another common application is the use of brass balls in the pumps of sprayers used to apply fertilizer and pesticides to lawns and crops.

Monel Balls

Monel balls provide an even higher resistance to corrosion than brass balls. Monel is composed primarily of nickel and copper, and also has smaller amounts of other elements such as iron, silicon, manganese, carbon, aluminum, titanium and sulfur. Monel balls are impervious to the effects of fresh water, salt water, steam, petroleum products, ammonia, acids, many bases and calcium chloride. Monel also has a relatively high tensile strength of 79 to 90 Kpsi and yield strength of 24 to 40 Kpsi. Monel has a hardness of 85 to 95 Rockwell B, while its sister alloy, k-monel can be hardened to about Rockwell 27 C. K-monel also offers superior resistance to bases. On the other hand, monel balls are relatively expensive because of the difficulty involved in machining them.

Monel balls are frequently used in pump, valve and metering applications in water treatment and chemical plants because they resist attacks by a wide range of chemicals, and because their strength enables them to withstand high flows and pressures. In particular, monel balls' ability to withstand ammonia makes them particularly useful in wastewater treatment and chemical plants. Monel balls' corrosion resistance



enables them to provide longer life than chrome or stainless steel balls in water supply, wastewater and hydroelectric applications. They are used in meters that measure the flow of liquid and gases because their ability to withstand most any chemical makes for a more versatile instrument. Since monel balls are resistant to both petroleum oils and water, they are ideal for valves in the oil and gas industry. The added hardness of k-monel makes them well suited for use in bearings that must survive aggressive environments.

Tungsten Carbide Balls

Tungsten carbide is a homogenous mixture of tungsten carbide grains in a binder matrix, with cobalt being the most commonly used binder matrix. The tungsten carbide grains are fused into a solid matrix of cobalt metals under extreme heat and pressure in a process called sintering. There are many different grades of tungsten carbide available, making it possible to provide balls that are tailored for most any application. In general, a higher percentage of cobalt will provide a tougher but softer grade, while a lower percentage of cobalt will provide a harder but less tough grade.

The hardness of tungsten carbide is evidenced by the fact that it is commonly used for tools used to cut steel and other metals, and for armor piercing ammunition. Its abrasion resistance and resistance to shock are both excellent. Tungsten carbide is also practically inert so it is able to resist corrosion in nearly any environment. But it should be noted that bases with a pH below 4 have a tendency to attack the binder. Tungsten carbide is also one of the most

costly ball materials.

Naturally, tungsten carbide balls are used in applications where extreme hardness and wear resistance are required. Tungsten carbide balls are used in heavy machinery applications because of their wear resistance and strength. They are frequently used in the down-hole tool industry for hard banding, which refers to covering the outer surface of the lower portion of a tool with a wear material to enhance its life. Other common applications for tungsten carbide balls include ball screws, bearings, valves, flow meters, pivots, detents and tips. For example, tungsten carbide balls are often used as tips for ballpoint pens and instruments used to test the hardness of materials.

Ceramic Balls

Ceramic balls provide excellent corrosion resistance, abrasion resistance and resistance to high temperatures, along with exceptionally low weight. The melting point of silicon nitride, one of the most common ceramic ball materials, is 1,900˚C compared to 1,370˚C for stainless steel. Some types of ceramic balls are capable of withstanding temperatures in excess of 3,200˚F. There is little or no increase in bearing friction as temperature increases in most applications. Ceramic balls also show very little deformation under pressure, as their hardness reduces the coefficient of friction, thus maximizing the amount of energy that is converted to work.

A number of different ceramic materials are used in ball applications. Silicon nitride balls provide excellent performance in applications involving high speeds, high loads and high temperatures. The material does not require lubrication in most applications, and is not magnetic. Aluminum oxide or alumina balls resist very high temperatures and can survive most corrosive materials, with the exception of hydrochloric or hydrofluoric acid and strong bases. Ruby sapphire balls provide the highest possible resistance to temperature and also excellent corrosion resistance. Zirconia balls provide excellent corrosion resistance.

Ceramic balls are often used in aircraft braking assemblies. These systems must be able to withstand a very high amount of heat and pressure, yet in any aircraft application weight is an important factor. Ceramic balls provide weight savings over hollow steel balls sufficient to save many thousands of dollars in fuel costs per year and per plane. Ceramic balls are also frequently used in wind turbines used to generate electricity because of their high strength and abrasion resistance, as well as their inherent insulating properties that prevent arcing.

Bioinert ceramics, such as alumina oxide and zirconia, also provide the important advantage of being non-reactive to biological organisms. Bioinert ceramics are used as load-bearing implants, such as implants for finger and toe joint replacement. One surgeon using a ceramic ball and socket to replace toe joints reported a success rate of 95% relief of pain and 80% for restoring mobility similar to comparable good joints.

Titanium Balls

Titanium balls are desirable for their low density, anti-corrosive properties, and high tensile and compression strength. Titanium isn't easy to form, but manufacturing processes have been developed that can make a 0.125-inch-diameter titanium ball round to within 10 millionths of an inch. High-performance bearings are one common application for titanium balls. Another application is medical implants such as hip implants. Titanium has a weight advantage over its main competitor in the implant field—Cobalt-Chrome-Molybdenum. But Cobalt-Chrome-Molybdenum generally offers longer life. Other applications include connectors for cables, check valves for pump sprayers and body jewelry.

Precision balls play a critical role in a wide range of equipment. Equipment that must survive in aggressive environments requires special ball materials that can survive chemical attack and other hazards. Brass, monel, tungsten carbide, ceramic and titanium provide excellent performance in the vast majority of these applications.

Work with a ball supplier who can help carefully examine the requirements of your application to select a material that will provide the required level of corrosion and temperature resistance at the right price.

For more information:

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Designing for Static and Dynamic Loading of a Gear Reducer Housing with FEA

M. Davis, Y.S. Mohammed, A.A. Elmustafa, P.F. Martin and C. Ritinski

Management Summary

A recent trend has been a movement to more user-friendly products in the mechanical power transmission industry. A good example of such a product is a high-horsepower, right angle, shaft-mounted drive designed to minimize installation efforts. Commonly referred to as an alignment-free type, it allows the drive package mounting to be quicker, more cost effective and require less expertise during installation. This facilitates the use of the drive in applications such as underground mining, where there is little room to maneuver parts. The most common application for the alignment-free style drive is for powering bulk material handling belt conveyors.

An alignment-free drive is direct-coupled to the driven shaft only; it is not firmly attached to a foundation or rigid structure. A connecting link or torque arm connects the drive to a fixed structure, which limits the drive's rotational movement about the driven shaft. The electric motor is supported by the reducer housing through a fabricated, steel motor adapter; the coupling connecting the motor shaft and reducer shaft is enclosed by this motor adapter.

Sumitomo Drive Technologies is working on a design of the alignment-free system by using finite element analysis (FEA) to help guide the design process. FEA was used to test the cast iron housing to determine any potential problem areas before production begins. Once analyses were completed, the motor adapter was redesigned to lower stresses using the information from the FEA and comparing it to field test data.

Introduction

Sumitomo Drive Technologies' goal is to maximize the use of standard products and to expand this design philosophy to applications beyond underground mining.

Gear reducers allow electric motors producing relatively small torque to create high output torque through a series of gears (Refs. 1–4). The weight of both the motor and reducer, plus the movement of the complete drive assembly, can create high stresses on the interface between the reducer and the motor or motor adapter. Motor-induced vibrations due to gear meshing, etc., also play a significant role in reducer analysis. (Refs. 5–10). These vibrations are greater at start-up, and can produce large dynamic forces and torques that increase the risk of gear reducer housing failure at the interface with the motor adapter. In order to determine if the current reducer design meets the requirements of the proposed alignment-free drive systems, the reducer housing was analyzed under both static and dynamic loads using FEA. Pertinent results, structure optimization proposals, and conclusions are introduced in the following sections.

FEA of Gear Reducer Housing

FEA modeling. In order to simulate the system effectively, the entire system was analyzed as an assembly. Based on an existing and operating prototype design, the alignment-free drive was modeled in *Autodesk Inventor*. Figure 1 shows the entire assembly. The drive is connected to the motor adapter, which varies in size depending on what type and model of coupling it houses. The motor is also connected to the motor adapter on the right side by a series of bolts.

The solid model was converted to a step file (.stp) and imported into *PTC Pro/Mechanica*.

The FEA model was meshed in *Pro/Mechanica* using p-type elements, and a simple linear analysis was performed. Bolts were modeled using *Pro/Mechanica's* fastener application. This method simulates the bolt as a spring element passing through the two fastened parts. The load is completely transferred through the bolt rather than the touching components. The entire assembly mesh is shown in Figure 2. The FEA model had a maximum of 133,812 elements. Although this assembly is very large, it was simplified by removing many structurally insignificant features. Analyzing the entire system (reducer housing, coupling box and motor) as an assembly made it very complicated to simulate. More complexity in the model, in terms of features, means more elements and hence less accuracy. Significant effort was made to simplify the model while maintaining the structural properties of the system.

Both the static and dynamic analyses were conducted in this environment. The loads applied are the weight of the entire system and the torque reaction due to the action of the output shaft. The initial torque on the system at startup is about 300% of the rated torque. This factor of three has been taken into account while applying the loads. The alignment-free system is designed to be both flippable and reversible. The term "flippable" describes the reducer's capability of operating in both right-side-up and upside-down positions. "Reversible" refers to the reducer's ability to operate in both CW and CCW shaft rotations. Analysis of the housing was done in such a way as to test with the torque applied in both the clockwise and counterclockwise direction on the output shaft.

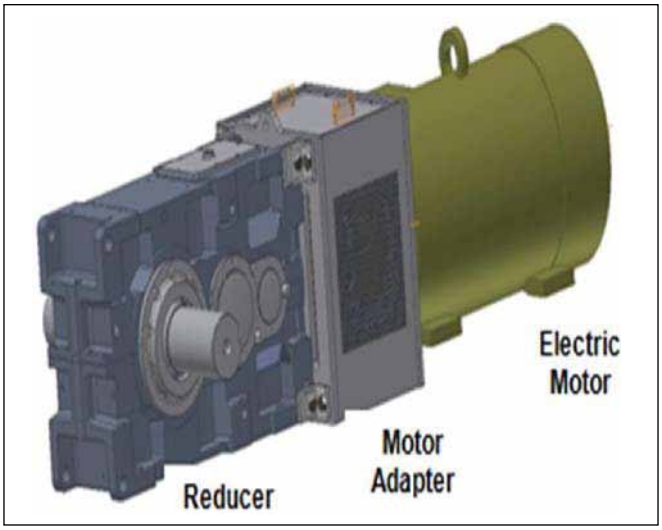

Figure 1—Alignment-free drive system.

