February 2009

PTE

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- Getting Green: Fanuc, Romax, Portescap, SKF and Purdue
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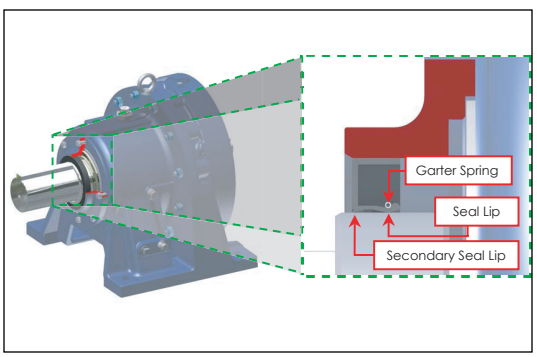

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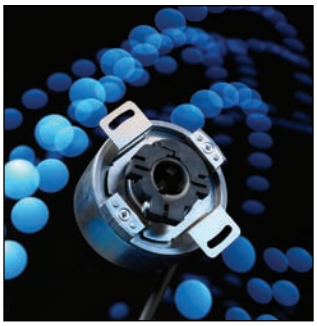

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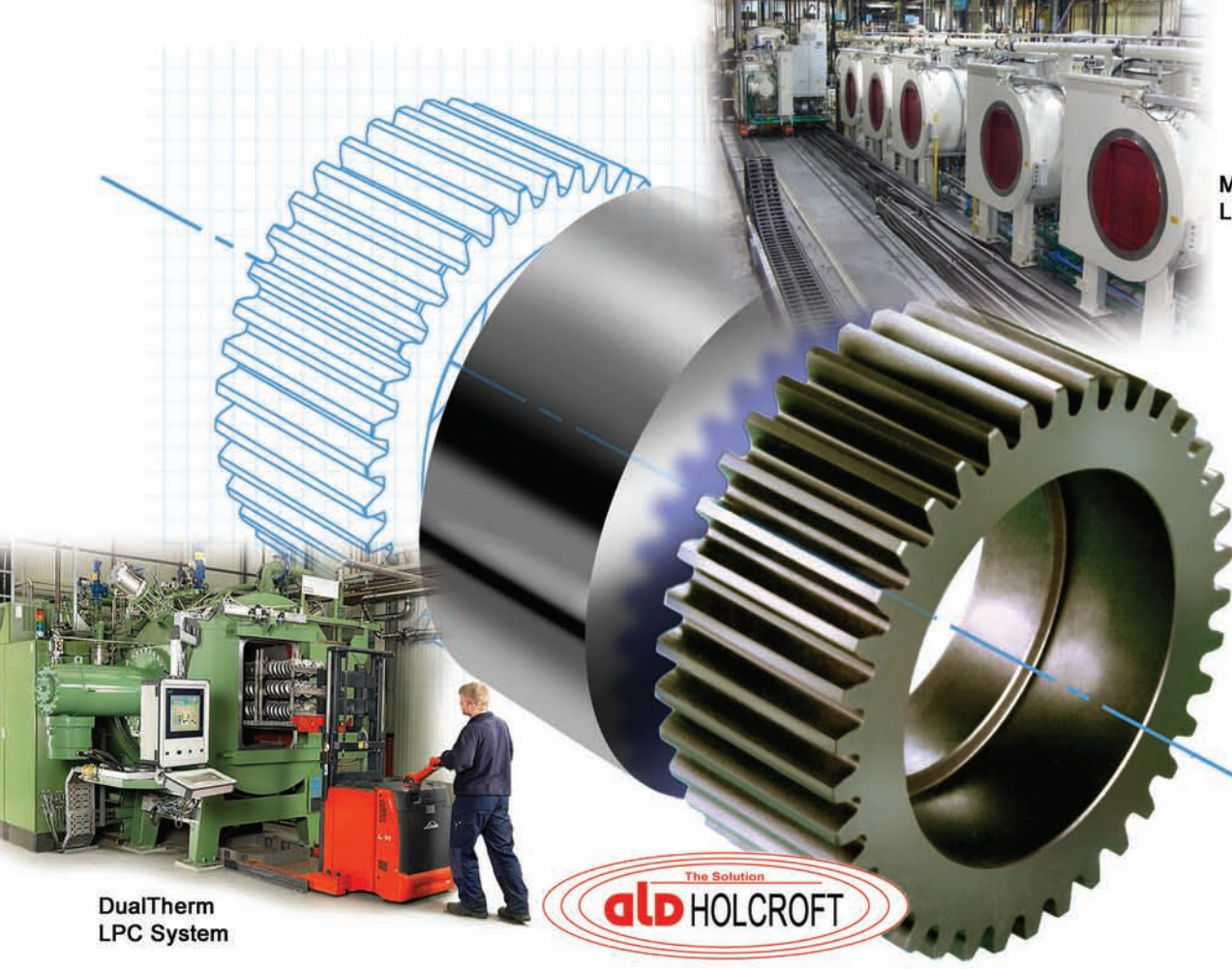

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LPC System

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The Solution
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Yes. ModulTherm

is a powerful gear design tool from ALD-Holcroft

ModulTherm® is a low pressure carburizing (LPC) system that allows engineers to design out problems like intergranular oxidation (IGO), post heat treat machining, and poor surface finish. It gives gear designers unparalleled control over alloy selection, heat treatment, quenching, and end product performance.

What's unique about the ALD-Holcroft system is multiple quench options. In addition to 20 bar high pressure gas quenching (HPGQ), ModulTherm systems provide oil, water, and press quench capabilities. With this versatility, gear designers can work with low and high alloy steels without sacrificing strength and fatigue resistance.

ModulTherm gear design benefits include alloy flexibility, no IGO, no decarburization, little or no part distortion, and excellent root and deep blind hole penetration.

ModulTherm gear manufacturing benefits include quench flexibility, the industry's largest vacuum chambers, 15 to 25% shorter cycle times than atmosphere furnaces, part-to-part consistency, less machining, less destructive testing, lower product costs, and a low Green House Gas emission profile.

ModulTherm installations are fully integrated, fully automated systems with up to 20 vacuum chambers. Lower volumes are handled by DualTherm®, a dedicated LPC/HPGQ system.

ALD-Holcroft Vacuum Technologies Co., Inc. has 80 years of vacuum-based gear processing experience. Our e-mail address is sales@ald-holcroft.com. Our phone number is 248.668.4130. If you design, manufacture, or heat treat gears, call. With an ALD-Holcroft ModulTherm or DualTherm LPC system, everyone wins.

Go to www.ald-holcroft.com to learn more about ModulTherm and DualTherm

Coreless Design

MAXIMIZES MOTOR EFFICIENCY

Portescap, a Danaher Motion Company, introduces the Athlonix high-power density brush DC motors, which are compact, highly-efficient endurance motors that provide high speed-to-torque performance in a lighter package. The Athlonix motors feature a coreless design with a self-supporting coil and magnetic circuit that provide high power density and prolonged endurance for the motor life. They have an output power up to nine watts, and they are available in 12, 16 and 22 mm frame sizes.

"Athlonix motors are powered by a proprietary self supporting coil, whose design optimization flows from more than 70 years of Portescap research and design. The result is maximized magnetic flux and turn-density for a given diameter, within the Athlonix motor platform," says Udayan Senapati, brush DC product line manager for Portescap. "In contrast, typical self-supporting coils have inherent turn-density limitations that affect the magnetic flux density in the magnetic circuit, which further limits output and endurance of the motor."

The coil design allows for a low motor regulation factor in which energy efficiency is near 90 percent, depending on motor load conditions. The result is a motor that performs better over its lifetime, and the package weight has been reduced to 15–53 grams, depending on the frame size.

"The motor regulation factor, measured by R/k^2 where R is the coil resistance and is the torque constant, is a critical measure of a motor's power density over its performance lifetime," Senapati says. "The lower the motor regulation factor, the lower will be the heat loss at higher loads, thus enabling the motor to retain high power density with sustained endurance. The heat loss from a motor is detrimental not only in terms of reduced efficiency, but it also degrades motor performance over the life of the motor. Superior motor regulation, then, is the key to levels of performance and endurance that set Athlonix apart from conventional technologies."

Athlonix motors have motor regulation factors lower than most comparative motors by 5–20 percent, according to a Portescap press release. The result here is consistent power density over the motors' lifetime. They also are capable of higher throughput than other motors because of the quick acceleration they're capable of.

The Athlonix motors are well suited for applications such as medical analyzers and electronic assembly that require constant pick-and-place operations during machining, assembly and scanning. They are also suitable for medical pumps, secure door locks, watch winding mechanisms and robotics.

For more information:

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Sales.america@portescap.com
www.portescap.com

Wind Turbine Couplings

PASS "HELL HOLE" TEST

The Composite Disc Couplings from Zero-Max, Inc., designed specifically for the wind turbine industry, feature composite disc packs at each end of a center spacer. The disc packs are patented and offer strength and flexibility to the coupling. They permit a surplus of parallel and axial misalignment, and they stay torsionally stiff through the harmonic ranges of a wind turbine's oscillating load.

"These couplings withstand extreme misalignment while remaining torsionally stiff and have passed the 'hell hole' test at Tehachapi, California wind farm," says James Motz, a member of the Wind Team for Zero-Max.

"The couplings were tested under conditions simulating a 20-year load spectrum of continuous operation. Once fatigue tested, the 'hell hole' location was selected for field testing in a wind turbine whereby the coupling would experience wind conditions in excess

continued

of 80 mph with continuous direction changes," Motz says. "The Zero-Max couplings survived these conditions that put over 50 wind turbines not using our coupling out of commission. The Zero-Max coupling continues to operate uninterrupted at this writing."

The coupling's center spacers can be produced from steel, composite glass fiber or 6061-T6 aluminum, depending on the application. They can be engineered to sustain more than 70,000 Nm of torque, depending on the material, by using finite element analysis.

Gearbox damage is averted by eliminating amperage leak through the flex elements electrically insulating the turbine's generator from the gearbox. The coupling protects the generator by shifting lower reaction loads to the generator bearings, and the coupling's composite material survives in extreme environmental elements including temperatures ranging from –57 to 121 degrees Celsius and the moisture and chemicals common to wind turbines.

"Zero-Max has been a leader in design and engineering of wind turbine couplings that outlast the life of any wind turbine built for more than 50 years," Motz says. "Today's Zero-Max's wind turbine coupling technology and facilities have advanced and expanded to serve leading wind turbine manufacturers worldwide with designs that exceed any OEM turbine coupling life requirements."

For more information:

Zero-Max
13200 Sixth Avenue North
Plymouth, MN 55441-5509
Phone: (763) 546-4300
Fax: (763) 546-8260
www.zero-max.com

Safety Relay

MOUNTS INTO PLC RACK

The QS Safety Relay from Mistubishi Electric is incorporated directly into the PLC rack or through direct, high-speed CC-Link for the standalone networked version. The result is detailed intelligence identifying plant safety conditions readily available through the relay.

"This is a major step forward for plant owners and machine operators," says Jeremy Shinton, Q Series product manager for Mitsubishi Electric.

"Typically a manufacturing plant will have a number of safety circuits on it, each with its own standalone safety relay protecting one particular aspect of the process. If one of these circuits trips, the whole plant may be effectively shut down and production lost while engineers inspect the machine or process line looking for the appropriate relay and circuit to identify its cause and correcting the reason before restarting operations.

"The new Mitsubishi intelligent QS Safety Relay addresses this on two levels. Firstly the tripped circuit is instantly identified at the control system. This information can then be visualized by HMI< SCADA or simple panel indicators, which dramatically reduce the circuit search and locate time. Secondly, a history of trips and their causes can be logged and analyzed, leading to identification of recurring issues, which can thus be addressed."

Data from the relays can link into higher level control systems, such as manufacturing enterprise systems (MES), supervisory control and data acquisition (SCADA) and other management information generating systems. The QS Safety Relay supervises eight variables per connected safety circuit, including safety input status, safety output status, safety relay coil status and safety relay contact status. The possible combinations of these result in a diagnostic system that stems

from the control system's assessment of the overall status. Detailed safety circuit status is communicated straight to the control system.

"Most importantly the QS is powered independently from the PLC," Shinton says. "So if the PLC fails it does not affect the safety circuit. This stays independent, protecting man and machine come what may."

Several QS relays can be equipped to a PLC rack, and each supports up to three extension relays, so they can connect to separate field devices like drives, switches, light curtains, interlocks and temperature monitors. The networked CC-Link version is capable of creating smaller standalone groups. This version also supports up to three extension relays, and multiple CC relay stations can be configured. One result is that a safety trip will only shut down that part of the plant.

"We developed QS from listening to what our customers told us in that they wanted something with more intelligence than a standalone safety relay but that a dedicated safety PLC was too specialized and costly," Shinton says. "The fact that installation is as simple as clipping a standard module onto a PLC rack or a DIN rail and that no programming is involved means there is no learning curve to slow take-up."

For more information:

Mitsubishi Electric Europe
Automation Systems Division UK
Travellers Lane
Hatfield, Hertfordshire, AL10 8xB
Phone: 01707 276100
Fax: 01707 278695
www.mitsubishi.co.uk/automation

Chokes for Inverters in Wind Turbines

CONSERVE ENERGY

SMP's energy-efficient chokes for inverters in wind turbines are maintenance-free and endure a long service life. Low loss materials and a compact design are responsible for the energy savings features the chokes offer. The SMP chokes have been tested and approved for offshore wind farm usage.