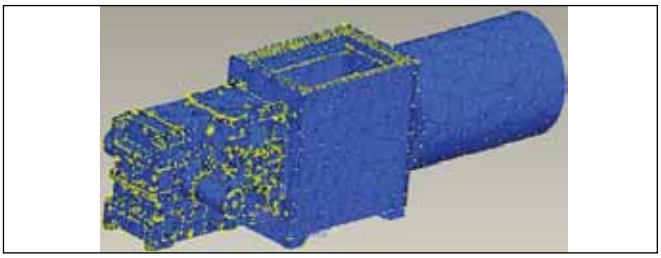

Figure 2—FEA model mesh.

Figure 3—Bracket and bracket located on housing.

The reducer housing is typically made of cast iron. The motor adapter is made of plates of A36 and structural tubing. This design allows the motor adapter to be relatively lightweight. Both the top and the bottom of the adapter have a cover plate that can be quickly and easily taken off for access to the coupling. The reducer housing and the coupling box are bolted together. Figure 3 shows corner brackets that were put in place as additional support, if needed. These corner brackets were included on the prototype units, pending confirmation of the housing strength analysis.

Static analysis. The reducer housing is connected to the rest of the assembly by four bolts at the high-speed, end-face of the housing. Besides the bolts there is also a fail-safe device in the form of brackets at the four corners of the end-face of the housing. As a conservative approach, static analyses were conducted with and without the brackets. The free-body diagram of the entire drive system is given in Figure 4, and it details how the loads were applied.

The stress without the brackets was high, but not fatal. With the brackets, however, the stress was reduced considerably. Figure 5 shows the stress distribution around the bolt holes of the reducer interface. The stress distribution on the

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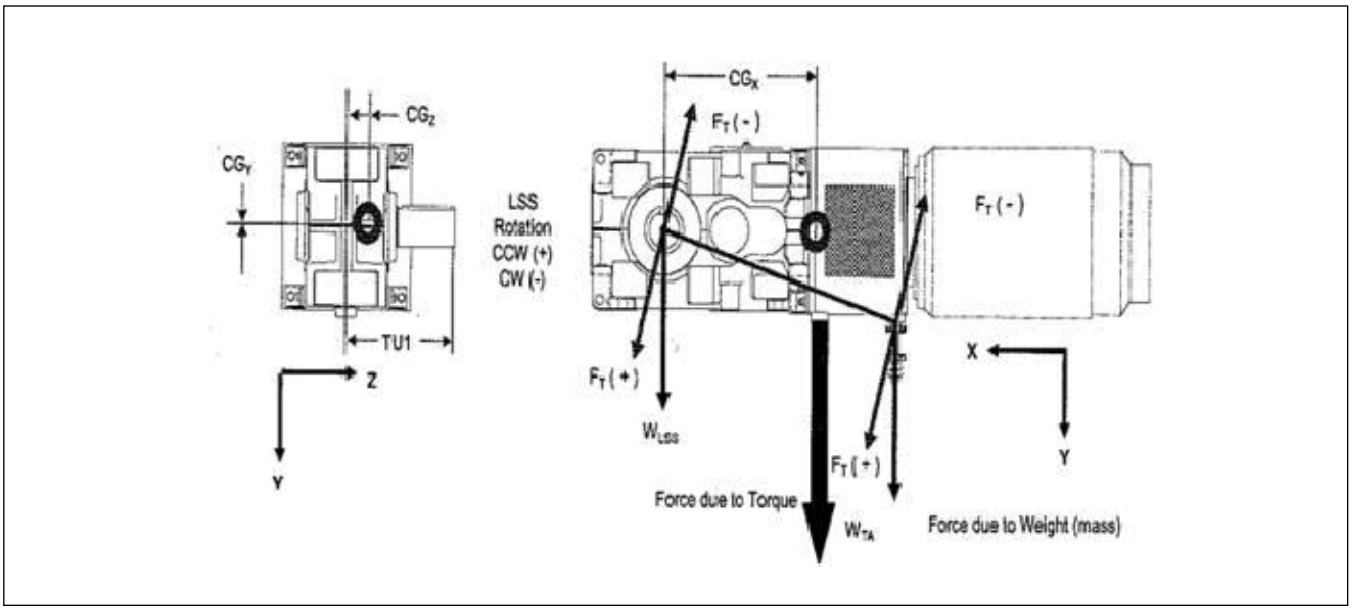

Figure 4—Free-body diagram.

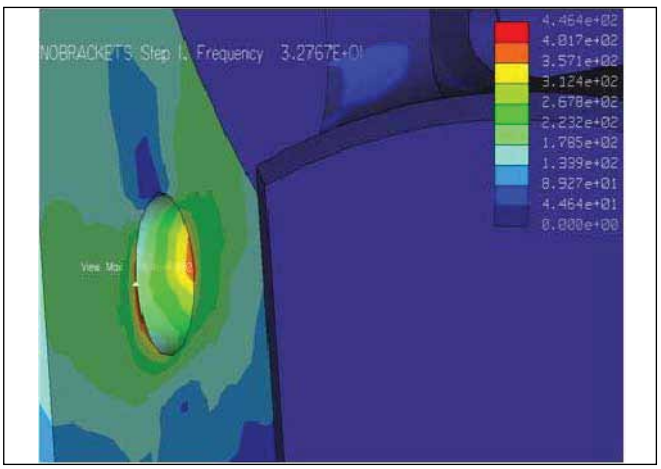

Figure 5—Stress distribution on reducer interface.

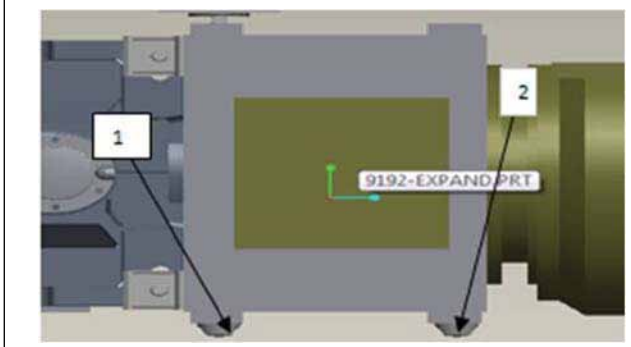

Figure 6—Torque arm positions.

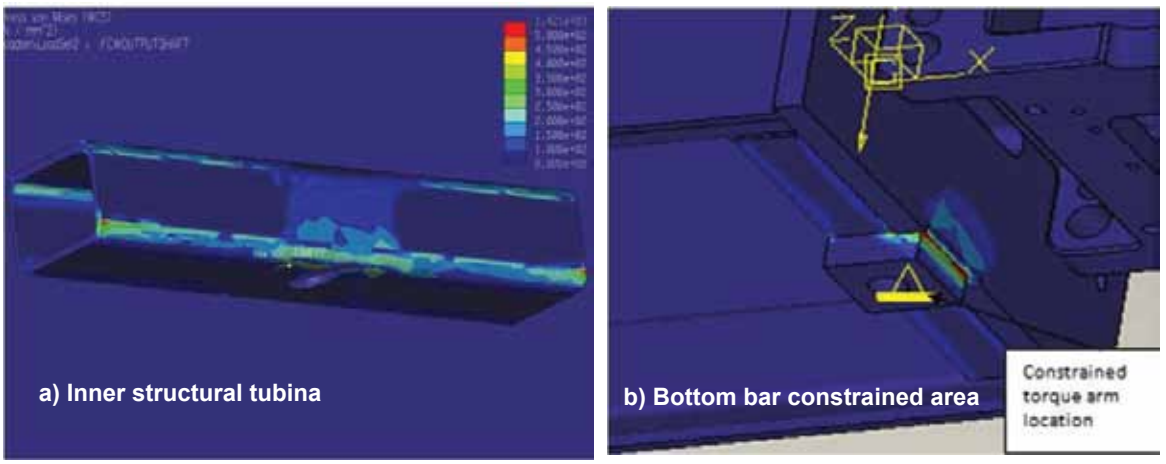

Figure 7—Static analysis stress field.

rest of the housing shows the area of high stresses.

Many of the high-stress areas are the sharp edges and holes. Higher stresses are due to the stress concentration in the area where the geometry is smaller and thinner. These are the particular areas of concern. Two cases arise as a result of variable torque arm location (Fig. 6)—(1) the torque arm is designed in such a way as to only allow slight movement in the negative Y-direction (Fig. 4); and (2) when the loads associated with a counterclockwise output shaft rotation are applied, the reducer is forced down on the torque arm, allowing no further movement along the Y-direction.

With the model constrained at the torque arm location (Ref. 1; Fig. 6) with zero degrees of freedom in every direction, high stresses were seen on the structural tubing in Figure 7a. This tubing and the area surrounding show stresses above failure. Figure 7a shows that stress concentration in two major areas—the circular mounting hole and the round corners of the structural tubing. The maximum stress on the structural tubing is 543 MPa, and it occurred on the outermost edges of the exterior of the tubing. This stress concentration area is very small and should be omitted due to stress singularities at those points.

A local maximum stress occurred near the edge of the mounting hole of 400 MPa. Because A36 steel tubing has an ultimate tensile strength of around 450 MPa, this stress could cause the tubing to yield. With the weight of the system, and the external torque applied, the structural tubing of the motor adapter could fail in those areas of high stress.

Figure 7b shows the mounting hole that was constrained during the analysis. High stresses were seen on the edge of this mounting bar, due to a pinching effect. When the loads are applied while that location is held fixed, a significant amount of bending stress is created in the area where the mounting bar meets the structural tubing and outermost motor plate (Fig. 7b). The local maximum stresses of this outermost plate are around 200 MPa, and therefore will not cause failure.

Similar analyses were conducted with counterclockwise torque and the two locations of the torque arm. These analyses, however, showed lower stresses and were disregarded. In this way, a worst-case loading scenario was obtained.

In the static analysis, the plate at this interface—between the motor adapter and the reducer box—exhibited much higher stresses than the reducer, and is thereby the limiting factor of the design. The greater thickness of the reducer housing at the interface allowed that area to produce little stress.

In order to get lower stresses, many of the parts were redesigned in an iterative process. The plates and structural tubing were thickened, but the stresses were still high and the cost of these modifications would increase the production cost. Eventually, the solution that proved to be easy and cost-effective in terms of manufacturing was to extend the bottom bar to the entire width of the coupling box. This causes the reaction forces from the torque arm to act over the entire coupling box instead of a small region, thereby lowering the stresses.