"Today's wind turbines are more efficient than ever before. Until only a few years ago, the maxim for wind power was: it has to be cheap," says Stefan Schauer, technical sales manager at SMP. "The awareness that efficient installations can be highly profitable has grown only over the past few years."

The inductive components provide a high energy storage capacity at low volume, lower losses, good EMC characteristics and cost-effective design. They are built either as single-conductor chokes for high-current applications, individual chokes, choke modules or LC filters, depending on their application.

For more information:

Westendorf Associates, Inc.
SMP U.S. Distributor
P.O. Box 22
Elm Grove, WI 53122-0022
Phone: (262) 641-9730
Fax: (262) 364-3732
kwestendorf@westendorfassoc.com
www.westendorfassoc.com

Incremental Encoders

MINIMIZE DOWNTIME

The DFS 60 Incremental Encoders from Sick Stegmann are offered in a fully programmable version that can accommodate any value between 1 and 65,536 pulses per revolution. The programming tool enables system integrators and distributors to choose any number of lines within this range over their PC or laptop computer, and they can set the zero pulse width to 90 degrees, 180 degrees or 270 degrees while programming the electrical interface to HTL or TTL.

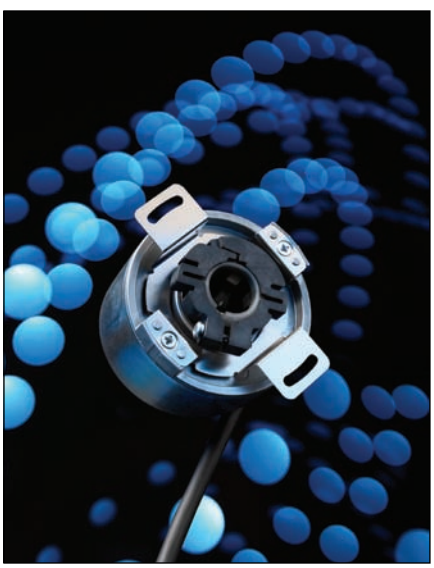
The DFS60 determines angles, positions, speeds and accelerations in automation technology. The encoders come in blind hollow shaft, through hollow shaft and solid shaft modes. They are designed with a metal code disc to increase robustness and temperature tolerances. The design permits a 30 mm distance between bearings to reduce vibration and improve bearing life.

The incremental encoders come with an optional pluggable outlet used either as a radial or axial cable outlet to reduce installation depth and allow easier cable replacement.

"DFS60 programmable versions eliminate the need to purchase, stock and prepare machine-oriented line count versions," says Cathy Castle, marketing manager for Sick Stegmann. "As a result, warehousing is simplified and made more cost effective, and downtime is minimized due to the immediate availability of an encoder that is quickly and easily programmed to the user's various requirements."

For more information:

Sick Stegmann
7496 Webster Street
Dayton, OH 45414
Phone: (800) 811-9110
Fax: (937) 454-1955
sales@stegmann.com
www.stegmann.com



Bent-Axis Motors

COMPLEMENT NEW PUMP FAMILY

The first sizes of H1 bent-axis motors from Sauer-Danfoss, 80 cm^3 and 110 cm^3, complement the recently released family of H1 axial piston pumps. With the bent-axis motors, Sauer Danfoss offers, a complete H1 transmission system focused on electrical control.

"We are pleased to introduce the H1 bent-axis motors, which perfectly complement the successful H1 pump family," says Hans-Peter Nissen, product portfolio manager. "With proven 32-degree bent-axis technology, zero-degree capability and higher overall efficiency, our new motors offer OEMs a number of significant advantages. The H1 propel system provides improved horsepower management and enables advanced anti-slip or wheel-assist control functions."

The H1 bent-axis motors have improved efficiency and a low pressure drop in the galleries to improve fuel economy and free up power for other vehicle functions. "Tier 4 and Euro IIIb emission standards will require intelligent utilization of engine power," Nissen says, "and this will be strongly supported by our new H1 family of products."

By reducing the axis angle to zero degrees, there is no torque interruption or drastic change in speed when the work range is changed to travel range, so the control is more precise. "Zero-degree capability enables OEMs to provide additional features, including accurate anti-slip and torque control functions, which increase vehicle productivity and optimize power utilization," Nissen says. "Even true two-speed applications, for example a crop sprayer, can be supported by this great feature."

The H1 motors were designed around advanced electrical controls to permit various vehicle control concepts to be produced with the same motor hardware. The system can be set to match specific vehicle function requirements by changing the software parameter settings. They are capable of higher speed, which allows a high corner power and power density. As a result, the motors' size does not increase with increased power.

For more information:

Sauer-Danfoss Inc.
250 Parkway Dr., Suite 270
Lincolnshire, IL 60069
Phone: (847) 876-1700
Fax: (847) 876-1799
www.sauer-danfoss.com

Remote Monitoring System

TRACKS ENERGY USAGE

The HOBO U30/ETH remote monitoring system, from Onset Computer Corporation, is an industrial grade system that monitors energy and provides real-time, remote access to facility energy and environmental data over an Ethernet connection.

Energy and facility managers can apply networked monitoring solutions over the entire facility to track energy usage, HVAC/R systems performance

and green building efficiency. Data collection efficiency is optimized for users to generate long-term, facility-wide energy profiles more affordably.

The HOBO U30 can be set with alarm conditions for any connected sensor, and if conditions exceed the user-defined limits, notifications are automatically sent over e-mail or cell phone text messages.

For outdoor or harsh environmental condition monitoring, the system has a NEMA 6, double weatherproof enclosure. Various sensors are accessible to measure parameters including temperature, relative humidity, kW, kWh, AC voltage, AC amps, DC amps, gauge and differential pressure, CO_2 and others. The HOBOlink software accesses current and archived data, sets alarm notifications, relays activations and manages the system from a desktop.

For more information:

Onset Computer Corporation
P.O. Box 3450
Pocasset, MA 02559-3450
Phone: (800) 564-4377 or
(508) 759-9500
Fax: (508) 759-9100
www.onsetcomp.com

Washdown Wheels

EXTEND BEARING LIFE

Bishop-Wisecarver introduces the newest addition to the DualVee product line, the DualVee washdown wheels, which are designed for extreme conditions of food processing equipment linear motion applications. The wheels extend bearing life and are interchangeable with standard vee wheels in case of replacement. A patent-pending design protects against intrusions of high velocity washdown fluids.

"Applications in washdown environ-

continued

Power Up!

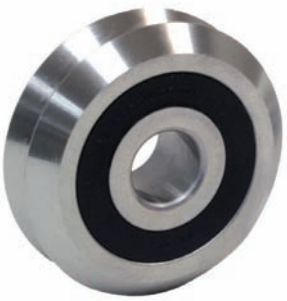
If you have a background in gears, bearings, motors, belts, couplings, sensors or actuators, we'd like to talk to you. Power Play, the back page feature in *PTE*, is all about your industry. If you've got a funny anecdote, an interesting observation or perhaps a limerick on motion control, feel free to send it our way. This column is dedicated to the stories too radical to make the cut in industry or product news. We need story ideas, and we're confident you can provide them.

The rules are quite simple: submit a story idea about the power transmission industry, make it entertaining as well as informative, and become a *PTE* magazine editor-at-large today (salary not included). Submit your award-winning material to *publisher@powertransmission.com.*

ments typically experience frequent bearing replacement due to the ingress of highly corrosive fluids and loss of lubrication," says Nigel Watson, engineering manager at Bishop-Wisecarver. "Dualvee washdown wheels can increase replacement intervals nearly three-fold, resulting in less downtime, higher productivity and lower costs."

The DualVee washdown wheels are constructed from stainless steel and are available in sizes two and three. They feature extra protection from liquids and debris with FDA-approved grease, an outer shield and an inner seal. When a stream of high-velocity washdown fluid comes in contact with the wheels, a rubberized metal shield deflects fluid and conforms to the surface of the wheels, sealing out liquids.

The inner seal provides the most defense against fluids by retaining the internal lubrication grease and further preventing any possible fluid leaking. Any extra fluid between the shield and the seal drains is spun out by centrifugal force.



"With the introduction of this patent-pending design, Bishop-Wisecarver has filled a gap that existed in the bearing market previously for food and beverage applications," says Pamela Kan, president of Bishop-Wisecarver. "We are proud of the inventiveness of our engineering team for providing the answer to this problem, and for, once again, reinforcing our position as the pioneer and industry leader in guide wheel technology."

For more information:

Bishop Wisecarver
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Pittsburg, CA 94565
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Six Keys to Sustainable Manufacturing

Scott Hibbard,
vice president of technology, Bosch Rexroth Corporation


Scott Hibbard

The federal government estimates that manufacturing uses about one third of the energy consumed in the U.S., so manufacturing companies can play an important role in building a sustainable future.

The good news is that engineers, especially design and manufacturing engineers, are already stepping up to the plate. Every day, they design products that conserve energy, reduce waste, and eliminate pollution while manufacturing those products in a sustainable way.

But there's more to do. And the present climate of economic and environmental concerns challenges engineers to optimize manufacturing processes and make them more sustainable.

Here are six key steps in making manufacturing more sustainable. The first two are pretty obvious, and many of us are doing a good job with these. But the last several are things design engineers need to be thinking about constantly.

1. Optimize current use of fossil fuels.

This is a given. Cutting energy cost is a win-win situation in today's environment. There seems to be little argument that we are close to "peak oil," when half the known oil reserves in the world have been consumed. The only argument left is when it will (or did) occur. Save today by turning machinery off when it is not being used. Replace a single-speed motor with a variable-speed or servo drive to reduce energy consumption. Use a variable-speed hydraulic pump. Also take a look at other alternative sustainable sources of energy—whether it's wind, solar or hydroelectric.

2. Eliminate waste.

Another no-brainer. Only consume what you need for the final product. Sounds very simple to us today, but I think we all know that, in the past, our primary objective was to reduce cost or time to market. Nobody knew or cared whether we were using more than we needed. This applies to every industry, whether it's the amount of metal, paper, packaging material, etc. used. Reevaluate whether investing in precision manufacturing equipment can be justified by waste reduction.

3. Reduce or, hopefully, eliminate pollution.

When you walk around a trade show these days, one of the hot topics is how to reduce environmentally unfriendly materials used in products, as well as byproducts in manufacturing processes. You hear things like renewed interest in dry or near-dry machining, using as little coolant as possible while you're doing metal removal. Or deburring, taking the burrs off of finished material after you've cut it, another process using quite a few powerful chemicals.

4. Recycle.

Look at the amount of metal chips that are made in metal removal processes. People used to just fill up huge hoppers, and haul them to a recycling facility. Now they're starting to look at the cost of energy involved. One solution is "chip puckers," devices that compress chips, remove the coolant and turn them into "hockey pucks" that are a lot easier to transport and use a lot less energy. Or, even better, a chip management facility in-house that melts chips and processes them into small billets that can be transported to foundries for reuse.

5. Recover energy, don't turn it into heat!

Hybrid cars recover energy otherwise wasted during braking. Did you know machines can do it too? Power sharing has its roots in machine tools, where the servos used in metal cutting machines and seam machines share power through a single power supply. We can actually take power during deceleration and return it to the main lines. In the past, that energy was wasted, turned into heat, like the brakes on a car.

Another great example is in coordinating the cycles of several metal presses. At first you might think, "Have all the presses go up and down together and then move the material." But we found that if you skew the cycles slightly, you can use the decelerated, regenerative power in one to help accelerate the other one. That has no effect on the process time, no effect on the cycle time, and it doesn't cost more. But it saves energy.

We've started to apply our knowledge of shared servo power to other industries like packaging machinery, automation and printing presses.

6. Save Time.

Just saving time, by itself, is indirectly an energy savings. If you can run a cycle faster without using more energy to do it, you can shut it down and save power. Or if it's a large-scale, high-production facility, you can reduce the number of machines you need to produce the same quantity of material.

The challenge of the future.

These are challenges engineers are meeting that will make manufacturing sustainable in the coming years.

Here at Bosch Rexroth, we've got a whole lot of Dilberts in our facilities who just love a good challenge like "How can I make this product consume less energy?" and "How can I make the product using as few resources as possible?" You can really see it on people's faces every day.

Unfortunately, when most people hear about sustainability, they think of big-ticket items—like solar panels or wind farms. But, though they may not have the glamour or get all the attention, it's the "workhorse" devices like servo drives, hydraulic pumps and bearing assemblies that will create the sustainable manufacturing of the future. I think we prove that to ourselves and to our customers on a daily basis.

The Green Revolution

A GLOBAL WIN-WIN

Matthew Jaster, Associate Editor

Green technology is more than changing a couple of light bulbs or reducing waste. In 2009, the concept is relevant in every facet of manufacturing as companies make a greater push towards energy efficiency and sustainability. In the power transmission and motion control fields, this technology has been integrated into the daily routine, both as an environmentally friendly business venture and a way to offer green products to customers. It's apparent that the revitalization of manufacturing, both here and abroad, will center on energy technology. Many companies have already taken note of the benefits of going green.

Green Technology with SKF

With expertise in material, tribology, rheology and friction management, SKF is currently supporting several green technology initiatives. By reducing the friction of rotating

continued

SKF's E2 bearings are applicable to all types of gearboxes, transmissions, motors, fans and compressors. (Courtesy of SKF.)

SKF actuators control positioning of window sun blinds.

components, SKF's combination of bearings, seals and optimum lubrication reduces energy consumption and CO_2 emission.

"The impact is important considering that we have billions of bearings running in the world in many applications," says George Dettloff, CEO and president of SKF USA Inc. "This adds up to an enormous saving for the planet."