Figure 8 shows the results from the static analysis with the extended bar. With this bar extended, the stresses were around 60 MPa. These stresses were located on the bar mounting hole. With this small modification, a significant reduction in stresses was achieved.

In order to further verify these stresses, the resulting reaction force on the torque arm was compared to the forces applied to the model. The total weight of the reducer (–11,929 N), coupling box (–7,573.3 N) and motor (–23,583.2 N) in the Y-direction gave a reaction force on the torque arm in the Y-direction of + 43,085.5 N. Applying the SFy = 0 gives the same result, and the model is consistent.

Dynamic analysis. *PTC Pro/Mechanica* was also used to perform the dynamic analyses. Dynamic analysis measures a system's response to a number of time-driven loads. In particular, dynamic random analysis was used. Dynamic random analysis measures the response of a system to a power spectral density function (PSD) (Refs. 16–17). The load input is a force or acceleration PSD given over a range of frequencies. In order to conduct a dynamic analysis, a modal analysis must first be run. A modal analysis calculates the frequencies of failure (Refs. 18–20).

To ascertain the validity of both the assumptions and the calculations, acceleration versus frequency data was collected in three different planes, and in various locations from the prototype of the alignment-free drive. A magnetic probe and machinery health analyzer were connected to the prototype to acquire this information. Figure 9 shows the acceleration versus frequency in graphical form from the readings taken from the prototype.

The modes of failure acquired during the prototype test were very close to those calculated in the modal analysis, and further verified the accuracy of our analysis which can be seen

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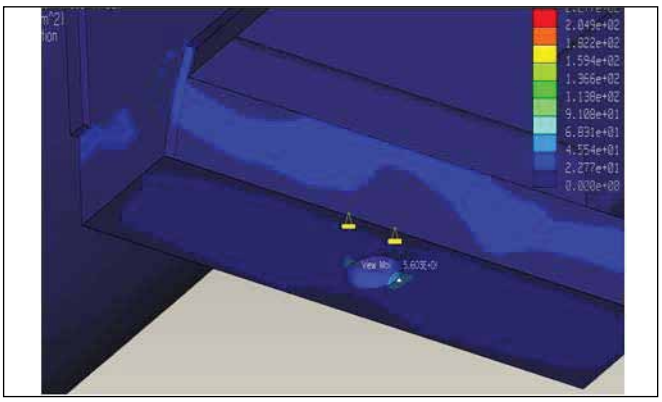

Figure 8—Extended bar stress field.

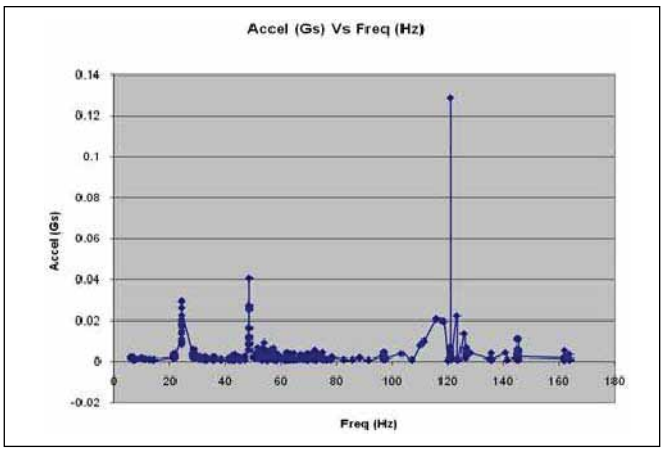

Figure 9—Acceleration versus frequency graph.

in Table 1.

The results in Table 1 show that the error in the analysis is comparable to the error computed according to (Ref. 13). Since the FEA model was extremely large, there was a larger window of acceptable error.

The acceleration versus frequency tables were also used as inputs in the dynamic random analysis to show how the system responded to various frequencies. The model was constrained—as shown in Figure 7b—and the loads were applied in a similar fashion as the static analysis, except that for the dynamic random analysis, the PSD data was used as the input to the analysis. Figure 10a shows one of the internal, structural tubing members. This member showed the maximum stress of the entire system. The resulting maximum stress on the internal structural tubing was 450 MPa. This stress, however, was over a small area and can be disregarded due to a singularity region at that point. The realistic stress was around 300 MPa.

Figure 10b shows the stress distribution on the motor adapter front plate. This is the location where the adapter is bolted to the reducer. This area also showed stresses near 300 MPa under dynamic loading. From these results, it is clear that there was a significant reduction in stress on the motor adapter with the new design. The reducer housing and the motor adapter will not fail under running loads.

Based on the FEA research results, optimization proposals are made to increase the structural integrity of the alignment-free drive and reduce the chance of failure. The suggestions are:

Modify the four (top and bottom) bottom mounting bars so that they extend the full length of the motor adapter. This allows for a greater load distribution of the reaction forces caused by the fixed torque arm. This larger contact area will not cause high stresses on the internal structural tubing. This becomes even more important as the design is applied to larger capacity reducers, couplings and motors. These extended bars can also be used as a skid-pad that will aid in transportation and will also allow the reducer to sit on the ground, if need be.

The analyses shown are for the case where the external torque load is applied in the counterclockwise direction to the output shaft, and drive is constrained in the torque arm position nearest to the reducer location No. 1. In this case, the motor adapter and the entire motor act as a cantilever beam extending from that torque arm position. Since the majority of the weight of the drive system is due to the motor, there are significantly higher stresses on the reducer and motor adapter interface and bottom torque arm location pad. Since both torque arm positions 1 and 2 shown in Figure 3 are valid configurations for the drive, it is suggested that when space and application allow, put the torque arm at the position nearest the motor. This effectively shortens the moment arm caused by the cantilevered motor, and also puts the center of gravity of the system above the constraint.

When the drive system was analyzed with the external torque acting in the clockwise direction, the stress results were much smaller than when it acted in the counterclockwise direction. That is because this torque will effectively subtract from the moment created from the weight of the motor acting at a large distance from the torque arm because they are acting in opposite directions. Again, when space and application allow, orienting the output shaft so that it is driving in the clockwise direction will significantly lower stress and decrease the chance of failure.

Table 1-Comparison of Frequency

Mode	Estimated	Experimental	%
	(Hz)	(Hz)	error
1	28.3	24.9	12.0
2	51.1	48.6	4.9
3	137.8	121.8	11.6

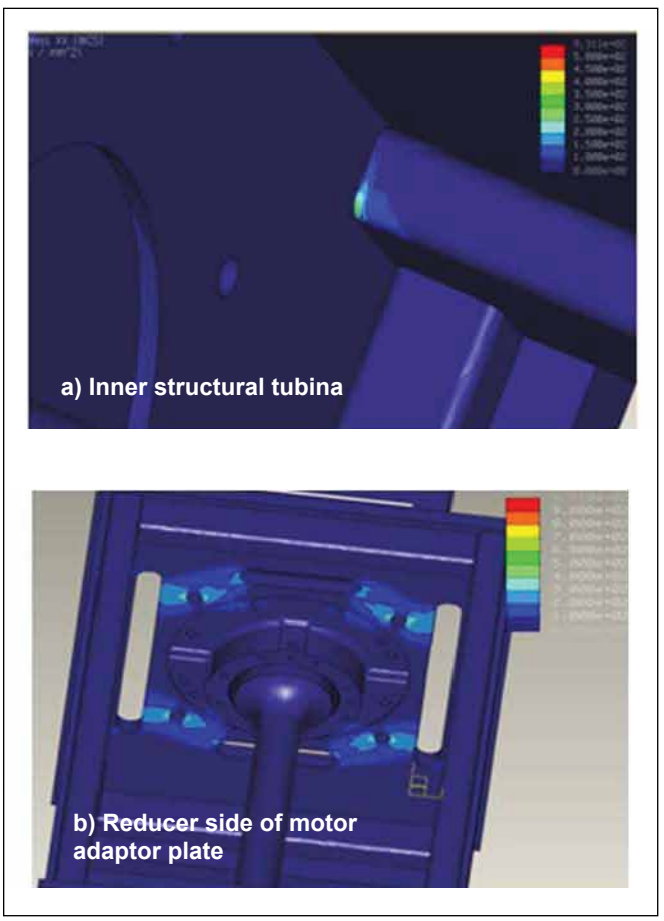

Figure 10—Dynamic, random analysis stress distribution.

Conclusion

The failure of gear reducer housing units is directly related to the combination of both static and dynamic loadings. High stresses arise in the gear reducer housing from both the large sizes of the components, improper gear meshing and impact, and from vibrations coming from the system. FEA analysis showed the stress areas that would cause failure. The failure would begin by localized yielding of the structural tubing at the mounting hole and propagate along the length of the tubing. These areas were looked at more closely.

The redesigned size of the bottom bar had a significant effect on the maximum stress experienced on the structural tubing and the area surrounding it. The data collected from the prototype helped us verify the FEA and show that the redesign of the bottom bar would be sufficient to reduce the stresses and prevent failure of the alignment-free gear reducer housing system.

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Reducing Electricity Cost through Use of Premium Efficiency Motors

Guillermo J. Costa

Management Summary

A report published in 1998 by the U.S. Department of Energy showed that electric motor applications consume approximately 679 billion kilowatt-hours, i.e.—63% of all electricity used by U.S. industry. The Department of Energy report also revealed that the electrical consumption of these industrial motors could be reduced by up to 18 percent if "proven efficiency technologies and practices" were applied by businesses. Thus, efforts directed toward the replacement of standard industrial motors with premium efficiency counterparts presents businesses with a significant opportunity to reduce operating costs. A comparison between premium and standard efficiency motors from 0.25 to 10 horsepower is conducted; comparisons of full-load efficiencies are shown, and estimated payback periods are calculated. Methods for calculating the yearly kilowatt-hour consumption and yearly cost savings of premium efficiency motors for this horsepower range are also given. The cost advantages of premium efficiency motors are summarized, and relevant examples of real world cost savings are shown.

The need for energy efficiency continues to become increasingly important in various industries as energy costs continue to rise and competitive pressures increase. When these factors are coupled with the uncertainty of available electricity—such as during the California electricity crisis of 2000–2001 (Refs. 1–2)—potential actions on the part of businesses that increase the overall efficiencies of their operations gain increasing relevance. Of course, seeking a profit advantage over competitors is hardly novel, and premium efficiency motors are unique in that they allow a business to realize cost savings while changing very little of its current operating procedures. And, in many cases, switching to premium efficiency motors is all a business needs to recoup cost savings that are worth several times the cost of the motors. This practice of continued energy improvements is not only a wise business philosophy, but is also a legal requirement: the Energy Policy Act of 1992 established minimum efficiency stan-

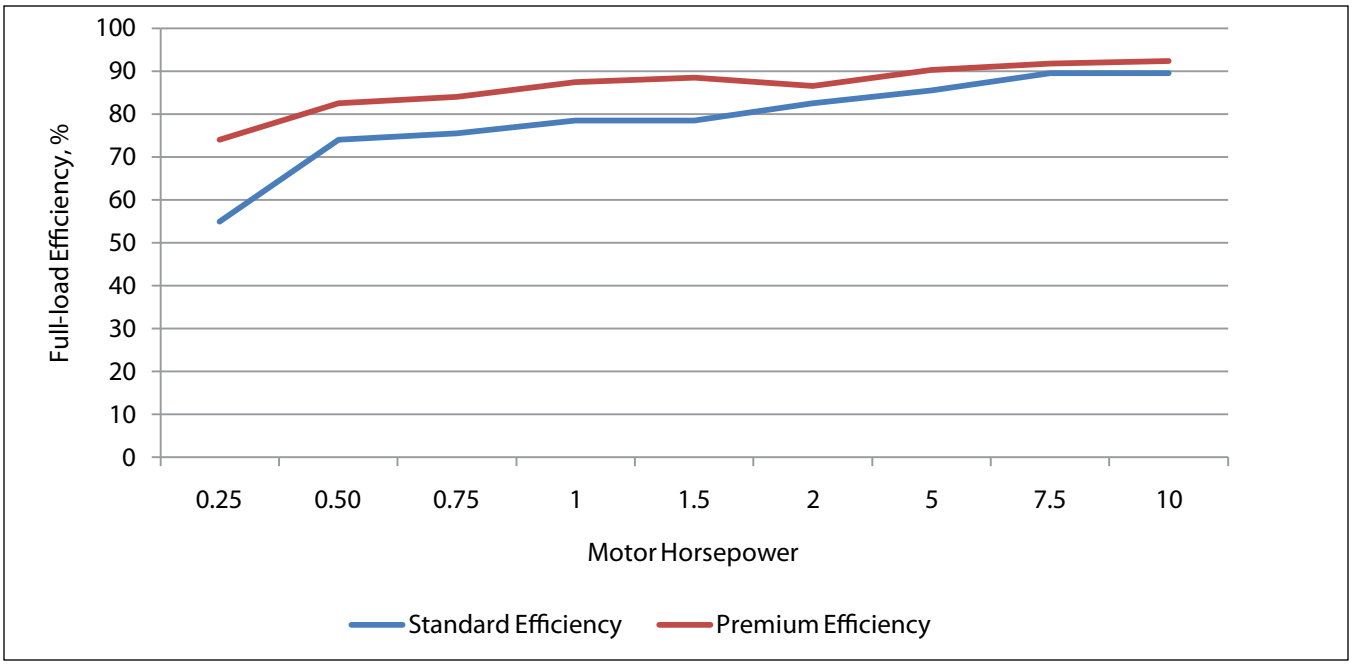

Figure 1—Comparison of full-load efficiency ratings by horsepower—standard versus premium efficiency class motors.

dards for all industrial electric motors manufactured after October 1997, yet only about 10 percent of all motors currently in use comply with these minimum levels (Ref. 4). Newer laws, such as the Energy Independence and Security Act of 2007, impose even more stringent standards of energy efficiency (Ref. 5). Even a cursory examination of the industrial landscape regarding the future of electric motors demonstrates a constant trend towards increased motor efficiency. Thus, the employment of premium efficiency motors rather than their standard efficiency counterparts represents a very real potential cost savings for industry.

Factors That Determine Energy Costs

There are several key factors that determine the electrical cost of a facility; however three are the most crucial to reducing energy costs. These factors are (Ref. 6):

1. Kilowatt-hour consumption
2. Fuel charge adjustments
3. Kilowatt demand

Kilowatt-hour consumption. Kilowatt-hour consumption is the easiest of the four factors for most to understand, as it is the most familiar measure of energy consumption. The kilowatt-hour consumption rate is the amount of electrical energy that has been consumed during a given billing period; the total consumption is then determined at a given interval (usually monthly). Note that this rate does not differentiate between when or how the energy was used.

Fuel charge adjustments. Fuel charge adjustments are given within the same billing period as kilowatt-hour consumption, and represent an adjustment cost based upon the utility's cost of producing power. The fuel charge adjustment is normally given as a rate- per-kilowatt-hour consumed. Note that this adjustment may change several times per year, based upon the utility's production needs. For instance, if waterpower can contribute greatly during the spring to the utility's ability to produce electricity, the fuel charge adjustment might be very low; conversely, if the utility then has to burn a great amount of oil or coal later in the year to meet its production needs, the fuel charge adjustment will increase.

Kilowatt demand. Demand is based upon the amount of power consumed during a given period of time and is perhaps the least understood factor in determining energy costs (Ref.7). Demand is measured in kilowatts, and is used to determine the amount and type of equipment (transformers, wire, generators, etc.) needed by the utility to supply a customer's maximum energy consumption at any given time. In many ways, kilowatt demand is analogous to the horsepower rating of a car: the engine is sized for the maximum amount of energy needed to accelerate the car at a predetermined rate at any point in time, although the actual amount of horsepower used at a given time might be relatively low, such as when cruising at a steady speed on the freeway. Similarly, kilowatt demand is not constant throughout the day, but can vary as equipment is turned on

continued

Nomenclature	
C	electricity cost in dollars-per-kilowatt-hour
E	motor nameplate efficiency
E_{pe}	nameplate efficiency of premium motor, decimal
E_s	nameplate efficiency of standard motor, decimal
HP_{load}	average load horsepower
K	kilowatt-hours
S	dollar savings per year
$T_{operating}$	operating hours per year

and off as needed. Note that kilowatt demand is never zero; even during periods of shutdown, certain constant-load devices such as lighting, HVAC and security systems incur a demand.

Additional Advantages of Premium Efficiency Motors

Reduced lifetime cost. In order to fully understand the advantages of premium efficiency motors, one must look beyond the initial purchase price of the motor itself, which in many cases is 15–30% greater than the acquisition cost of a standard efficiency motor of identical output (Ref. 8). This difference in acquisition cost is due to the differences in design between the two motor types: premium efficiency motors feature larger-diameter copper windings, laminations of higher steel grades, specially designed precision air gaps between the rotor and stator, etc.

However, one must keep in mind that the initial purchase price of a motor will account for less than 2% of the motor's total lifetime cost. The bulk of the motor's lifetime cost is in its electricity use, which accounts for up to 97% of a motor's lifetime cost (Refs. 9–10). For instance, if a motor has a purchase price of $1,600, its total energy costs would be over $80,000 (Ref. 11). The difference in initial purchase price also quickly becomes irrelevant when one considers that the energy savings quickly eclipse the difference in acquisition costs, which in many cases means that the motor has recouped the difference in purchase price in just a few months, and a large percentage of premium efficiency motors have paid for themselves completely through energy savings in less than two years (Ref. 12). Of course, the savings continue even after the motor has paid for itself, and over the course of its useful life, a premium efficiency motor will repay many times its original value (Ref. 13).

Increased motor life and ancillary savings. The design differences between the standard and premium

Table 1—Operating Cost and Savings Comparison at Continuous Operation—Standard versus Premium Efficiency.

Type	Data	Horsepower								
		0.25	0.50	0.75	1	1.5	2	5	7.5	10
Standard	Efficiency	55	74	75.5	78.5	78.5	82.5	85.5	89.5	89.5
	Annual consumption, kWh	2,970	4,416	6,492	8,325	12,487	15,843	38,216	54,672	73,016
	Average purchase price	$120.32	$140.63	$149.65	$175.89	$179.17	$188.19	$259.94	$589.38	$629.33
	Annual operating cost	$464.28	$690.14	$1,014.65	$1,301.16	$1,951.75	$2,476.16	$5,973.18	$8,559.34	$11,412.45
Premium	Efficiency	74	82.5	84	87.5	88.5	86.5	90.2	91.7	92.4
	Annual consumption, kWh	2,200	3,947	5,815	7,443	11,038	15,058	36,101	53,092	70,789
	Average purchase price†	$191.76	$320.23	$349.68	$388.53	$410.47	$410.47	$449.36	$886.11	$983.24
	Price difference	$71.44	$179.60	$200.03	$212.64	$231.30	$222.28	$189.42	$296.73	$353.91
	Annual operating cost	$343.89	$616.92	$908.85	$1163.33	$1725.28	$2353.56	$5642.55	$8298.23	$11064.31
	Efficiency Difference	19%	8.5%	8.5%	9%	10%	4%	4.7%	2.2%	2.9%
	Annual savings, kWh	770.24	468.50	676.88	881.84	1448.91	784.34	2115.36	1670.55	2227.40
	Annual savings, dollars	$120.39	$73.23	$105.8	$137.83	$226.47	$122.59	$330.63	$261.11	$348.14
	Differential payback period, years	**0.59**	**2.45**	**1.89**	**1.54**	**1.02**	**1.81**	**0.57**	**1.14**	**1.02**
	Total payback period, years	**1.59**	**4.37**	**3.31**	**2.82**	**1.81**	**3.35**	**1.36**	**3.39**	**2.82**

† Average purchase price from factory-authorized distributors, not list price from vendor.

efficiency motors are more than just superficial. Premium efficiency motors will tend to run cooler than standard efficiency motors, resulting in less wear on motor bearings, lubricants and insulators. This reduced operating temperature also generates less waste heat into the air (Ref. 10) surrounding the motor, leading to reduced ventilation and air conditioning requirements for the motor and yielding additional energy savings. Premium efficiency motors will also operate with less slip than a conventional motor, resulting in an increase in output shaft rotation speed. Additionally, premium efficiency motors offer a reduction in operating cost even at zero-load. Given the tighter tolerances in design and manufacturing, premium efficiency motors will tend to last longer than their standard efficiency counterparts, reducing maintenance and replacement costs.

Premium Efficiency Motor Costs and Savings Calculations

The most important aspect of premium efficiency motors is that the difference in efficiency is not constant throughout a given horsepower range. Typically, the difference in motor efficiency will be greatest for smaller-horsepower motors, and the greatest difference in efficiency is found in the fractional horsepower range, as shown in Fig. 1. This must be taken into account when analyzing a given application for possible cost savings to be found through premium efficiency motors.