Furthermore, the company has expertise in reliability systems, asset management and the newly developed "SKF's Client Needs Analysis–Energy and Sustainability" tool, a facilitated assessment by SKF energy experts.

"These tools enable customers to estimate and achieve energy savings for an entire manufacturing process or a specific application and product," Dettloff says. "When used together with SKF's 'Documented Savings Program' tool, customers appreciate the real value we provide because the savings per machine can be identified and used as benchmarks for other savings elsewhere in the plant."

At the core of this green movement are SKF's E2 bearings, energy efficient as a result of optimized geometries, lubrication, special cages and manufacturing techniques. These bearings exhibit significantly less friction torque and friction loss than conventional bearings—at least a 30 percent reduction. With applications in electric motors, pumps, gearboxes and wind turbines, the E2 bearings run cooler, reduce lubricant use and extend machine life.

In addition, SKF has been involved in many energy efficient projects that extend beyond bearings including:

- Saving weight for commercial and business jet airplanes with fly-by-wire actuation and auto throttle systems.
- Window blinds with electric actuation that save energy at an average of 40 percent per year.
- Condition monitoring units for wind energy that prevent downtime and make renewable energy sources more efficient.
- Replacing pneumatic actuation with mechatronic actuation provides a 70 percent savings for energy in robotic applications.
- Centralized lubricating system and minimal quantity lubrication systems that provide less lubricant than traditional systems, yet lubricate just as well.

SKF's Maintenance Strategies and Practices are delivering more efficiency to large manufacturing plants, saving high amounts of energy and preventing breakdowns, so that the machinery lasts longer. And SKF's remanufacturing service can repair a worn bearing at significantly lower cost than the original new product cost, giving energy and materials savings for the manufacture of new products.

"We have many solutions and services that really contribute to reduce energy consumption, lubricant consumption and CO_2 emission," Dettloff says. "Many new projects are under way to promote green technology practices."

In addition, the sustainability section at *www.skf.com* takes green technology a step further, utilizing knowledge engineering, sustainability reporting and energy efficient solutions in its SKF Care concept. Sustainability is a major key to SKF, according to Dettloff, with the SKF Care approach to business, the environment, employees and the community.

"Our customers see our offers to save energy and to promote green solutions and they are facing the same challenges and opportunities that we do for developing greener products and for running their own factories in the most efficient way," Dettloff says.

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Miniature Motion Solutions at Portescap

The advantages of going green with motion solutions are multifaceted, ranging from energy efficiency to reduction of disposable, non-biodegradable waste. Green motor technology at Portescap, a Danaher Motion company, evolves in the design stage where the engineers model extensively electromagnet circuits of the motors to optimize power output as a function of input power.

Once optimization has taken place, the engineering team works with operations and sourcing experts to choose environmentally friendly materials in motor manufacturing. The efforts here range from choosing epoxies, solders and metals that are used in the design and manufacturing of coils, magnets, commutators and housings that are assembled into miniature motors.

"The efficiency of Portescap BLDC motors can reach up to 90 percent when the electro-mechanical circuit is optimized for a given application," says Simon Pata, business unit manager, BLDC technologies. "This implies a high conversion rate of electrical to mechanical power, thus minimizing energy waste and loss."

Portescap has a wide variety of high-efficiency motors that help lower the total cost of ownership of machines, reducing the amount of total power required to move the designated load. Efficiency is also increased, extending the required time for routine maintenance.

"Athlonix brush DC motors feature lower self heating and high efficiency that are attained using coil optimization. This allows the motor to have a higher product performance while increasing the energy savings. Also, the lower motor regulation factor allows the motor to last longer with sustained performance," says Udayan Senapati, product line manager, Brush DC technologies.

As a motor provider for pumps, analyzers and surgical hand tools, Portescap can offer the medical industry a variety of green solutions. Energy efficient motors can be beneficial in applications ranging from portable ambulatory pumps to floor-mounted automated laboratory analyzers.

"A medical analyzer that is designed for 24/7 assay analysis and uses five 100 W brush DC iron core motors with a total energy usage of 500 W can gain 100 W of energy savings by using ironless brush DC technology," Senapati says.

The other benefit is motion solutions that reduce non-biodegradable waste.

In certain segments of the medical industry, for example, there is a migration from non-motorized single-use disposable hand tools to environmentally-friendly motorized solutions. Autoclavable motor solutions are a positive impact to the industry as they facilitate multiple uses of power surgical tools, thus reducing waste output by a factor of 100 to 1,000 based upon the application.

Autoclave is a process of sanitizing and sterilizing surgical devices for multiple use and, hence, such devices with autoclavable motors reduce environmental waste while increasing reusable life. Portescap designs and manufactures autoclavable BLDC motors that can be sterilized in excess of 1,000 cycles without any performance compromises. These brushless DC motors have inherent design and manufacturing elements that make the motors withstand pressure- and temperature-treated steam environments used to clean and disinfect surgical devices. Portescap continues its innovation in motor technologies that can be autoclaved through multiple cycles by the appropriate choice of materials and sealants in motor design.

"Portescap's other focus is motor electromechanical design optimization. Our BLDC motors are efficient, thus consuming less energy and running at cooler temperatures, which is exactly what the handheld powered surgical hand tool manufacturers are looking for," Pata says.

"Portable medical devices that run on battery power benefit from 'going green' both in terms of improved efficiency and less disposables," says Dave Beckstoffer, product specialist, Stepper Technologies. "Hence, there are a multitude of advantages and benefits that companies can bring to the customers by designing and producing green products, and such efforts would be a competitive edge for those in the medical arena."

The majority of Portescap motors are RoHS-compliant, and the company restricts the motor content of lead, mercury, cadmium, hexavalent chromium, polybromiated biphenyls (PBB) or polybromiated diphenyl ethers (PBDE) in all phases of design and manufacturing. By using materials that have less impact on the environment, Portescap intends to be a participant and innovator in the green revolution of designing and manufacturing environmentally friendly motors.

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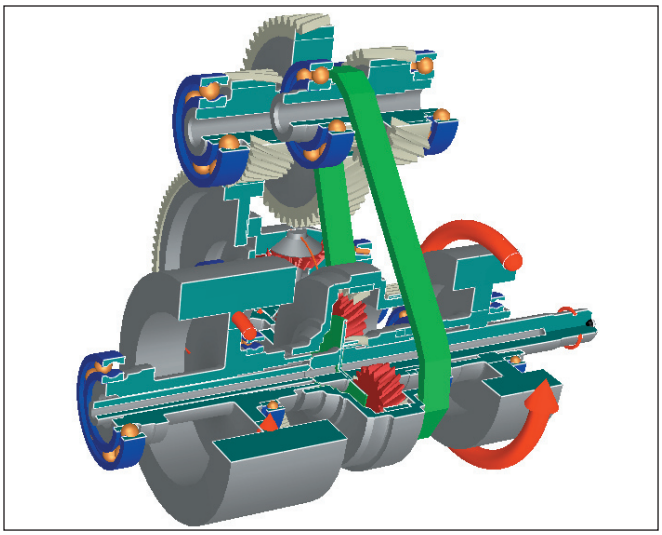
Romax Enters Hybrid Technology Market

Although hybrid equipment represents a logical progression for automotive transportation, few manufacturers have fully committed to the technology. This is due to the increased complexity of the operating systems and modes of operation, the variety of hybrid configurations available and the range of driving scenarios that must be considered. As a result, real-world gains in efficiency are difficult to realize.

Romax Technology has recently entered the hybrid market with a range of capabilities that enable manufacturers to achieve the potential gains of hybrid technology. The service provides

continued

Portescap offers a variety of green solutions for motors utilized in pumps, analyzers and surgical hand tools. (Courtesy of Portescap.)



An example of a split hybrid transmission system. (Courtesy of Romax Technology.)

methods for visualization, analysis and comparison of different driveline configurations. While hybrids remain a complex optimization process, the capabilities offered by Romax will enable engineers to steer a more efficient path towards a solution.

"In order to optimize any system, a thorough understanding of the underlying modes of operation and processes is essential," says Dr. Philipp Guttenberg, hybrid group leader at Romax. "Energy flow paths through a hybrid driveline are complex, with multiple energy routes from the fuel tank to the wheels. To be able to visualize and subdivide the key energy flows throughout the driveline is a vital step in knowing which direction to modify the driveline."

Guttenberg adds that seeing the quantities of energies flowing through the various components provides an understanding of where and how energy losses occur.

"Furthermore, the tools can be applied in the validation of existing simulation models of vehicle drivelines. Romax can provide these capabilities, using patented energy analysis methods and visualization tools to provide a new breed of hybrid vehicle engineers with advanced analytical solutions," Guttenberg says.

With the range of hybrid configurations possible—for example, parallel, split, combined or series hybrid—direct and qualitative comparison of these different options is not readily achievable. How, for instance, should the gearbox operating efficiency of a parallel hybrid, as in a Honda Insight, be compared with the more complex transmission systems of a split hybrid, as employed in the Toyota Prius?

"Romax can answer this question, and we've developed techniques that take detailed knowledge of energy flows within the driveline and condense them to more generic driveline overviews, enabling direct but still detailed comparisons to be made between different driveline structures," Guttenberg says.

The energy analysis methods that Romax has developed offer huge potential for the optimization of hybrid drivelines. The techniques developed are generic in their nature, and as such could find use in a variety of applications, including combined heating and power (CHP) systems and national grid issues. These tools can be applied in any application where a multiple energy distribution path exits within an energy system.

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FANUC Offers Technology Solutions to Green Manufacturers

Due to the response from its green technology robotics at both Solar Power International 2008 and PackExpo 2008, FANUC Robotics is actively pursuing solutions for green manufacturers in several alternative energy fields.

"The ability to showcase our technology has led us to further explore how our solutions can be incorporated into customers' applications," says Rush LaSelle, general manager at FANUC Robotics West. "We have continued to be impressed by the strong market response to, and in many cases, the adoption of the technology being offered by FANUC Robotics."

FANUC offers a wide range of products and services to alternative energy manufacturers and suppliers. The company has successfully installed solutions throughout the solar supply chain from wafer cutting and handling to final assembly.

"The ability to provide solutions, from the most cost-driven applications to those representing the highest technical risk on one platform, is a critical consideration for many of our customers," LaSelle says. "Our proven track record in the solar industry has been an important factor for companies interested in manufacturing on multiple continents."

Operations within the solar industry that are currently implementing robotic automation include tray and dunnage loading/unloading, process load/unload, sorting into boxes, wafer handling, wafer machine toll tending and complete mode build (framing, edge delete, assembly, j-box installation).

FANUC has more than 200 model variations with payload capabilities ranging from 2 kg to 1,200 kg. The company also offers simulation packages, application software, controls and integrated vision products.

"We are able to provide alternative energy manufacturers and suppliers a competitive advantage compared to manual processes, hard automation and offshore manufacturing," LaSelle says.

Some of the advantages that FANUC provides green

FANUC offers more than 200 robotic models. (Courtesy of FANUC.)

More than 200,000 FANUC robots have been installed worldwide. (Courtesy of FANUC.)

technology manufacturers include reduced costs by eliminating fixed automation, quick production startup with robotic technologies, the ability to design small batch sizes by using robots to process and transfer components, eliminate errors and scrap with an integrated process validation system and increased uptime with reliability and support.

"From brick, wafer and module lines for the solar industry, to carbon fiber lay-up and trimming for wind energy, FANUC and our manufacturing partners look at every step to optimize our customer's operations," LaSelle says.

For more information:

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University Research Increases Efficiency of Hydraulic Pumps

The MAHA Fluid Power Research Center at Purdue University is working on advanced methods of surface design that improve the efficiency of hydraulic pumps and motors. Dr. Monika Ivantysynova, director of the center, says the research team is using an in-house simulation code that models the physics of the various phenomena taking place in the rotating group of piston pumps and motors.

"The code has helped us in creating new ideas for advanced surface design such as microstructured surfaces and new macrostructured surface geometry," Ivantysynova says. "The goal is to reduce energy dissipation in lubricating gaps of pumps and motors. Currently, 60 to 90 percent of pump and motor losses are due to losses generated in these lubricating gaps."

The microstructured surface generates hydrodynamic effects that can help reduce losses due to viscous friction through a small increase of gap heights. This effect, according to Ivantysynova, helps to reduce losses especially at lower pressure or lower displacement in variable displacement pumps.

"Consequently, the efficiency increases in these ranges of operation where normally the efficiency of pumps and motors is very low," Ivantysynova says.

These narrow gaps are located at several locations between the cylinder walls and the piston and between the cylinder block and the valve plate. The research team at MAHA is testing various piston machines and has equipped test rigs with special sensors to support their theoretical work and benchmark the code.

The test rigs focus on steady-state measurements of pumps and motors, low-speed testing and start-ability management of motors, dynamic performance, measurements of tribological systems, measurement of instantaneous cylinder pressure during real-time pump operation, thermal measurement of valve plate/cylinder block interface and sound intensity and measurement.

Using a software tool known as *CASPAR*, developed by Ivantysynova's research team, engineers can determine the calculation of real flow ripples at both ports, further the calculation of the instantaneous cylinder pressure, the internal and external volumetric losses, viscous friction forces, gap heights, oscillating forces and moments exerted on the swash plate.

CASPAR is a design tool developed using the *C++* programming language. Models implemented and solved in *CASPAR* consider the time-dependent change of gap heights due to oscillating forces, the interaction between machine parts, the dependency on design and operating parameters and the energy dissipation within the gaps.

"Pumps and motors need to be designed using computer-aided methods that ensure the complex physical nature of phenomena is considered in the design process," Ivantysynova says. "A general goal in pump design should be to ensure full lubrication in the entire range of operating and to minimize the number of parts. The simplest design is the best solution."

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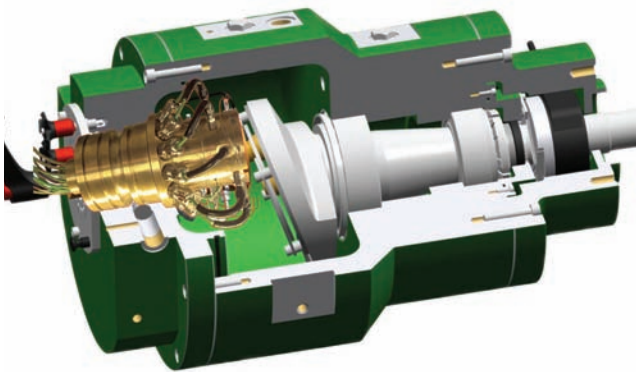

Going Green 101

Lindsey Snyder, Assistant Editor

Perhaps you don't need convincing that sustainability is the wave of the future. But where to start? Resources of all types—from websites to trade shows to white papers—are waiting to help green your operation. Most areas are home to regional business alliances devoted to helping local manufacturing outlets contribute in an environmentally sound manner. Here are a few go-to resources for going green.

GreenBiz.com. This online news and information resource shows how to align environmental responsibility with business success. There are more than 8,000 resources, including daily news posts and feature articles, reports, checklists, case studies, and links to organizations, technical assistance programs, government agencies and recognition programs. *www.greenbiz.com*

Bosch Rexroth Sustainable Manufacturing Website. Learn about sustainability in specific applications such as hydrostatic regenerative braking systems, energy efficiency in pneumatics and hydraulic gearboxes and pitch drives for wind turbines. Get free application assistance and solutions for conserving energy. Visit *www.boschrexroth-us.com/sustainable*.

EIATRACK. This internet tool is useful for manufacturers with outlets abroad for quickly and cost-effectively navigating and keeping up to date on the labyrinth of environmental regulations and legislation in every country. Try the online demo at *www.eiatrack.org/public/eiatrack/about/*, and browse the website to learn more about how EIATRACK can improve your environmental credentials and your bottom line. *www.eiatrack.org*

Green Manufacturing Expo. Network at one of these conferences offered in different locations throughout the upcoming year and co-located with major design and manufacturing trade shows organized by Canon Communications. They are being held March 11–12 in Charlotte, NC, June 9–11 in New York City and September 22–24 in Rosemont, IL. For more information, visit *www.devicelink.com/expo/gmx09/*.

The United States Business Council for Sustainable Development. The U.S. BCSD is a non-profit association of businesses whose purpose is to deliver highly focused, collaborative projects that help its members and partners demonstrate leadership in the United States on sustainable development and realize business value. Learn more about the U.S. BCSD at *www.usbcsd.org*.

Recycling is just one way to go green. There are many resources available to learn about other methods. (Courtesy of Gleason Cutting Tools.)

One OEM's Tin Scraps are Another OEM's Gold

Metals recyclers most actively operate on a smaller, regional level, so be sure to use local resources to find scrap services conveniently nearby. Here are a few to try.

Schnitzer Steel Industries, Metals Recycling Business. Operating with 35 facilities in 13 states, Schnitzer Steel recycled 5.5 million long tons of ferrous metals and 383.1 million pounds of nonferrous metals in 2007. For more information, visit *www.schnitzersteel.com/metals_recycling.aspx*.

Premier Metals Recycling Inc. This Chicago-based company purchases all types of nonferrous recyclable metals to maximize scrap revenue for manufacturers. For more information, visit *www.premiermetalsrecycling.com*.

Western Metals Recycling, LLC. WMR is the largest full service metals recycler in the Intermountain West. Services include buying ferrous and nonferrous scrap, baling, car crushing, plant cleanup and providing industrial containers. For more information, visit *www.wmrecycling.com*.

ASCO Metals. Located in Santa Fe Springs, CA, ASCO Metals serves the scrap recycling needs of Los Angeles, Orange and Riverside Counties. For more information, visit *www.ascometals.com*.

Franklin & Son. This industrial scrap and steel supply company is independently owned and located in Dowagiac, MI. Franklin & Son buys all ferrous and nonferrous scrap metals for recycling. For more information, visit *www.franklinandson.net*.

Tri-Miss Services. Tri-Miss provides quick, reliable scrap metal recycling services in the Mississippi area. For more information, visit *www.trimissrecycling.com* or call (601) 352-5027.

Need New Stuff? Upgrade Plant Energy Efficiency

Energy may be the simplest and most significant area to cut costs and reduce carbon footprints, but there are other benefits to upgrading lighting and HVAC systems facilities managers will notice. Lime Energy is a company providing efficiency consulting services to commercial and industrial businesses and implementing lighting upgrade services, mechanical and electrical conservation services, water conservation services and renewable energy solutions. According to Dave Laybourn, director of marketing at Lime Energy, companies will enjoy new lighting and HVAC equipment, which in turn will allow employees to work in a safer, more comfortable environment. Plant accuracy may improve, as will a company's image.

"Some of these facilities guys, at the end of the day, they're happy for saving on the utilities bills, but what they really wanted was new lights, and they got them," Laybourn says. "For a lot of people it really is the opportunity to upgrade their facility, get the new things they've been wanting for a long time and cloak it all under the cape of energy efficiency.

"The other thing that is overlooked is the benefit to the company after doing an energy efficiency retrofit—the benefit to their image. They get to do a local press release and say their company, after this retrofit, is going to save a million kilowatts a year, which is equal to one and half million pounds of CO_2. It's huge for their image."

Lime Energy issues press releases through their own agency for each project and posts them all to their website, so interested visitors can read about other companies' experiences.

The average cost of installation ranges greatly depending on facility size, but Laybourn estimates $100,000 to $150,000 of initial investment is involved. The return on investment is what's key here. Laybourn says companies will get at least a 20 percent ROI in the first year and in some cases as much as 40 to 50 percent.

"This high ROI is the icing on the cake. There's no other thing people can do in their plants that are going to get them a 30 percent ROI."

Uni-Select USA, a network of independently owned auto parts dealers in North America, conducted a lighting retrofit project at a warehouse in Auburn, WA in 2008. Lime Energy replaced the metal halide lighting with high-output fluores-

continued

Lime Energy helps commercial and industrial companies upgrade lighting services, implement mechanical, electrical and water conservation systems and other renewable energy solutions. (Courtesy of Lime Energy.)

Aerospace supplier ORCON Corp. saved almost $55,000 in energy costs through a lighting retrofit project Lime Energy was enlisted to help with. (Courtesy of Precision Fluorescent.)

cent fixtures that use half as much energy. The result was an energy reduction of 375,518 kilowatt-hours per year.

"The project went very well with no disruption to our daily production, and the light levels have greatly improved over our previous lighting system," says Gayle Moeller, operations manager of the Uni-Select Northwest Division. "The new lighting system is significantly brighter and we have improved the order accuracy in our warehouse operation to nearly 100 percent. The project made financial sense due to the energy cost savings and the $79,000 grant from Puget Sound Energy; however, factoring in the increased efficiency and the reduced cost of rework means this project's rate of return is calculating at a rate that is exponential rather than linear."

After installing more efficient lighting, managers appreciate the high ROI, and employees enjoy working in a safer, cleaner and more efficient environment. (Courtesy of Lime Energy.)

ORCON Corporation, an aerospace supplier headquartered in Union City, CA, completed a lighting retrofit in March 2008, and ORCON saved almost $55,000 in reduced energy costs. "The new lights seem to have energized the workers," says Bill Fuson, facilities maintenance manager for ORCON. "I have been here 20 years and I can't say enough good things about how this went, plus it was very economical with a fast payback."

Lime Energy operates from 16 offices around the country. For more information, visit *www.lime-energy.com* or email *info@lime-energy.com*.

Also for energy efficiency information:

The National Association of Energy Services Companies. NAESCO is a national trade organization that represents energy service companies (ESCOs), distribution companies, distributed generation companies, engineers, consultants and finance companies. Track down local ESCO's based on project size and service sector using the "find a provider tool" on the association's website (*www.naesco.org/providers/default.aspx).*

Bartering Waste for Profit

Separating miscellaneous steel scrap from chips is merely the first step in byproduct synergy where one company's waste is identified for reuse by another company. (Courtesy of Gleason Cutting Tools.)

Industrial ecology or industrial symbiosis, a relatively new way of looking at manufacturing processes, encourages companies to collaborate and match unwanted byproducts as resources for new products and processes. The Chicago Waste to Profit Network is one of a small handful of local organizations that holds meetings for companies to network with others and establishes opportunities for byproduct synergy (BPS) and material reuse. The Waste to Profit Network is sponsored by Chicago Mayor Richard Daley, the Chicago Manufacturing Center, City of Chicago, State of Illinois and regional EPA.

There is a current initiative by IMEC, formerly known as the Illinois Manufacturing Extension Center, to institute another network throughout the state of Illinois. Another similar network is known as Bridging the Gap, in Kansas City. The idea of byproduct synergy developed in the late 1980s and has slowly gained attention.

"What's different about the Chicago Waste to Profit Network from most waste exchanges is that we have an active role in finding synergies," says Bill Hoffman, director of sustainability services at the Chicago Manufacturing Center. "So we collect information from companies about what their needs are and what their byproducts are and then try to make matches between companies that have a byproduct and other companies that have a need for that byproduct."

Since its inception in 2006, the network has helped divert 20,000 tons of waste in the first year and about 40,000 tons of waste in 2007. Companies of all sorts have enjoyed the benefits, including manufacturers like Mittal Steel, Naylor Pipe, S&C Electric and metal scrap service providers like Acme Refining, EPI Concrete Products and General Iron.

For network participants, "It has really been a great thing for them because they have in several cases been able to expand their business," Hoffman says. "Companies that have byproducts they're disposing have been able to find outlets for this material and reduce their cost or disposal."

Regional BPS projects are at various stages of development in Connecticut-Massachusetts; Ohio; Mobile, AL; Houston and Austin, TX, according to the U.S. Business Council for Sustainable Development.

For more information on the Chicago Waste to Profit Network visit *www.wastetoprofit.org* or contact Libby Allen Augustine at (312) 542-0496 or *lallen@cmcussa.org*.

Other similar networks include:

Kansas City Regional By-Product Synergy Project (BPS). For more information, contact Richard Gordon at Bridging The Gap, (816) 561-1061, ext. 114 or e-mail him at *richard.gordon@bridgingthegap.org*.

By-Product Synergy Northwest. Learn more about this Pacific Northwest network, which is organized by the Pacific Northwest Pollution Prevention Center, at *www.pprc.org/synergy/* or contact Debra Taevs at (503) 336-1256, *dtaevs@pprc.org*.

National Industrial Symbiosis Program (NISP). This U.K. organization was a precursor to organizations in the U.S., except it is a government-sponsored program. For more information, visit *www.nisp.org.uk*.

“Mom, this order is ready to be shipped out...and what’s for dinner?”

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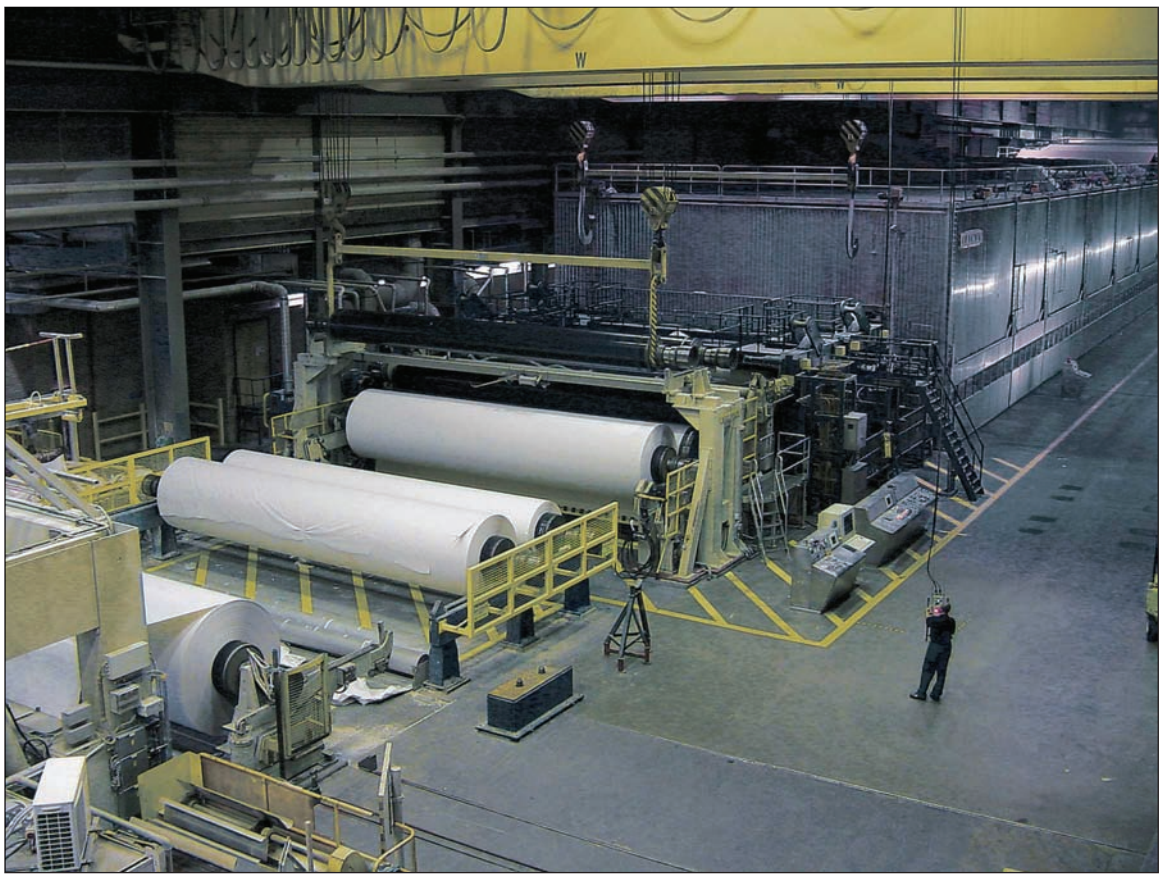
Power with Precision

CAN DIRECT DRIVE TECHNOLOGY IMPROVE YOUR BOTTOM LINE?