Simple calculations can show the cost savings that may be realized by premium efficiency motors in any given situation. These are given by the following equations:

$$K = \frac{HP_{load} \cdot 0.746 \cdot T_{operating}}{E} \quad (1)$$

$$S = 0.746 \cdot HP_{load} \cdot C \cdot T_{operating} \left[\frac{1}{E_s} - \frac{1}{E_{pe}} \right] \quad (2)$$

As may be seen, operating costs and potential savings are directly related to motor horsepower, motor efficiency and the number of hours that a motor operates. The savings gained from switching to a premium efficiency motor are directly related first and foremost to the motor's rated horsepower and the number of hours per year that the motor will be in operation. Due to the reduced field slip of premium efficiency motors (resulting in higher output shaft rotation speeds), "sizing down" a motor for an application becomes a possibility, as shown in the story of International Paper, which appears later in this article.

Real-World Examples of Cost Savings with Premium Efficiency Motors

Although premium efficiency motors represent a significant potential for cost savings in most applications, the savings opportunities they present are more than mere theory. The following stories illustrate several real-world cases where premium efficiency motors yielded a significant increase in value to the businesses that utilized them (Refs. 16–20).

General Electric Supply. General Electric is one of the founders of the electrical industry in the United States, and has been in the electric motor business for over 100 years. GE Supply, a subsidiary of General Electric, began distributing electric motors in the 1920s. GE Supply has noticed that as the customer base for electric motors becomes smaller, the competition among distributors to increase or maintain motor sales becomes increasingly fierce. Premium efficiency motors allow GE Supply to provide its customers with a value-added alternative to conventional motors, despite the marketplace being traditionally price-driven.

Crown Pacific Lumber Company. Crown Pacific conducted an ener-

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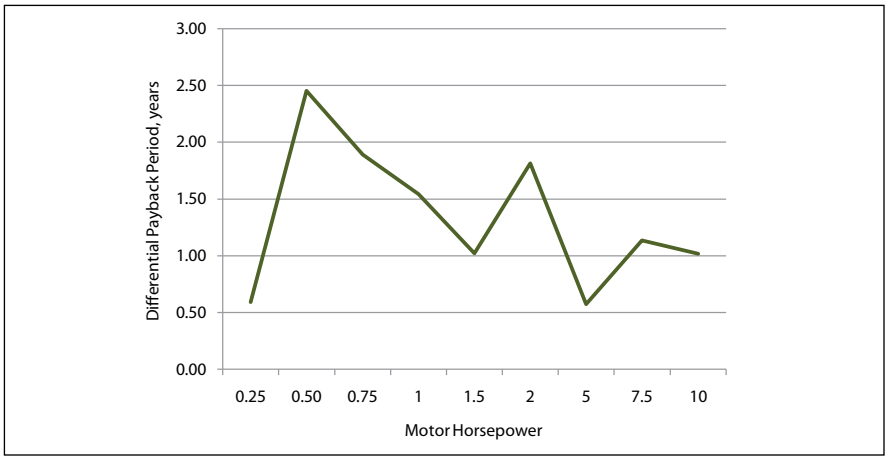

Figure 2—Calculated differential payback period by motor horsepower, based on average purchase price from distributor.

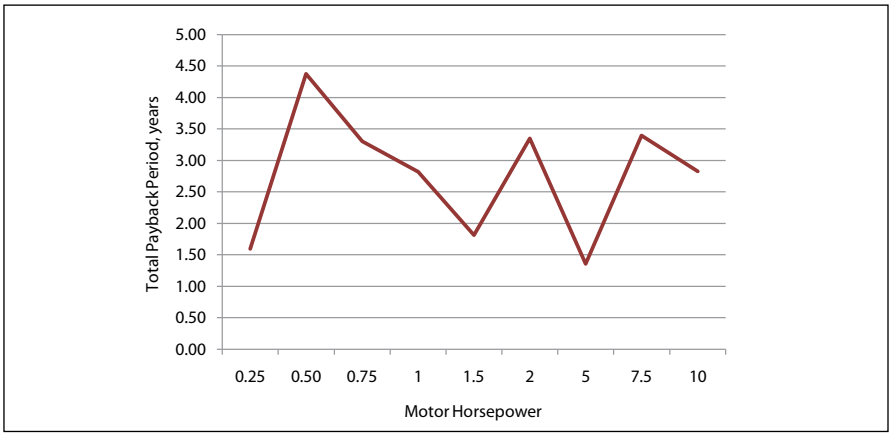

Figure 3—Calculated total payback period by motor horsepower, based on average purchase price from distributor.

NOTE: Figure 2 shows the amount of time required for the motor to pay back the difference in purchase price between itself and its standard efficiency counterpart; Figure 3 shows the amount of time required for a premium efficiency motor to pay back the entirety of its initial purchase price. Generally speaking, premium efficiency motors should be considered when a standard efficiency motor is due for rewinding or replacement, or when designing new machines or processes. Savings may also be realized by replacing standard efficiency motors that have already been rewound, are oversized or are under loaded. Premium efficiency motors are best able to return significant cost savings to the user when the motor's annual operation exceeds 2,000 hours (Ref. 15).

gy survey of over 300 motors at the Gilchrist mill near La Pine, Oregon in 2000 and early 2001. Two standard efficiency motors, which were operating the mill's air compressors, were discovered to cost over $49,000 per year to operate. Subsequent investigation revealed that these motors were operating at a nominal efficiency of just 89%. One of these motors was replaced with a premium efficiency equivalent, which saved Crown Pacific $3,400 per year in operating costs and over 100,000 kWh of electricity. The payback period for this motor swap was 1.8 years.

Weyerhaeuser Company. With over 50,000 electric motors in operation company-wide—or approximately 81% of the company's electrical load—finding the most efficient motor possible became crucial to the $20 billion company. However, they also needed an efficient motor that reduced unplanned downtime and maintenance costs. A multidisciplinary team led by Weyerhaeuser senior scientist John Holmquist selected the Reliance 841 XL Premium Efficiency motor as the company's go-to motor for its applications. Replacing the larger motors at its North American Paper Corporation facility in Longview, Washington—which produces enough newsprint to reach to the moon and back every two weeks—saw a significant cut in the plant's average monthly power bill of $4 million. These savings, combined with incentives and rebates from local utility companies, produced payback periods for the premium efficiency motors in less than one year.

Hydraulic Institute. The Hydraulic Institute (HI) has provided industry standards, education and information exchange to the pumping industry for over 85 years. Recently, HI has been engaged in an ongoing endeavor to develop new industry standards for optimized pump designs and reductions in life cycle costs, and premium efficiency motors have been the key to this effort. Because pumps are used in such a wide variety of industrial processes—chemical, oil and gas, forestry and irrigation, among others—HI recognized the enormous savings potential inherent in optimized system design, and premium efficiency motors were the cornerstone of their plan. HI's 200-page guide, "Pump Life Cycle Costs: A Guide to LCC Analysis for Pumping Systems," brought premium efficiency motors to the forefront of the pump industry, and has received high praise for providing guidelines to reduce the operating costs of each element of a pump system.

International Paper. The International Paper plant in Courtland, Alabama was experiencing vibration and cavitation issues with a white water pump that had been installed in the facility in the 1970s. The pump's high vibration levels—0.6 to 0.7 inches per second—led to bearing failures, packing defects, misalignment and increased maintenance costs due to impeller damage. This gave the pump motor a mean time between failures of nine months. Traditional solutions, including laser leveling, precision blade balancing of the impeller, wear plates and new pump casings, did nothing to alleviate the problem. The company finally turned to the root cause failure analysis (RCFA) process. RCFA focused the company's attention to specific failure mode analyses, leading to the discovery of cavitation damage on the low-pressure side of the impeller, denoting a suction issue. The plant ultimately decided to install a new pump designed to run at a lower speed than the original, and the new pump was to be powered by a premium efficiency motor.

Using a premium efficiency TEFC motor, the plant saw almost immediate results. The new pump motor's operating temperature dropped by 75°F, reducing the thermal growth misalignment from 0.006 to 0.001 and vastly improving motor life. Motor bearing temperatures decreased by 30°F, improving lubricant life and performance. The reduced energy consumption created more reliability for control valves, allowing valves that had been run at 20–30% open to now be run 50–70% open. In the five years since the premium efficiency motor has been installed, the pump has not needed any maintenance work whatsoever.

Conclusion

Premium efficiency motors allow for a realization of significant cost savings, and will often pay for themselves many times over during their useful life. Their advantages of reduced energy consumption—even at zero load—higher rotation speeds at a given voltage and prolonged operating life should weigh heavily on the minds of businesses faced with the possibility of replacing their standard efficiency motors with premium efficiency alternatives. Although slightly more expensive than standard motors, it has been demonstrated that a premium efficiency motor will pay back the difference in acquisition cost via energy savings quickly, oftentimes in less than two years. In some instances, the motor's savings would pay for the entire acquisition cost of the motor in 18 months or less. This is, of course, neglecting the additional cost savings presented by utility companies in the form of discounts and rebates for using premium efficiency motors.

Premium efficiency motors, however, are not a panacea for all problems. Because of the reduced field slip, certain applications—such as centrifugal loads (compressors, fans, etc.)—will see an energy consumption equal to the cube of the application's rotational speed. Thus, increasing the rotational speed of the motor without the use of reduction gearing or variable-frequency drives in these applications may cause energy usage to increase with a premium efficiency motor. However, proper facility planning and correct motor specification for a given application will maximize the cost savings potential of using a premium efficiency motor.

The greatest difference in efficiency between motor classes was found to be for one-quarter- and 1.5-horsepower motors (19% and 10%, respectively). But this efficiency differential does not necessarily translate into the greatest cost savings, as the five-horsepower motor was found to have shorter payback periods than the 1.5-horsepower motor, despite the five-horsepower motor's lower efficiency differential. Likewise, it was determined payback periods were not linear with respect to motor horsepower. The premium efficiency motors with the greatest economic return to the user were found to be the one-quarter- and five-horsepower variants. Each of these not only had the shortest differential payback (0.59 and 0.54 years, respectively), but also the shortest total payback (1.59 and 1.36 years, respectively). Yearly cost savings in total

dollars were found to be directly related to output horsepower, though the five-horsepower motor is again an outlier in this regard. Research showed that the five-horsepower premium efficiency motor yielded an annual dollar savings nearly on par with the 10-horsepower motor. Therefore, efforts to increase plant efficiency via reductions in operating costs should focus primarily on replacing one-quarter- and five-horsepower motors with premium efficiency variants. The five-horsepower motor is of particular importance in this regard, as it is very common in a large variety of industrial applications.