Jack McGuinn, Senior Editor



The paper industry was one of the first to use direct drive technology in a big way. (Photo courtesy of ABB.)

Manufacturers relying upon drive systems in their production process have long sought ways to improve gearbox efficiency. While a gearbox-driven system has been the mainstay for manufacturers, it has also been, among other things, the source of frequent breakdowns, expensive line stoppages and increasingly costly maintenance. Gears and bearings wear out and must be replaced; gearboxes leak oil, which must be replenished and scoured from the factory floor; and, they are often bulky and take up much needed real estate in and around the machine being run—a paper machine, for example. Add to that the fact that such issues compromise a machine's precision and controllability, and it is no wonder that manufacturers had come to search for a better way to run their production lines.

Depending on whose history you fol-

low, a "better way" began to appear as far back as the 1950s, according to Jeff Arnold, technology specialist/direct drive, for Danaher Motion.

"In the 1950s, Kollmorgen Inland Motor, in cooperation with MIT, developed the original direct drive torque—or DDR for direct drive rotary—motor for use on stabilized platforms in inertial navigation systems," he says. "This brush DC motor, with its large-diameter, thin-ring design, was ideal for this lightweight, high-torque application."

At ABB Inc., it wasn't until the late 1990s that the technology improved and the company jumped into the electric propulsion industry with the introduction of their Azipod direct torque control (DTC) motor.

"Marine propulsion—outboard motors for cruise ships is what ABB started with," says Chuck Hollis, ABB manager for ACS drives. "They go underneath the ship, and the propellers are directly attached to the shaft of the motor, which is underwater in a pod. It has revolutionized the propulsion of these cruise ships—the new Queen Mary II has got seven of them on her. And we license the technology to a couple of other (companies), so they're not all built by us, but ABB started that technology in 1996-97, and the use of permanent magnet (PM) motors definitely drove it.

"There are all kinds of advantages to it, not least of which is that these cruise ships don't need tugboats anymore."

Indeed, the pm-motor direct drive now provides these ships with far greater precision and controllability as they wend their way through the seaports and harbors of the world.

And at Siemens Energy and Automation/Direct Drives, they, too, entered the direct drive arena in the 1990s.

"As a supplier to machine tool builders, Siemens' initial direct drive motor offering was for applications involving motorized spindles for machining centers, turning centers and grinding machines," says David Plews, project leader/applications engineering. "In 2000, Siemens acquired the direct drive business of Krauss-Maffei, which was integrated into the Siemens Machine Tool organization as Siemens Linear Motor Systems (SLMS). SLMS offers direct drive linear motors as well as direct drive torque motors.

As the three examples above indicate, direct drive can be used in any number of applications where such things as positionability, controllability, accuracy and precision are paramount. Such applications include: handling systems, pick-and-place and sorting applications, circuit manufacturing machines, measuring machines, machines for optical inspections, laser cutting, milling and grinding machines, packaging and labeling machines and machine tools.

At ABB, the bread-and-butter component of their direct drive line is what they call the DriveIT Direct Drive Solution, which consists of a permanent magnet synchronous motor controlled by a low-voltage AC drive, based on its ACS 600 or ACS 800 AC drive, and connected directly to a motor/load without gearboxes or pulse encoders. This is coupled with ABB's direct torque control (DTC) software, which optimizes motor control and eliminates the need for an encoder to provide speed feedback.

Ken Graber, ABB team leader, marketing and communications for low voltage drives, products and systems, breaks it down further regarding the benefits.

"Elimination of the gearbox via these new permanent magnet motors/drive configurations saves space and installation costs, energy and maintenance, and provides more flexibility in production line and facility design. The AC motor also delivers high torque at low speed—a benefit traditionally associated with DC motors—and, in doing so, also eliminates the necessity of a DC motor and associated brush replacement and maintenance.

For an application-specific example, ABB's Hollis talks about the company's entrée into markets other than electric propulsion for cruise ships—specifically, dryer sections of paper machines for the pulp and paper industry. But it was in fact the marine application and ABB's Azipod motor that opened the door to other applications.

"Within ABB, some of the pulp and paper guys said, 'That's (the Azipod) pretty cool; we ought to do something with this,' " Hollis relates. "And they determined that they could eliminate gearboxes if we had low-speed motors. So they decided to eliminate gearboxes primarily on the dryer sections of paper machines. Typically, you've got a big gearbox, and a big, long motor sticking out and, and the motor was in the way. It was an inline thing, and some people said

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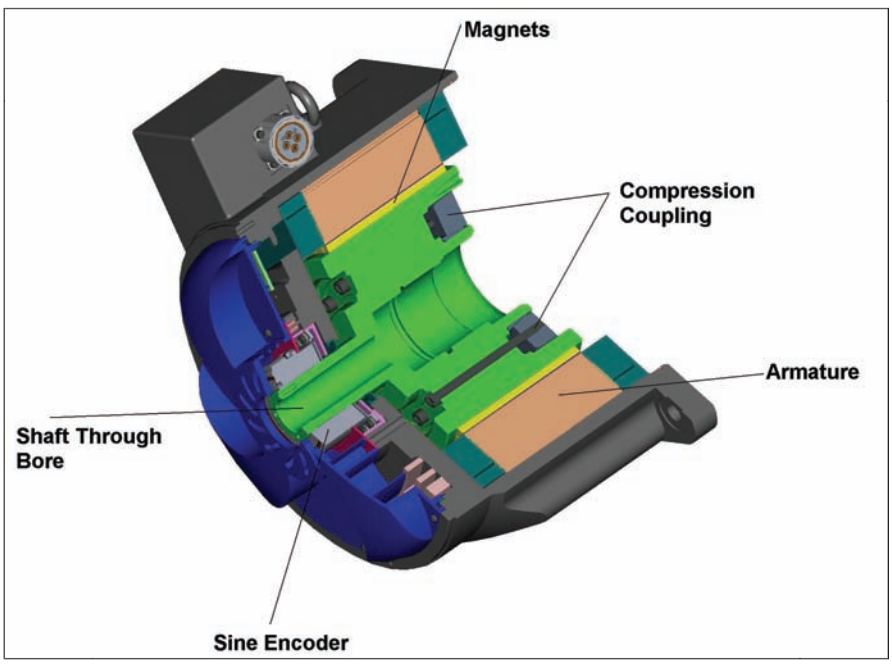


A cutaway view of a Danaher permanent magnet motor. (Illustration courtesy of Danaher.)

'The thing's in the way, we can't move the paper to where we want it,' etc. And they said, 'Why don't we just take the gearbox out and we'll use a low-base-speed motor, and then we won't have this size problem.' And that's what has driven a number of the situations that have been looking at this direct drive technology."

Siemens' Plews lays out some other applications suited for direct drive.

"For servo (positioning) applications, direct drive motors are best suited for those with high-dynamic requirements, low processing forces, a requirement for smooth motion and precise positioning," he says. "An example would be a high-speed machining center designed for cutting aluminum. Machines at the other end of the spectrum would not be optimal applications; e.g., a machining center for cutting steel, which requires lower cutting speeds and higher cutting thrusts than aluminum.

"Direct drives offer advantages in positioning accuracy due to the elimination of lost motion between the motor and the load—i.e., backlash in the gearbox. A typical rotary application might be a roller in a winding operation, where dynamic response and smooth motion are required."

And yet, according to Plews, direct drive does have its limitations, most of them application-driven.

"Gearbox designs offer the ability to adapt the machine to a varied torque and speed requirement by changing the gear ratio. With a direct drive design, this is obviously not possible. Direct drive designs also require a high level of technology to achieve high dynamic performance.

"Also, machine designs which need to be adapted via different ratios based on the final use, are the most notable examples" of where direct drive takes a back seat to the gearbox approach. "Designs using multi-range gearboxes, which allow for a wider, constant power range, are also impractical to convert" to direct drive.

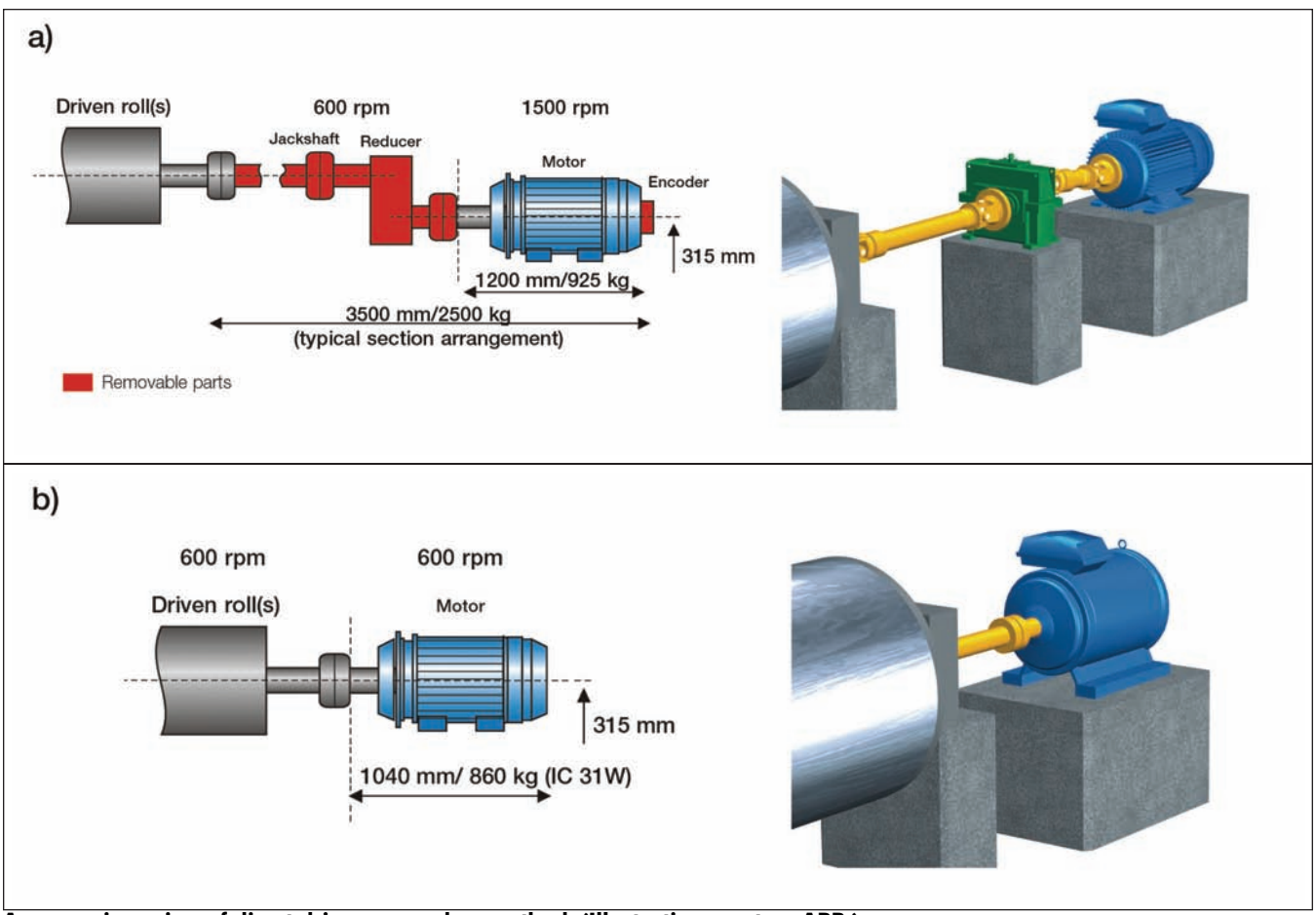
Plews adds that direct drives are often the more expensive option.

"While direct drives have their advantages, the cost advantage of gearboxes in applications where the advantages offered by direct drives are not required ensures that gearbox-based designs will remain in use for years to come."

That aside, Danaher's Arnold extols direct drive's virtues.

"The best applications for DDR (direct drive rotary) motors are industrial process control machines that can benefit from the DDR proposition." According to Arnold, the DDR "proposition" is:

- Improved accuracy (up to 50 times)—improves quality of product being manufactured
- Faster response time—increases machine throughput
- Fewer parts—reduced assembly time, less inventory, compact design
- Zero maintenance and no wear components—unlike mechanical transmissions
- Greater reliability—eliminate



A comparison view of direct drive vs. gearbox method. (Illustration courtesy ABB.)

mechanical transmission parts that can break
- No inertia matching requirement—often allows use of a smaller motor
- Reduced audible noise—up to 20db reduction

Arnold adds that "One application that benefits from the accuracy and response of the DDR motor is a CNC machine that makes precision gears. It takes the performance of a DDR motor to make a really good gear."

ABB's Hollis concurs with that opinion and offers up one of his own.

"Everyone wants to replace a gear ratio of more than 8 to 1," he says. "And these motors are not cheap—they're pretty expensive. So there's just no doubt that it is much cheaper to get torque multiplication in a gearbox than by building a low-base-speed AC motor with lots of torque capability. Direct drive is not a threat to gearboxes, I can tell you that."

As for the expense of direct drive, we put the question to Plews at Siemens of whether the cost of those permanent magnet motors will be coming down anytime soon.

"Yes—as with any emerging technology, the cost of the technology will come down as new approaches are developed," he says. "For example, the Siemens 1FN6 linear motor series features a secondary section free of magnets. For applications with long travels, such as handling systems to load an automated machine tool cell, this has a positive impact on the cost of a direct drive solution."

Bottom line, direct drive technology would appear to be very application-specific. We asked Danaher's Arnold to boil it down for us as to when—and when not—direct drive is the answer.

"In an application where overall size of the package is paramount, a mechanical transmission may allow for a smaller total envelope solution," he says.

On the other hand, "Any machine that can benefit from improved accuracy and response time, improved readability, reduced maintenance, reduced parts count and assembly time should be considered for using direct drive rotary motors."

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A Cartidge DDR motor from Danaher is used in applications like stamping presses and tire balancing machines. (Photo courtesy of Danaher.)

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Bellows Couplings

PROPER SELECTION FOR OPTIMAL PERFORMANCE

By Andrew Lechner

For many years bellows couplings have been near the top of the list of flexible coupling choices for high-performance motion systems. Their high torsional stiffness, low moment of inertia and minimal restoring forces under misalignment make them a preferred choice for maintaining tight control over the load. This is especially critical when considering that the flexible coupling most often represents the point of least stiffness in an electromechanical system. In this way, couplings have a significant effect on the stability of the

continued

R+W America covers the basics through advanced sizing formulas and theories surrounding the design and application of precision couplings for servo motors. (Courtesy of R+W America.)

entire system, as well as the positional accuracy of the load.

When not selected properly, however, bellows couplings can lead to frustrating failures and costly machine downtime. This article seeks to explain some of the natural behaviors exhibited by bellows couplings as well as the proper selection procedures. It will also point out some of the pitfalls associated with bellows coupling selection and serve as a guide to proper application.

Most commercially available bellows couplings utilize a stainless steel tube which has been hydroformed to create deep corrugations. These serve to make the bellows flexible across axial, angular and parallel shaft misalignments while maintaining the torsional rigidity inherent to a metallic tubular structure with a relatively large outside diameter. In shaft coupling applications, the stainless steel bellows absorbs the slight misalignments created by perpendicularity and concentricity tolerances between the mounting surfaces of the two components being connected. They also serve to absorb any axial force created by, among other things, thermal expansion of the motor shaft during operation, all the while minimizing torsional deflection and maintaining constant velocity. Exact transmission of velocity, angle and torque, if not maintained, would compromise performance of any servo motion system.

But all of this work places stress on the bellows—particularly parallel misalignment between the two shafts while transmitting torque. Lateral misalignment compensation causes the bellows to flex into an "S" shape, with an angular bend at each end of the bellows, concentrating stress primarily on the end-corrugations closest to the mounting hubs. Excessive misalignment over time can work-harden these areas of the bellows, making them brittle as they flex around their circumferences. Enough torque can eventually cause the hub to tear away from the bellows, often during an emergency stop or an aggressive acceleration, but quite possibly during normal operation as well.

While improved concentricity of the mounting faces of the coupled components (i.e., closer shaft alignment) can reduce lateral misalignment and ensure against such failures, it is important to note that this mode of failure is closely related to torque as well. High misalignment reduces the torque capacity of couplings. Just as a misaligned coupling will not normally tear until torque is applied, a coupling which is aligned precisely can often transmit more torque than expected.

Since such a continuum exists between misalignment and torque, manufacturers of bellows couplings continuously face the challenge of properly rating couplings for the correct combinations of misalignment and torque. Some manufacturers, as in any industry lacking a set standard for such ratings, are more conservative in their ratings, and others more liberal. This is evident in the variety of ratings for peak torque versus maximum misalignment values across manufacturers of couplings whose products are otherwise structurally similar.

The more conservative have selected a shaft misalignment range in line with what the majority of electromechanical systems can readily handle: approximately 0.1–0.2 mm. Some are rated for slightly more misalignment and others slightly less, but generally speaking, peak torque ratings will be found to be similar across bellows couplings with this range of misalignment ratings and a similar outside diameter. The associated torque ratings normally assume that the maximum misalignment condition will exist in the application.

This approach has worked for many years and normally allows for the coupling to fit well into assemblies involving the appropriately sized components. But not all coupling manufacturers use such a rating system. Some, for example, will offer inflated torque ratings along with shaft misalignment tolerances in line with the norm for the industry, with the fine print stating that significant torque de-ratings must be applied if any significant use is to be made of the coupling's flexibility. Designers should be aware of such potential pitfalls as

Table 1—According to torque

In most cases couplings are rated according to the peak torque to be regularly transmitted.

The peak torque may not exceed the rated torque of the coupling.

By rated torque we mean: the torque that is continuously transmittable within the specified acceptable speed and misalignment ranges.

The following calculation has proven itself to be a good rule of thumb:

$$T_{KN} \geq 1{,}5 \cdot T_{AS} \quad \text{(Nm)}$$

T_{KN} = rated torque of coupling (Nm)

T_{AS} = rated torque of coupling (Nm)

Table 2—According to acceleration torque

For precise rating, the acceleration torque and moments of inertia of the entire machine have to be taken into consideration.

In the case of servo motors ensure that their acceleration or deceleration torque is greater than their torque by a multiple.

S_A = Shock or load factor

S_A = 1 (uniform load)

S_A = 2 (non-uniform load)

S_A = 3-4 (Shocking load)

Values for S_A = 2-3 are usual for servo drives on machine tools.

$$T_{KN} \geq T_{AS} \cdot S_A \cdot \frac{J_L}{J_A + J_L} \quad \text{(Nm)}$$

T_{KN} = rated torque of coupling (Nm)

T_{AS} = max. acceleration torque on the on the driving element (Nm)

- or max. deceleration torque of the load (Nm)

J_L = machine moment of inertia (Spindle + slide + workpiece + half of coupling) (kgm^2)

J_A = motor's moment of inertia (kgm^2)

Table 3—According to torsional stiffness

Transmission errors due to the torsional load:

$$\varphi = \frac{130}{\pi} \cdot \frac{T_{AS}}{C_t} \quad \text{(degrees)}$$

φ = torsional deflection (degrees)

C_t = torsional stiffness of coupling (Nm/rad)

T_{AS} = max. torque (Nm)

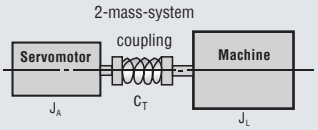
misinterpreting the published capabilities and inadvertently selecting an undersized product. Fortunately, most manufacturers of bellows couplings seem to have settled on combinations of ratings that allow for a reasonable level of shaft misalignment to exist, without yielding a maximum torque rating that would cause the coupling to be too large for the assembly into which it will be installed. Further, some manufacturers offer coupling designs with additional corrugations and even double flexures, which allow for a magnification of the lateral misalignment compensation within a given torque rating while still maintaining a relatively high level of torsional stiffness. In general, proper bellows coupling selection should normally begin with a torque calculation.

A quick, safe and easy bellows coupling selection would be to take the peak torque capacity of the servo motor, multiplied by any applicable gear reduction ratio, and multiplied by a safety factor of 1.5. The appropriate bellows coupling would then be required to have a torque rating greater than or equal to that of the calculated torque (Table 1).

A more precise calculation takes into account the moments of inertia and actual torque required to accelerate the load by first overestimating the required torque of the application through the use of generalized service factors, and then reducing the torque value by taking into account the moments of inertia of the drive and the load. Inertia mismatch can be critical to coupling longevity, as reflected load inertia in aggressive start/stop or reversing applications can produce significant spikes in torque, often beyond those estimated through the use of current limits into the drive amplifier. Selection by torque is most common; however, calculating the required torque rating of the coupling is a step that can be skipped by those more experienced with bellows couplings, in the event that their position accuracy requirements would result in a torsional stiffness value corresponding to a torque rating far in excess of the actual power requirements of the application (Table 2).

Table 4—According to resonace frequency

For the mech. substitutional model of the 2-mass-system the following is valid:



As a value of practice the following is valid: $f_e \geq 2 \times f_{er}$

$$f_e = \frac{1}{2 \cdot \pi} \sqrt{C_T \cdot \frac{J_A + J_L}{J_A \cdot J_L}} \quad (Hz)$$

C_1 = torsional stiffness of coupling (Nm/rad)

f_e = mechanical resonance frequency of the 2 mass system (HZ)

f_{er} = mechanical frequency of the drive (HZ)

As previously noted, the flexible coupling is normally the most compliant of components in any mechanical motion system, making its torsional stiffness a critical factor in terms of maintaining positional control over the load. Possessing the highest torsional stiffness of any commercially available servo motor coupling, bellows couplings are routinely employed in applications with very high-precision positioning requirements. Calculating torsional deflection angle based on the torsional stiffness of the coupling takes a very simple formula (Table 3).

There are some rare cases, however, in which servo loop gains set high enough can result in a mechanical frequency that will excite the natural frequency of the coupling. In these cases, elevating the coupling torsional stiffness is required in order to avoid a situation where the rate at which the coupling springs back from a torsional impulse does not match that at which the next impulse would take place. While auto-tuning features in most modern servo drives have eliminated this potential problem for most applications, in some cases this would still be necessary, and the following calculation allows for proper coupling selection based on mechanical resonant frequency (Table 4).

Properly selected bellows couplings result in the best possible control over the load in any high-performance servo application. Sequentially, the selection criteria generally begins with ensuring that the coupling will have sufficient torque rating to accelerate the load, followed by checking that coupling misalignment tolerances are inline with practical expectations of the accuracy with which coupled shafts will be aligned. In general, higher misalignment tolerances can be achieved at potential compromise to torsional stiffness, though in most applications bellows couplings have ample torsional stiffness to begin with. In those cases where a coupling with a good mechanical fit has marginal torsional stiffness in light of stringent requirements, shaft alignment must be addressed in order to accommodate the very high stiffness requirement. Contact a coupling expert for future servo coupling requirements and ensure that optimal performance will result.

Andrew Lechner *has been product manager at R+W since 2001, responsible for servo coupling applications. He co-wrote an article on the topic of thermoplastics in coupling design that was featured in the spring 2007 issue of PTE.*

With Electric Motors,

Size Indeed Matters

Edward Hage

Introduction

In this paper, Edward Hage, founder of *specAmotor.com*, an online motor calculation and selection tool, focuses on the overheating of electric motors. Presented here is a calculation method with which the temperature and heat development of a direct current (DC) motor and a brushless motor can be predicted accurately. This prevents overheating and overdimensioning.

Overheating vs. Overdimensioning: Which is Worse?

Overheating and overdimensioning (sizing) may seem to be issues that have nothing in common with each other. However, they are the two sides of the same coin when choosing and buying electric motors.

Overheating is the most common failure mechanism for an electric motor that is sized too tightly. Especially in modern electric motors with strong magnets and compact design, the motor has trouble deflecting its heat. Overheating can lead to:

- Failure of the winding isolation, what results in a short circuit and possibly burnout;
- Failure of the bearings, resulting in a jammed motor;
- Degradation of the magnets (the magnets permanently lose force), so that the motor will never be able to deliver the peak torque it is designed for.

All of which is why it is important to prevent overheating. Usually this is achieved by choosing a larger-size motor than was initially calculated. The necessary degree of oversizing is often educated guesswork because the true end-temperature is unknown. Overdimensioning is often the price for the extra security.

But by determining the temperature of the motor in detail, excessive oversizing can be avoided. You would know exactly where the boundary is, so a motor can be chosen with the right know-how. It is not proposed here to look for the boundary of permissibility. What is proposed is that oversizing can be done correctly when the boundaries are actually known.

This paper explains how one can predict the motor temperature. For this it is necessary to deviate from the "ideal" representation of a motor where the dissipation is linearly dependent upon the torque. In reality, the dissipation will increase more than linearly when a larger torque is demanded from the motor. The far-reaching consequences of this fact will be explained. This results in a calculation method with which one can work practically when determining the most suitable motor for your application.

Heat Development in the Motor

When the motor provides torque, a current will flow that causes a dissipation in the finite resistance of the motor windings. This will result in the following effects to take place:

- The windings will heat up, and this will increase the Ohmic resistance R of the windings.
- The magnets will heat up, and this will decrease the motor-constant k.