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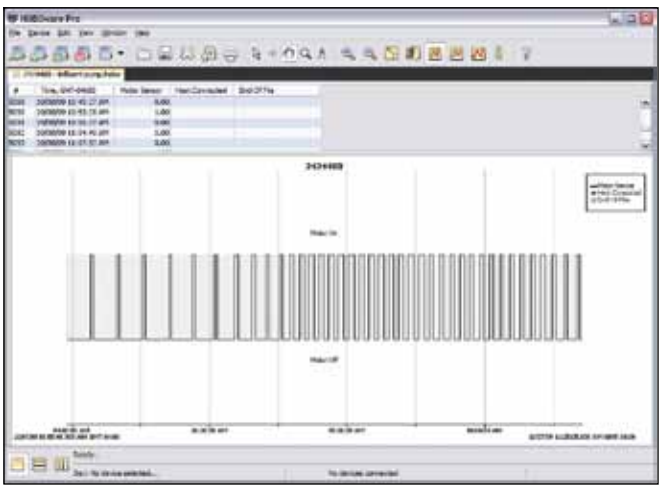
Data Loggers Gauge WASTEWATER PLANT'S MOTOR EFFICIENCY

Evan Lubofsky, Onset Computer Corporation

In keeping with a national push to bring greater energy efficiency to wastewater treatment plants, a Pennsylvania facility used data loggers to analyze motor utilization, a first step toward cutting energy costs and meeting environmental rules.

Upper Allen Township conducted an audit of motor run times on existing equipment at its wastewater facilities with data loggers manufactured by Massachusetts-based Onset Computer Corporation. The goal was to gather information that would help the facility choose new technologies and processes that reduce energy intensity and nutrient flow.



The *HOBOware* software system downloaded, graphed and analyzed the information gathered from the wastewater treatment plant's motors (All photos courtesy Onset Computer Corporation).

This article explains why the Cumberland County wastewater facility needed to improve its efficiency, and how its contractor, Reynolds Energy Services, employed data loggers to gather preliminary information.

Importance of Upgrades

The decision to improve the plant's efficiency reflects a national movement to reduce consumption at energy-hungry wastewater facilities. After labor, energy is the highest expense at the 15,000 publicly-owned wastewater treatment plants, which serve about 70 percent of the U.S. population, according to the Consortium for Energy Efficiency (CEE). The facilities account for as much as 35 percent of the energy used by some municipalities.

As a result, several towns and cities are directing funds from the American Recovery and Reinvestment Act (ARRA) toward wastewater treatment improvement. Upper Allen Township applied for a portion of the $2.2 million in ARRA funds received by Cumberland County, but the town was unsuccessful due to the overwhelming number of requests the county received for funding.

In addition to reducing energy, planned improvements at Upper Allen Township's Grantham wastewater treatment plant will help Pennsylvania meet federal standards estab-

Onset's HOBO U9 Motor On/Off data loggers were attached to the motors to conduct a detailed energy audit. The focus was on the aeration process, which is comprised of motors and fans and is the plant's biggest energy thief.

lished to protect the Chesapeake Bay. Located about two hours west of Philadelphia, the Upper Allen Township wastewater system daily treats between 500 and 700 thousand gallons of wastewater on average. The treatment plant was most recently expanded and upgraded in 1990 and uses a sequencing batch reactor system with aerobic digesters. The facility is scheduled for additional improvements in 2010–11 to meet anticipated changes to the National Pollutant Discharge Elimination System (NPDES) permit's requirements in connection with the Chesapeake Bay Tributary Strategy, which designates river-specific cleanup strategies needed to reduce the amount of nutrients and sediment flowing into the bay.

Streams in Cumberland County flow into the Susquehanna River, which in turn feeds into the Chesapeake Bay. The river has been deemed a major source of nitrogen, phosphorous and sediment found in the bay. As a result, the U.S. Environmental Protection Agency has devised a "pollution diet," known as a Total Maximum Daily Load (TMDL), intended to drive actions for cleaning local waters and the Chesapeake Bay. This policy requires Pennsylvania wastewater treatment plants to cap their nutrient flow into Susquehanna tributaries in order to win approval as permits come up for renewal.

Data Loggers Reveal Inefficiencies

Studies estimate that potential exists to reduce energy use 15 percent to 30 percent at U.S. wastewater plants. The extent of savings depends upon the facility size, type, technology and regional operating conditions. While motor replacement might reduce energy use about two percent, modifications in process control might cut consumption 30 percent, according to CEE.

The aeration process, which uses fans and motors, consumes the most energy. Gaining maximum efficiency in the aeration process is particularly important because it is a peak load operation, meaning the plant consumes large amounts of power when electricity prices are highest. Reynolds Energy Services, of Harrisburg, PA, conducted a detailed audit of the Upper Allen facility with an eye toward installing improved aeration technology that reduces energy use and meets environmental permitting requirements.

Equipment does not always perform as efficiently as manufacturers estimate for a variety of reasons. This is why the auditors attached Onset's HOBO U9 Motor On/Off data loggers on existing equipment at the treatment plant and pumping stations to "see how equipment is actually operating," says Michael Conchilla, Reynolds' project development manager.

The project focused on motor loads, particularly for the larger equipment—aerators and pumps at pumping stations. "We had a dozen different motors being logged," Conchilla says. "We were looking for runtime patterns, and how many hours per day they're being used. Many of the motors cycle on and off in small intervals. We wanted to see what those patterns are, what the collective hours are and extrapolate that out on an annual basis," he said.

Reynolds left the data loggers onsite for about four weeks.

continued

This was easy since the loggers are portable, rugged standalone devices that operate independent of any other apparatus or connection. The data loggers monitor the alternating current field generated by the motors.

"I got great results from tying the loggers to feeders in electrical cabinets rather than deploying them only on the motors. Some of the motor casings were too large to get a good field reading. I'll probably do this more in the future," Conchilla says.

After retrieving the data loggers, Reynolds downloaded the information and graphed and analyzed the data using *HOBOware* software, which allows quick information readout and plotting with export to spreadsheets.

"We needed to understand the run time patterns for each individual motor. If you can extrapolate that out for a year, you know how many kilowatt hours each motor is using," Conchilla says. "The township collects amp readings on a regular basis. This is used to estimate electrical draw on the motors. We use this and the runtime data to estimate actual kilowatt hour usage for each motor."

He added: "As long as you have the amperage data and run time, you can make the calculation. We used Microsoft Excel to do those calculations. I would export all the run time data from *HOBOware* to an Excel file, tabulate hours based on the period and extrapolate that out for the year."

Reynolds will use the information to help Upper Allen determine where upgrades to the system are necessary and where the expense can be avoided. After the new equipment is installed, the energy services company will continue to use data loggers to confirm results; a necessity because Reynolds is operating under an energy services performance contract.

Thanks to the data loggers, Upper Allen now can move forward with its efficiency improvements, assured that any guesswork has been removed. "You can't argue with the data," Conchilla says. "They tell you what's going on 24 hours a day."

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The data loggers were deployed on the motors (as pictured above), although some of the casings were too large to produce a good field reading, so they were also tied to feeders in the electrical cabinets.

PTRA
LOOKS TO THE FUTURE

The Power-Motion Technology Representatives Association Annual Conference will bring about 40 manufacturers to Charleston for informational presentations and networking (Courtesy of PTRA).

Southern hospitality may not be the focus, but the Power-Motion Technology Representatives Association (PTRA) will experience just that and more at its 38th annual conference in Charleston, SC. Members will explore the theme of "Impacting the Future" through educational presentations and amidst networking opportunities, intimate social events and the annual golf tournament.

The PTRA is an association of independent manufacturers' representatives and manufacturers dedicated to promoting the sales representative's function in the power transmission and motion control industries. Highlighted presentations include Alan Beaulieu, senior economist for the Institute of Trend Research, discussing "The Recovery—How Long and How Fast;" David Huether, chief economist for the National Association of Manufacturers, on "A Manufacturing Resurrection: Prospects for Growth in American Industry;" and David Mayer, vice president of marketing, Kaman Industrial Technologies, who will discuss how Kaman differentiates itself in today's marketplace and the role manufacturers' representatives play.

Much of the conference program focuses on general economic topics, but PTRA aims to have at least one speaker from the industry on the roster. "The general design of the program is to start with a '10,000-foot-view,' Alan Beaulieu from the Institute for Trend Research, followed by Dave Heuther of the NAM and then Dave Mayer from Kaman. Dave Heuther's presentation will be very relevant to our manufacturer members, although not specific to our industry. Dave Mayer's presentation will of course be directly relevant to the power transmission and motion control industries," says Jay Ownby, executive director of the PTRA.

In addition to the presentation program, there are three breakout sessions: "Build Solid Relationships by Backselling to Your Principals," "Improve Your Microsoft Office Efficiency (A Lot!): Learn to Leverage Time and Technology," and "Let's Soar: Actionable Tools to Take You and Your Rep Firm/Principal Relationships to New Heights." The breakout sessions are typically attended by smaller groups, about 1/3 of the total group; however, they are held at different times, so attendees can attend all of them if they choose. The format tends to be more involved than the other speaker presentations.

continued

Alan Beaulieu, senior economist for the Institute for Trend Research will discuss "The Recovery—How Long and How Fast." Attendees will hear from several other speakers and have the opportunity to participate in smaller breakout sessions.

"There is a presentation and Q&A, and there is much more interaction with the smaller groups. Each of these speakers will invite questions at any time," Ownby says.

According to the 2009 post-conference survey results, breakout sessions were cited as attendees' favorite part and also something attendees wished more time was devoted to.

"We always conduct a post-conference survey, sometimes at the conference itself, sometimes after. The two most valuable aspects of the conferences are always networking and education," Ownby says.

Another key feature is the RepMIX, which features a half day of planned, interactive meetings between manufacturers and representatives. Principal members can reserve a booth with chairs and a conference table where they can schedule up to eight 25-minute sessions, or any combination totaling four hours. These meetings can be arranged in advance of the conference.

"Typically around 60 percent of the PTRA membership attends the conference, which is around 40 manufacturers. Of the 40, 15–20 participate in the RepMIX," Ownby says.

"The majority of these use the RepMIX to interview reps for open territories; some who don't have any open territories use it to meet with their reps who are attending the conference."

Aside from the annual golf tournament, held at Patriots Point Links, where participants will take in views of Charleston Harbor and Fort Sumter across the fairways, PTRA is also running/walking for the South Carolina Chapter of the Cystic Fibrosis Foundation. Conference dinners are arranged as "dine-arounds," in which attendees choose between several restaurant options and dine in groups of eight to 10 instead of less intimate, full group meals. A closing banquet is held for all attendees to conclude the conference.