The increased resistance R will increase the electric dissipation (effect 1). When the motor constant is lower, a larger current I is necessary to provide the same torque T. This increased current will also increase the electric dissipation (effect 2). In Equation 1 the consequence of these two effects is summarized.

$$P_{elec}=I^2 R=\frac{T^2}{k^2}R \quad \uparrow\uparrow P_{elec}=\frac{T^2}{\downarrow k^2}\uparrow R \tag{1}$$

This increased electric dissipation will result in a further increase in temperature which, in turn, will increase the current I and the resistance R. This is a cumulative effect that finally results in an equilibrium for the dissipation. *(Note: The cumulative heating will not in all situations result in an equilibrium. At a significant overload of the motor, the dissipation and the temperature will rise to the extent that both terms will become infinite. In practice this will result in a burning of the motor. This certainly is not only a theoretical situation.)*

The effects of the temperature on R and k are described with Equations 2 and 3:

$$R(\theta_{winding})=R_{ref}\cdot\left(1+(\theta_{winding}-\theta_{ref})\cdot\alpha\right) \tag{2}$$

$$k(\theta_{magnet}) = k_{ref} \cdot \left(1 + (\theta_{magnet} - \theta_{ref}) \cdot TK_{Br}\right) \quad (3)$$

The resistance R is dependent on the winding temperature $\theta_{winding}$. R_{ref} is the reference resistance, and k_{ref} is the reference motor constant given for a reference temperature θ_{ref} of 20°C.

What these equations tell us is the following:

• The resistance R will increase linearly with the winding temperature according to α. This is a material constant for copper (the material of the windings) 0.00393 K[1]. The cumulative heating will not in all situations result in an equilibrium. At a significant overload of the motor, the dissipation and temperature will rise to the extent that both terms will become infinite. In practice, this will result in a burning of the motor.

• The motor constant k will decrease linearly with the magnet temperature, according to TK_{Br} (decrease because TK_{Br} always has a negative value). This is a material constant of the magnet and therefore differs per species of magnet. See Table 1 for an overview of these values.

Dissipation Twice as Large at Higher Motor Temperature

In Equations 1–3, the dissipation at elevated motor temperature can be determined. This is shown in Figure 1 for two values of TK_{Br}. The dissipation is expressed as a percentage of the dissipation at a normal ambient temperature (norm 100% at 20°C). For ease of calculation, it is assumed that the winding and magnet temperature are equal to each other.

Figure 1 shows that the dissipation rises significantly as a function of the motor temperature. At a temperature of 108°C, the dissipation (for TK_{Br} = – 0.2 %/K) is already 200%, or twice as large as the dissipation at ambient temperature.

The maximum temperature usually is determined by the isolation class of the windings. For the highest isolation class H, this amounts to a maximum winding temperature of 180°C (according to standard IEC: 2004 60034-1). Because the dissipation increases so strongly, it is very important to determine if the maximum temperature is approaching. To be able to determine this, more information about the motor is required.

Thermal Model Motor

The final motor temperature is dependent on the motor's construction. With a thermal model, it can be shown how the temperature depends on the parameters of the motor and the dissipation. In Figure 2, the thermal model is shown; it is generic for all electric motors with permanent magnets.

When there is thermal equilibrium—the temperature remains constant—the equilibrium temperatures for windings and house can be determined as shown in Equations 4 and 5.

$$\theta_{winding} = P_{elec}\left(R_{th1} + R_{th2}\right) + P_{fric} R_{th2} + \theta_{amb} \quad (4)$$

$$\theta_{house} = P_{elec} R_{th2} + P_{fric} R_{th2} + \theta_{amb} \quad (5)$$

The magnet temperature. The magnet temperature is not indicated in Figure 2. It is dependent on the construction of the motor. There are three constructions of motors admitted to the *specAmotor* database:

- Brushed motors
- Brushless motors
- Synchronous motors

In the case of brushless and synchronous motors, the magnets are mounted to the rotor, and the windings to the housing. In the case of the brushed motor, the magnets are mounted to the housing and the windings to the rotor.

For the brushless and synchronous motor, the magnet temperature is about the same as the winding temperature.

For a brushed motor, there is an air gap present between the magnet and the winding that dominates the thermal resistance. Therefore, the magnet temperature will be much closer to the housing temperature than the winding temperature.

As such, the magnet temperature can be summarized per motor construction as:

$$\theta_{magnet} = \theta_{house} \quad brushed\ motor$$
$$\theta_{magnet} = \theta_{winding} \quad brushed\ motor + AC\ synchronous\ motor \quad (6)$$

continued

Table 1—Decay of magnetic flux-density TK_{Br} for different magnet materials

Material	TK_{Br} (%K)
cast or sintered SmCo	-0.005% tot -0.07%
bonded (glued) SmCo	-0.04%
sintered $SmCo_5$	-0.04%
sintered Sm_2Co_{17}	-0.03%
Ferrite	-0.2%
Alnico	-0.01% tot -0.025%
bonded (glued) NdFeB	-0.2%
sintered NdFeB	-0.07% tot-0.16%
$Nd_2Fe_{14}B$	-0.1%

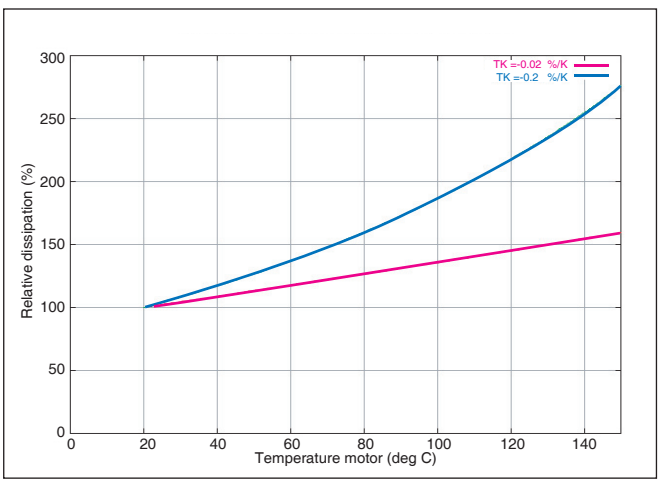


Figure 1—Dissipation increases at increasing motor temperature.

Simple thermal model. With the thermal model—as provided in Figure 2—the winding and housing temperature can be determined separately. To do this, it is necessary to know the thermal resistance between the windings and housing, and between the housing and ambient (R_{th1} and R_{th2}). Sometimes this information is not provided by the manufacturers and the temperatures cannot be determined. *SpecAmotor* is dependent on publicly available data, such as catalogs, from manufacturers. Often the manufacturers will give only one thermal resistance for the entire motor. If this is the case, *specAmotor* will apply the simple model of Figure 3.

In the simple model, there is only one motor temperature; there is no distinction between winding and housing temperature. Because the simple model can show less-accurate results than the detailed model of Figure 2, it is preferred to apply the detailed model.

When there is thermal equilibrium, the motor temperature can be determined as described in Equation 7. This formula applies to the simple thermal model.

$$\theta_{motor} = (P_{elec} + P_{fric})\, R_{th} + \theta_{amb} \tag{7}$$

For the sake of completeness, the following applies to the motor temperature (independent of construction of motor):

$$\theta_{motor} = \theta_{magnet} = \theta_{winding} = \theta_{house} \tag{8}$$

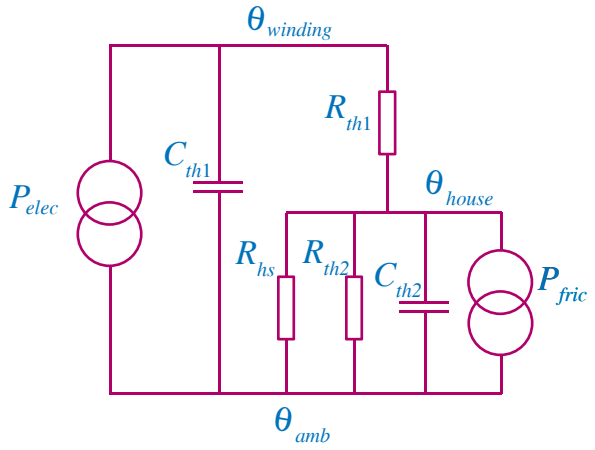
formula 7 Temperature motor for simple thermal model

Example: calculation of correct motor temperature. Now the motor temperature can be determined so that the influence of the enlarged dissipation becomes clear. For the calculation we assume for the ease of use the simple thermal model and an electric motor with the data and drive situation as mentioned here:

We have a workpoint $(T;\omega) = (1\ Nm;\ 2000\ rpm)$ *and the motor has the following features* $R = 10\Omega$, $k = 0.4714 Nm/A$ *(both at 20°C) and* $R_{th} = 1\ K/W$. *The ambient temperature is 20°C. Species of magnet is bonded NdFeB where* $TK_{Br} = -0.2\%/K$. *Friction is left aside.* (9)

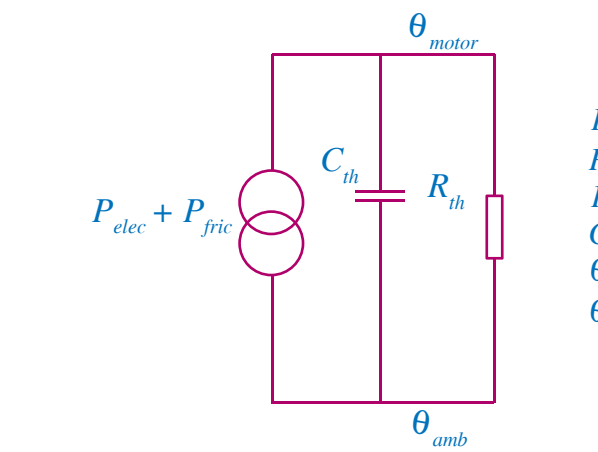
According to Equation 1, the dissipation is determined and substituted in Equation 7. This will yield the motor temperature:

$$P_{elec} = \frac{T^2}{k^2} R = \frac{1}{0.4714^2} 10 = 45W$$
$$\theta_{motor} = P_{elec} R_{th} + \theta_{amb} = 45 \cdot 1 + 20 = 65°C \tag{10}$$



P_{elec}	*electric dissipation*
P_{fric}	*mechanical friction*
R_{th1}	*thermal resistance between windings–house*
R_{th2}	*thermal resistance between house–ambient*
R_{hs}	*additional heatsink*
C_{th1}	*thermal capacity between windings–ambient*
C_{th2}	*thermal capacity between house–ambient*
$\theta_{winding}$	*winding temperature*
θ_{house}	*house vs. stator temperature*
θ_{amb}	*ambient temperature*

Figure 2—Detailed thermal model for PM (Permanent Magnet) motor.



P_{elec}	*electric dissipation*
P_{fric}	*mechanical friction*
R_{th}	*thermal resistance between motor–ambient*
C_{th}	*thermal capacity of the motor*
θ_{motor}	*motor temperature*
θ_{amb}	*ambient temperature*

Figure 3—Simple thermal model for PM motor.

The motor temperature thus becomes 65°C if *k* and *R* are independent of temperature. As we know, the dissipation will increase because *R* and *k* do change. These quantities become (Equations 2 and 3 substituted into Equations 8):

$$R(\theta_{motor}) = R_{ref} \cdot (1 + (\theta_{motor} - \theta_{ref}) \cdot \alpha) = 10 \cdot (1 + (65-20) \cdot 0.00393) = 11.77\Omega$$
$$k(\theta_{motor}) = k_{ref} \cdot (1 + (\theta_{motor} - \theta_{ref}) \cdot TK_{Br}) = 0.4714 \cdot (1 + (65-20) \cdot -0.002) = 0.429\ Nm/A \quad (11)$$

These values substituted in the same equations result in:

$$P_{elec} = \frac{T^2}{k^2} R = \frac{1}{0.429^2} 11.77 = 63.95W$$
$$\theta_{motor} = P_{elec} R_{th} + \theta_{amb} = 63.95 \cdot 1 + 20 = 84°C \quad (12)$$

The motor temperature is now 84°C and is 19° higher than initially determined. But this is not the final motor temperature, since *R* and *k* at 84°C are different again. Values for *R* and *k* must be substituted in Equations 1 and 7 repeatedly until the result does not change. In Table 2, the results of this iterative calculation are given. The real motor temperature is only revealed after 21 iterations and amounts to 112°C instead of 65°C.

Table 2—Results of iterative calculation.

Iteration	Θ motor (°C)	R (Ω)	k(Nm/A)
1	65.0	10.00	0.4714
2	84.0	11.77	0.4290
3	94.0	12.51	0.4111
4	100.0	12.91	0.4016
5	103.9	13.15	0.3959
6	106.4	13.30	0.3923
...11	111.1	13.56	0.3859
...16	111.9	13.61	0.3848
...21	112.0	13.62	0.3846

Result

From the example shown in paragraph five, we can conclude that the influence of the Ohmic resistance *R* and the motor constant *k* on the motor temperature is very significant. If this influence is not taken into account, a false end-temperature is calculated of 65°C, instead of the correct 112°C. It is easy to understand that such errors can lead to a premature failure of an electric motor.

Here a calculation method is presented with which you can now determine the end temperature of a motor in great detail. With some adjustments you can achieve similar results for the detailed thermal model.

The only thing left to do is collect the necessary motor data from different catalogs and websites of manufacturers. With that information, the way is free to make an objective comparison between the performance of different brands; the motors, after all, are all calculated in a similar manner. You won't be dependent on the subjective advice of a manufacturer.

The *specAmotor* Database

Finding the necessary motor data requires a lot of research. It would be ideal to be able to consult a database where all this data is collected, and to have something that will perform these calculations automatically.