The PTRA annual conference takes place April 11–14 at the Mills House Hotel in downtown Charleston. For more information, visit *www.ptra.org*.

calendar

February 19–23—Hydraulic Institute Annual Meeting. Marco Island Marriott Beach Resort, Marco Island, FL. The 2010 Annual Meeting is a networking and educational opportunity for executives, engineers and marketing professionals associated with pump and supplier companies in North America and Europe. Guest speakers are on the agenda as is the work of technical committees addressing industry standards, guidelines, electronic data exchange protocols and other topics. A CEO roundtable and executive discussion breakouts are scheduled, along with a special working session for sponsors of Pump Systems Matter (PSM), which is designing a pump systems optimization and energy utility rebate/incentive program. Registration is open to all Hydraulic Institute members, associate members, standards partners, PSM sponsors and eligible prospective members. For more information, visit *www.pumps.org/2010Annual*.

March 31–April 2—Concrete China. China National Convention Center, Beijing. Concrete China is the concrete industry's international event with exhibition, conference and training featuring raw materials, technologies, equipment and applications to cover the entire industry supply chain. Concrete China 2010 includes a seminar on new technology and equipment of concrete additive agents, training on basic theory, knowledge of GRC and more. It provides domestic and overseas concrete manufacturers, traders and research institutions with a comprehensive service platform on product display, technical exchange and cooperative negotiation, which promotes healthy development of the concrete industry and communication among domestic and overseas concrete enterprises. For more information contact CCPIT Building Materials Sub-Council by phone: 0086-10-68361826; e-mail *wangl@ccpitbm.org*, or visit *www.concretechina.org*.

April 9–11, 2010—Techno 4. CODISSIA Trade Fair Complex, Coimbatore, India. Techno 4 is a new trade exhibition focusing on four different sectors of the engineering industry: pumps and ancillary equipment; foundry; motors and rotating machines; and light engineering. The exhibition takes its cue from the rapid expansion of these four engineering sectors in the Indian economy, which stand as the largest contributor to Indian exports. Coimbatore is a hub for engineering businesses in India. It is the second largest city of Tamil Nadu and one of the fastest growing cities in the country. The business infrastructure is in place to hold successful trade events, including an international airport, telecommunication links and multi-lingual opportunities. For more information, visit *www.techno4india.com*.

April 19–23— Hannover Messe 2010. Hannover Fairgrounds, Hannover, Germany. The world's leading trade show for industrial technology returns in 2010 with the usually full lineup of trade shows. The eight co-located shows include Industrial Automation, Energy, Power Plant Technology, MobiliTec, Digital Factory, CoilTechnica, MicroNano Tec and Research and Technology. Italy is the official partner country in 2010. For more information, visit *www.hannovermesse.de*.

April 22–23—Smart Grid China Summit 2010. The Renaissance Beijing Hotel. Beijing, China. Over 100 authorities from the global electricity community gather in China to discuss smart technologies and solutions to upgrading the global power grid system. Attendees include governmental authorities, transmission and distribution automation, smart technology providers, research and development organizations, consultants and investors. One purpose of the summit is to provide an international information exchange about policies the Chinese government is planning and strategies international corporations will take to develop the smart grid. The event will showcase the latest products and technologies. For more information, visit *www.smartgridchinasummit.com*.

May 1–4—Bearing Specialists Association Annual Convention. Naples Grande Beach Resort and Spa, Naples, FL. The 2010 annual BSA convention adopts the theme "A Look Back to Step Ahead," in homage to the association's 44-year history as it looks to new opportunities and markets in the recovering economy. The intention is for attendees to answer the question of leveraging growth in the current economy with a three-part presentation consisting of a panel discussion about industry and economic lessons learned the past 20 years, a present industry overview and a future industry panel discussion. The convention will also offer industry updates from ABMA and BSA, as well as a session of pre-scheduled conferences. An opening reception and manufacturing appreciation event, golf tournament and a tennis round robin provide networking opportunities. For more information, visit *www.bsahome.org*.

June 8–9—CTI Symposium North America 2010. Four Points by Sheraton Ann Arbor Hotel. Ann Arbor, MI. This event, organized by the German Car Training Institute (CTI), focuses on the latest technical innovations in automotive transmissions, hybrid and alternative drive trains with experts and suppliers from the United States, Asia and Europe. This year's focus will also address improving efficiency of today's drive trains. The symposium will examine current debates on economics, politics and the environment. Topics will be examined from the perspective of technology, customers and the context of market success. CTI aims to emphasize the potential of development tools in light of the financial crisis. For more information, visit *www.transmission-symposium.com/north-america*.

Rexroth

OPENS DALLAS REGIONAL SERVICE CENTER

Mike Rowlett, left, president of Bosch Rexroth distributor Womack Machine Supply, lends a hand to Berend Bracht, president and CEO of Bosch Rexroth in the Americas, cutting the ribbon at the open house for the Dallas Regional Service Center.

An open house launched the Bosch Rexroth Dallas Regional Service Center in December. The state-of-the-art repair, upgrade and maintenance resource center services industrial and mobile hydraulics components.

"Looking into the future, I am proud to say that this facility is only a starting point when it comes to Rexroth and service," said Berend Bracht, president and CEO of Bosch Rexroth in the Americas, at the open house. "Rexroth is committed to servicing our customer-owned components and applications. That's why we are so excited to celebrate this milestone in Rexroth's history in the United States."

Rexroth has a strategic commitment to fortify its service business, and the Dallas Service Center is just one of a nationwide network of regional hydraulics service facilities the company is planning.

"This is a major investment by Bosch Rexroth to better serve our customers and develop new markets," Bracht said. "In these challenging economic times, we want to do everything we can to help our customers sustain and extend the profitable lifetimes of their Rexroth hydraulics components and systems. These regional service centers will let us deliver faster, more focused hydraulics repair services and ensure that our customers' world-class products and systems are properly serviced by trained Rexroth technicians, using only genuine Rexroth parts."

The Dallas Service Center provides warranty service, repairs and conversions as well as exchange programs to help manufacturers reduce their carbon footprint by reusing housings from retuned units. According to Jim Smith, director of the Regional Service Centers, industrial and mobile hydraulics customers will have access to field service in 2010. The center serves a broad range of industries, including offshore drilling, refining, automotive, plastics, construction, agriculture and steel manufacturing in Texas, New Mexico, Oklahoma, Kansas, Arkansas, Mississippi, Louisiana Alabama and parts of Florida.

"Customers have complained of receiving repair services from repair facilities that sometimes use lower-quality knockoff parts that have a high potential for malfunction or failure, rather than using best practices," Smith says. "With the new Bosch Rexroth Regional Service Centers, customers won't have to settle for cheap substitutes when you can get first-class repair and exchange service with factory-backed warranties from Bosch Rexroth, resulting in maximum equipment uptime and a minimum of unplanned service incidents."

The 14,000-square-foot Dallas Service Center repairs Rexroth motors and pumps as well as proportional and servo valves. Rexroth worked with business partner Womack Systems—a distributor of hydraulic, pneumatic and automation equipment—to develop service and repair programs targeting the region's hydraulic users. This included developing emergency repair programs featuring market-driven lead times for costing, repair and return of products to customers.

Southern California will be home to the next Regional Service Center set to open in early 2011. Other regional centers are planned to follow.

The view from outside the 14,000 square-foot Dallas Service Center, where Rexroth motors and pumps are repaired, as well as proportional and servo valves.

Carlisle

MERGES BUSINESS SECTORS

Carlisle Companies Inc. is combining its power transmission belt business, which was discontinued in 2008, with its tire and wheel businesses. Carlisle Power Transmission manufactures belts and accessories for industrial power transmission applications with annual sales around $115 million.

In the second quarter of 2008, Carlisle PT moved to discontinue operations. "We announced plans to sell our power transmission belt business in April 2008," says David A. Roberts, chairman, president and CEO of Carlisle. "We were close to selling the business to a strategic buyer last year when our transaction was derailed by the financial crises.

"During our extended sales process, we also considered retaining the belt business, which has remained profitable, and combining it with one of our other businesses. Though we recently received an offer near book value, the decision was made to retain and combine the belt business with our tire and wheel business. These two businesses have similar manufacturing processes and share common customers."

Carlisle serves the on- and off-highway vehicle and equipment industries. It is evaluating the financial statement impact and estimates pre-tax charges of $6.7 million related to fixed-asset charges and plant restructuring costs in the fourth quarter 2009.

NADCA

RECEIVES GRANT FOR FUEL EFFICIENCY DEVELOPMENT PROJECT

The North American Die Cast Association was granted $1.5 million in funding for its HyperCAST project, which develops materials and processes for cast, high-strength, lightweight frame, body, chassis and powertrain components for fuel efficient passenger cars as well as commercial and military trucks.

The technology being developed focuses on fuel efficiency and cost competitiveness for the potential of 60 percent weight reduction without compromising component performance, cost safety or recyclability. Self-propagating high-temperature synthesis (SHS) is the material technology in development. SHS is also known as auto ignition combustion synthesis for generating composite materials with magnesium-based

continued

composites as the primary focus.

NADCA is conducting the HyperCAST project in coordination with the Colorado School of Mines, Ohio State University, Case Western Reserve University, Worcester Polytechnic Institute, Purdue University and Oak Ridge National Lab. NADCA believes the HyperCAST technology holds dynamic potential for protecting the environment and creating jobs in the die casting and automotive industries. For more information, visit *www.diecasting.org/research/roadmap.htm*.

Needle Roller Bearings Sale

TRIGGERS CHAIN REACTION

With Timken's acquisition of Torrington in 2003, needle roller bearings (left) were added to its product offering of tapered roller bearings (right).

The Timken Company finalized the sale of its Needle Roller Bearings business to the Japanese JTEKT Corporation, December 31, and the advantage of this transaction has caused a ripple effect through JTEKT to its sales, marketing and distribution arm, Koyo Corporation.

"The completion of this deal is a win for everyone involved," says James W. Griffith, Timken president and CEO. "The Needle Roller Bearings business' new owner is committed to the automotive industry, which provides new opportunity to customers and the talented associates who are transferring with the deal."

Needle Roller Bearings manufactures engineered needle roller bearings for automotive and industrial applications. The company was taken over by Timken through the acquisition of Torrington in 2003. JTEKT acquired a global production network of 12 needle roller bearing manufacturing plants; in North America those include Cairo, GA; Dahlonega, GA; Sylvania, GA; Greenville, SC; and Bedford, Quebec.

During the last three months of 2009, Needle Roller Bearings suffered a loss of $59 million after accumulating $289 million in sales over the previous nine months. The divestiture is expected to reduce Timken's sales for the year, but the net effect on the company's earning is expected to be positive, according to Timken's press release, and is part of a broader restructuring.

"As to Timken, we've fundamentally changed our portfolio of business, in line with our strategy to optimize the enterprise," Griffith says. "The resources now in hand can be used to create greater value for our customers and shareholders, including pursuit of new growth in attractive industrial sectors."

The acquisition provided Timken with approximately $330 million, including retained receivables. Timken plans to allot the proceeds for general company purposes while providing more liquidity, and improving the company's financial position as it looks towards strong cash prospects from operations in the coming year, the release said.

Koyo Corporation of U.S.A, a JTEKT Group company, designs and manufactures a range of bearings to industrial markets that include automotive, agriculture, electric motor repair, steel, construction, power sports and wind energy.

JTEKT's acquisition of Timken's Needle Roller Bearing business enhances the research and development capabilities, expanded product offerings and increased North American capacity for Koyo through the subsequent formation of Koyo Bearings USA LLC. The combined technologies and expertise extend Koyo's market reach.

"The alliance with Koyo Bearings USA allows us to maximize productivity and strengthen our current product offerings to meet the demands for the agricultural, construction and power sports markets, as well as be even more competitive and technologically advanced in the aerospace, machine tool and office equipment markets," says Yoshio Tsuji, president and CEO of Koyo Corp. of USA.

With three manufacturing facilities in Orangeburg and Blythewood, SC and Washington County, TN, Koyo Corp. of USA also has an engineering and technical center in Plymouth, MI. This manufacturing base is now complemented by Koyo Bearings USA's five needle roller bearing facilities and the Greenville Tech Center located in Clemson University's International Center for Automotive Research Park.

"JTEKT's decision to acquire Timken's Needle Roller Bearings business offers an opportunity for considerable synergies between the two companies," says Rob Hamilton, director, industrial OEM and aftermarket sales, Koyo Corp of USA. "Our engineered and manufacturing experience joined with their resources and capabilities will allow us to expand our technological expertise and our product offerings into new industrial markets."

PMMI

PROMOTES TWO VICE PRESIDENTS

Katie Bergmann

Katie Bergmann was promoted to vice president of administration for PMMI, from director of administration; Maria Ferrante was appointed vice president of education and workforce development from her previous position as senior director of training and development.

PMMI is a trade association that represents companies manufacturing packaging, processing and related converting machinery, commercially available packaging machinery components, containers and materials in the United States and Canada.

Bergmann first came to PMMI in 2007 as human resources director. In this new position, Bergmann oversees and coordinates administrative duties for the association's Arlington, VA headquarters, and she manages all human resource functions.

Maria Ferrante

Ferrante has been with PMMI since 1999 when she started as director of technical services. She helped launch *PMT* magazine, where she served as editorial director. Over the years, she has fulfilled a growing role in PMMI's education programs, and Ferrante was named senior director of training and development in 2009. In her most recent promotion, Ferrante is responsible for developing PMMI's education and workforce development programs, which include PMMI's Certified Trainer program and PMMI U's new online learning options.

"PMMI's emphasis on education has been growing exponentially, as have our infrastructure needs," says Charles D. Yuska, president and CEO of PMMI. "As our attention on these areas continues to increase, we clearly needed to dedicate senior staff to them. Katie and Maria have proven their capabilities repeatedly. We're excited to see them step up to the plate to move these essential goals forward."

ad index

Gear Manufacturing

Gear Manufacturing

Gear Manufacturing

Help Wanted

Help Wanted

Power Generating Play

Never has generating alternative sources of energy been so fun. All that excess energy children have bottled up now helps power lighting for remote African villages.

On an 18-month missionary trip to Ghana, retired engineer Ben Markham visited rural schools and noticed the children were subjected to poor lighting and a lack of playground equipment. With the sun as the only source of light, Ghanian schoolchildren are very limited in the time they have to study. After school, daily chores often consume their days due to limited technological resources, like transportation. "The problem with Ghana is it's right on the equator, so they get about 12 hours of sunlight a day," Markham says. "There's no real time to do homework."

And then the light bulb switched on in Markham's head.

Back in the states, he began working with Brigham Young University (BYU) students and faculty to develop electricity-generating merry-go-rounds. And thus, in 2007, Empower Playgrounds, Inc. (EPI) was formed as a 501(c)3 public charity.

Although children have a reputation for housing excessive amounts of energy, they can't quite power a village on their own. "People think children generate a lot of energy, but it's not when you measure it in watts," Markham says.

Part of his goal is for the children to have fun while participating in valuable science education and providing a much-needed resource to their communities. "We try to design things so they're fun and not just work wheels. Most of their play energy goes for play, with about 30 percent being used to generate power."

It takes two to three children typically to produce 100 watts of energy on the merry-go-rounds. The mechanical design is responsible for everything else. "The children typically push the merry-go-round at 8–10 rpm," Markham explains, "The gearbox increases the rpm to 200 to 300, so the generator will produce an interesting amount of power."

The design of the merry-go-rounds has evolved since the first of 10 complete systems was installed in 2008. Markham describes the design: "The main bearing for the merry-go-round is a series Land Rover hub axle. These are readily available from Ghanaian junkyards. The entire deck of the merry-go-round—including the center covering—bolts onto the hub using the Land Rover lug nuts. It's like the merry-go-round is the wheel and tire on the vertical hub axle. From the hub, the axle is cut and machined for the u-joint coupling to an SEW-Eurodrive helical gearbox. The gearbox, which runs in reverse as a speed increaser, is coupled to the Ginlong Technologies 3-phase AC windmill generator.

"The 3-phase AC power wires run from the merry-go-round to a small enclosure inside the school. Inside the enclosure, a bridge rectifier changes the AC to constant polarity DC current, so it doesn't matter which direction the merry-go-round is pushed. The DC current goes to a smart power controller that manages recharging of the deep cycle 12-volt storage battery."

Markham has a patent pending on the design, not because he has any fear of revealing his trade secrets, but because he was concerned others could try and block him from using it for humanitarian reasons to pursue commercial ventures.

Four new systems were installed in 2009, while donations from the year provided funding for 25 complete merry-go-rounds. EPI recently received a major corporate sponsorship to develop custom LED lanterns designed specifically for its systems, which lower total system cost, recharge easier, improve the lighting and are more reliable.

Markham and his small staff are developing other projects, which include a power-generating glider swing-set that is in the prototype testing phase, but Markham remains dedicated to his initial goal of promoting fun education. "We have some other ideas, but we're not chasing development too much," he says, citing the substantial costs inherent in developing technology. "We would rather spend the money on building the merry-go-rounds, which we know work well."

For more information and to make a donation, visit *www.empowerplaygrounds.org*.

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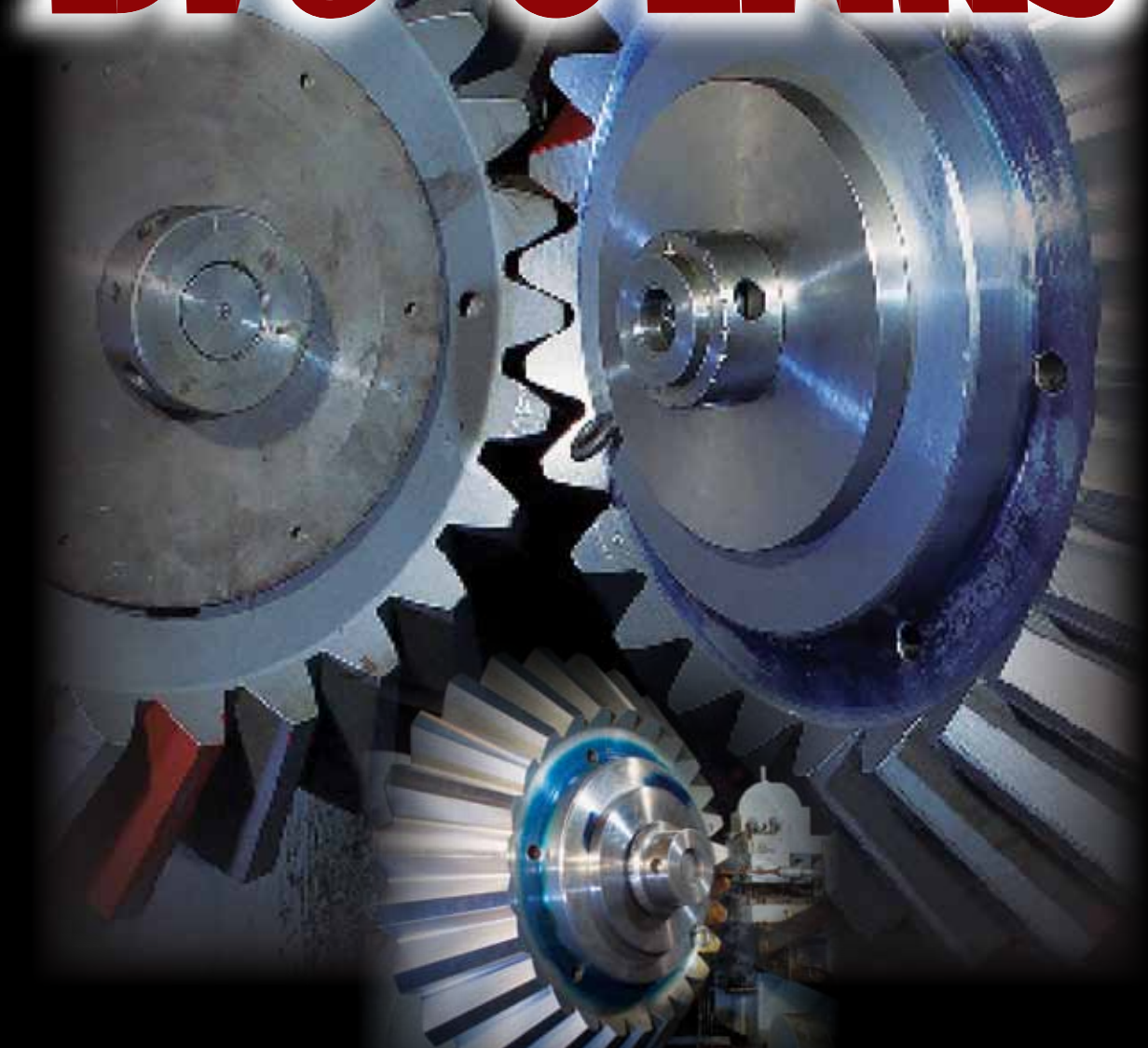

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