- *specAmotor* is a website that will do that for you for free.
- *specAmotor* calculates more than 6,000 motor configurations from 11 brands in this manner and uses, where possible, the detailed thermal model to produce an accurate result. The validity of a motor, however, is not only determined by the temperature. Other criteria that *specAmotor* uses are:
- Maximum current; the current is allowed to be very high for a short period, but not too high so that the magnets will demagnetize.
- Maximum speed; for a brushless motor this speed is determined by the bearing that is suitable up to a certain speed. For brushed motors, the maximum speed is usu ally limited by contact loss of the brushes as a result of the shape of the collector, which is accompanied by severe formation of sparks.
- Maximum power; for brushed motors this is usually limited by the commutation boundary.
- Maximum torque; when a reduction or gearbox is mounted to the motor, this reduction will allow for maximum peak torque. Larger torques will lead to mechanical damage of the reduction.
- Maximum voltage; especially relevant for brushed motors where an excessive voltage will cause sparks between brushes and collector and shorten the lifetime of the motor.

The calculations are validated by John Compter, an authority in the field of electric motor design who is employed by Philips Applied Technology.

Visit *http://www.specamotor.com* to try the service. It is free-of-charge and allows you to make an independent comparison between motors.

How Green is Your Gearbox?

Todd R. Bobak, Sumitomo Drive Technologies

Introduction

Rising energy costs and concerns about global warming are at the forefront of today's news. Turn to local or national TV programming, browse the internet or read the paper and one can find numerous stories about the seemingly irreversible energy costs and the subsequent impact that these costs have on simply doing business. As a result, we as individuals are becoming increasingly aware of the cost of energy and we are being introduced to a variety of methods and/or products that will minimize the impact of these costs.

In industry, power consumption in the manufacturing environment accounts for approximately 1/3 of all energy consumed annually within the United States. In the enclosed gearing industry, questions such as "How efficient is product X?" are becoming increasingly common.

Several factors influence how efficiency is lost during operation of the gearbox system. This paper will address some of these factors, and it will further provide recommendations and ideas for obtaining a highly efficient gearbox, while still taking into consideration application constraints.

Gearbox Efficiency—Defined

As it relates to enclosed gearing, efficiency is simply the ratio of the output power (power transmitted through the gearbox as usable work) to the input power. As no mechanical device is 100% efficient, this numeric value of efficiency will always be less than 1.

If the speed reducer in Figure 1 were 100% efficient, it would be concluded that the 3,600 in-lbs of torque being applied to the input shaft would generate 540,000 in-lbs of torque at the output shaft through the 150:1 gear reduction. It can be seen in this example that the output torque is less than the "expected" value due to the internal losses. Gearbox efficiency for this example can be determined as follows:

$$\text{Efficiency} = \frac{\text{Actual Output Torque}}{\text{Theoretical Output Torque}}(100)$$

$$= \frac{463,166}{540,000}(100)$$

Given this, it is calculated that the gearbox in this example is 85.8% efficient.

Efficiency of Gearing Types

The term "speed reducer" is a general one used in describing a device that increases torque while, at the same time, reduces the rotational speed of the prime mover (which is usually an AC motor). This is achieved through the interaction of gears within the speed reducer. Different gear types can be utilized to facilitate this reduction of speed/increase of torque. Each of these gear types has distinct advantages and disadvantages associated with it and, likewise, each of these gear types has different efficiencies associated with it.

Specifically, as it relates to efficiency, two gears in mesh incur losses in efficiency due to the sliding action of one gear tooth against the corresponding gear tooth of the mating gear. This sliding action reduces the overall efficiency of the gear set since useable power is converted to heat. It is not accurate to say that a specific gear type has a definite efficiency associated with it since factors such as reduction ratio, gear-manufacturing methods and lubricant (among others) all play a role in the efficiency of a gear set. Table 1 details three common gear types, along with their associated typical efficiencies.

It is not uncommon for speed reduc-

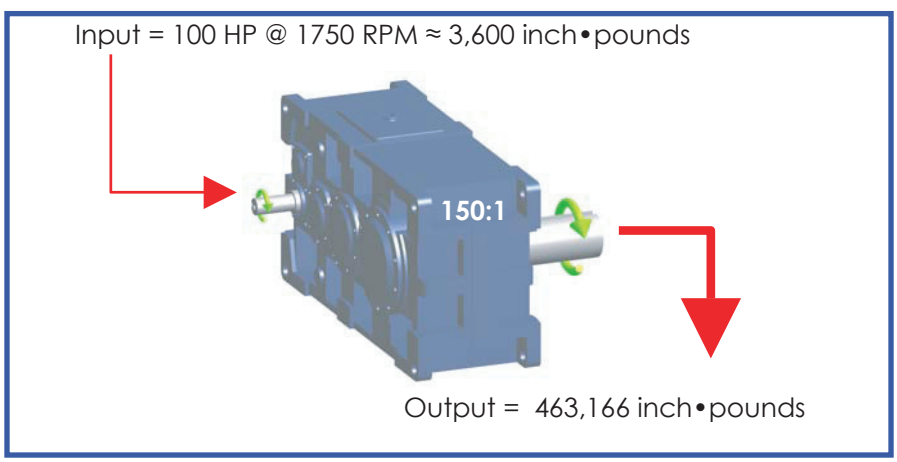


Figure 1—A gear reducer with output torque less than the expected value.

ers to incorporate more than one set of gears (or stages) to achieve the desired overall reduction ratio. In such cases, the overall efficiency of the gear train is the product of the individual efficiencies of each gear reduction stage. Say, for example, that a gearbox incorporates three stages of helical gearing. Accept as well that each stage has an efficiency of 98.5%. The overall gear train efficiency would be:

Efficiency 1st stage x Efficiency 2nd stage x Efficiency 3rd stage x 100 = Total Gear Train Efficiency

$$0.985 \times 0.985 \times 0.985 \times 100 \approx 95.6\%$$

To continue this example, it is possible that a multistage gearbox utilizes different types of gearing for each of its reduction stages. A right-angle gearbox (one where the output shaft is at a right angle to the input shaft) may utilize a spiral bevel gear set as its first reduction stage, followed by a helical gear set as its second reduction stage. Using the typical gearing efficiencies detailed previously, the efficiency of the gear train in this example can be calculated as follows:

Efficiency 1st stage x Efficiency 2nd stage = 0.92 x 0.96 x 100 = 88.0%

Oil Seals and Efficiency

Virtually all speed reducers incorporate the use of oil seals within their assemblies. These seals can be found on both the input and output shafts, as well as internally within the unit. Their primary function is to retain the lubricant within the gearbox while eliminating the ingress of dirt and water. There are a variety of different types of seals for a variety of different applications (i.e., axial shaft seals), but the most common type of seals used in industrial gearboxes are radial shaft seals.

The performance of a radial seal is dependent upon an interference fit that provides pressure of the seal lip against the shaft or collar surface. Through operation, the seal lip will gradually wear so that, in some cases, a garter spring is incorporated into the oil seal in order to maintain adequate seal lip pressure against the shaft. Additionally, a secondary seal lip may be utilized on the seal to prevent the ingress of contaminants into the system. (See Figure 2 for a view of a speed reducer with details of an oil seal for clarification.)

Since these seal lip(s) are riding against a rotating shaft (or collar), friction at this interface is developed and an energy loss (albeit small) is realized. The amount of this energy loss due to friction is dependent upon many factors that include shaft speed, shaft diameter and the surface finish/roughness against which the seal lip(s) are in contact. As an example, published data indicates that an oil seal riding on a 100 mm shaft (≈ 4") that is rotating at 500 rpm will generate frictional losses at a magnitude of 20 watts. While it is true that this is a seemingly minuscule value, it is common for some gearbox manufacturers to incorporate more than a single seal on a given shaft as an added feature to minimize or

continued

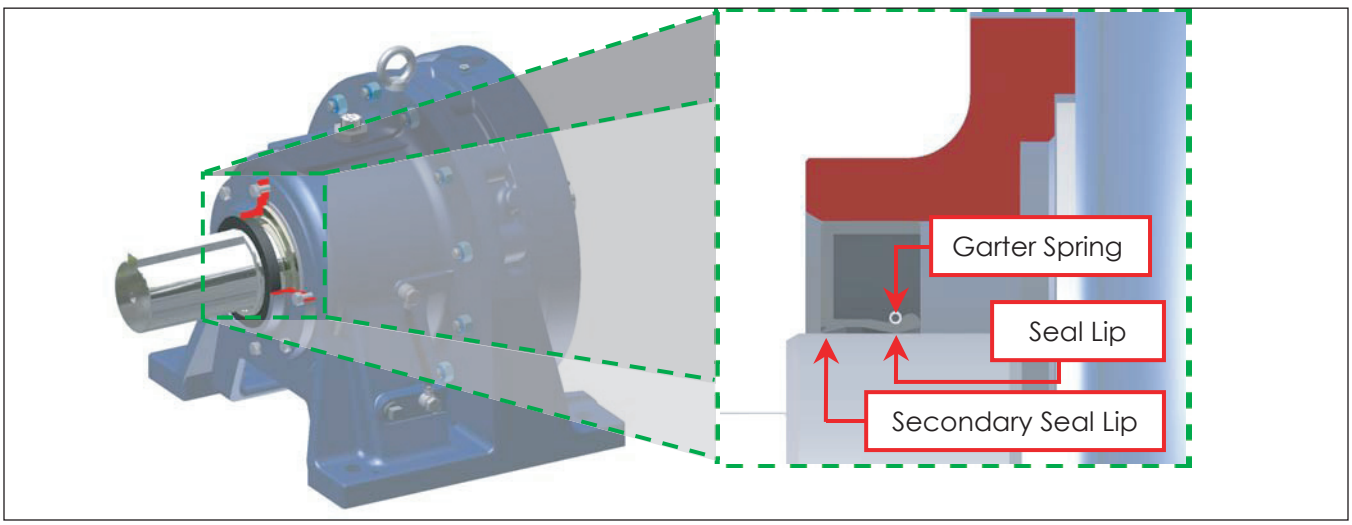
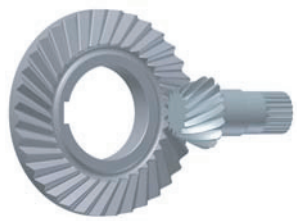


Figure 2—Speed reducer with oil seal cutaway showing additional ("secondary") seal lip.

Table 1—Three common gear types and their associated typical efficiencies.

	Gear Type		
	Helical	Worm	Spiral Bevel
			
Typical Efficiency:	≈ 96%	≈ 79%	≈ 92%

eliminate the possibility of lubrication leakage. Having said that, multiple seals within a single-speed reducer may develop frictional losses exceeding 100 watts (once again, depending on seal sizes and rotational speeds).

Bearings and Efficiency

Bearings are another component common to all speed reducers. Roller bearings are used to secure and support shafting and gearing within the unit. These roller bearings are intended to accept external loading (radial and axial) on the input and output shafts. Additionally, these bearings accommodate the internal forces generated by the gears in mesh. To accept these forces, roller bearings rely on balls (spheres) or rollers retained between an inner and outer race. Figure 3 shows a section of a helical gearbox with details of a deep-groove ball bearing for clarification.

A bearing is a low-friction device; it is not friction-free. As one race rotates about the other race, the balls (or rollers) likewise rotate/slide within the race. The rotating/sliding action of the balls (or rollers) creates friction between these bearing components, thereby creating an additional avenue for energy loss.

Like oil seals and gearing, the amount of energy consumed by a bearing is dependent on many different factors. Mathematical formulas exist that can be used to calculate the friction torque of a given bearing. This value of friction torque is a function of the coefficient of friction between the rolling elements of the bearing, the bore diameter of the bearing itself and the load acting upon it. It is expressed as:

$$M = \frac{\mu \bullet F \bullet d}{2}$$

where: M = Friction Torque (in • lbs, N•m)
μ = Coefficient of Friction
F = Bearing Load (lbs, N)
d = Shaft Diameter (in, m)

Using this equation, the friction torque for a ball bearing of size 6211 with a 4,250 pound radial load acting upon it is approximately 5.8 inch-lbs. Whereas, for a similarly sized tapered roller bearing (32211) operating under the same loading conditions, the friction torque is calculated to be 9.8 inch-lbs. These "required" torque values may seem relatively small in comparison to the overall requirements of the system, but these values are for one bearing only. Gearboxes typically incorporate the use of four or more bearings, each one of which has a friction torque associated with it.

It should be noted that some bearings contain integrated seals or shields, the purpose of which is to maintain lubricant within the bearing and/or to prevent the ingress of foreign matter into the race. Tapered roller bearings may incorporate a Nilos ring for the same purpose. Inclusion of such sealing devices further contributes to efficiency losses since these sealing devices are in direct contact with the rotating race(s) of the bearing.

Effects of Lubricant on Efficiency

For internal gearing, the use of the appropriate lubricant is crucial to obtaining maximum service life and reliability of the gearbox. The function of the lubricant is two-fold: first, it provides a thin film between the internal rotating components, as well as the gear teeth in mesh, thereby preventing direct metal-to-metal contact; and, second, it provides a medium through which heat—developed through normal unit operation—is dissipated.

As noted previously, the type of lubrication utilized in a gearbox plays a role in the overall efficiency of the unit. As the internal gearing moves through the lubricant, the lubricant is continuously displaced by the action of the gears striking it. This is typically known as churning loss, since power that could otherwise be used for the application is absorbed (or required) by this action of the gearing striking, pumping or moving the lubricant. For example, a gearbox lubricated with grease would be less efficient than if it were to be lubricated with oil. Intuitively, this makes sense since grease is typically thicker than oil and requires a greater amount of power to move the gearing through it. Imagine, for a moment, what it would be like to swim in syrup as opposed to swimming in water. Clearly, the thicker media (syrup) would require more personal power to "swim" through.

Another avenue for loss in efficiency specifically related to gearing and lubricant is what is known as windage loss. As the gearing rotates through the lubricant, and then out of the sump, a cer-

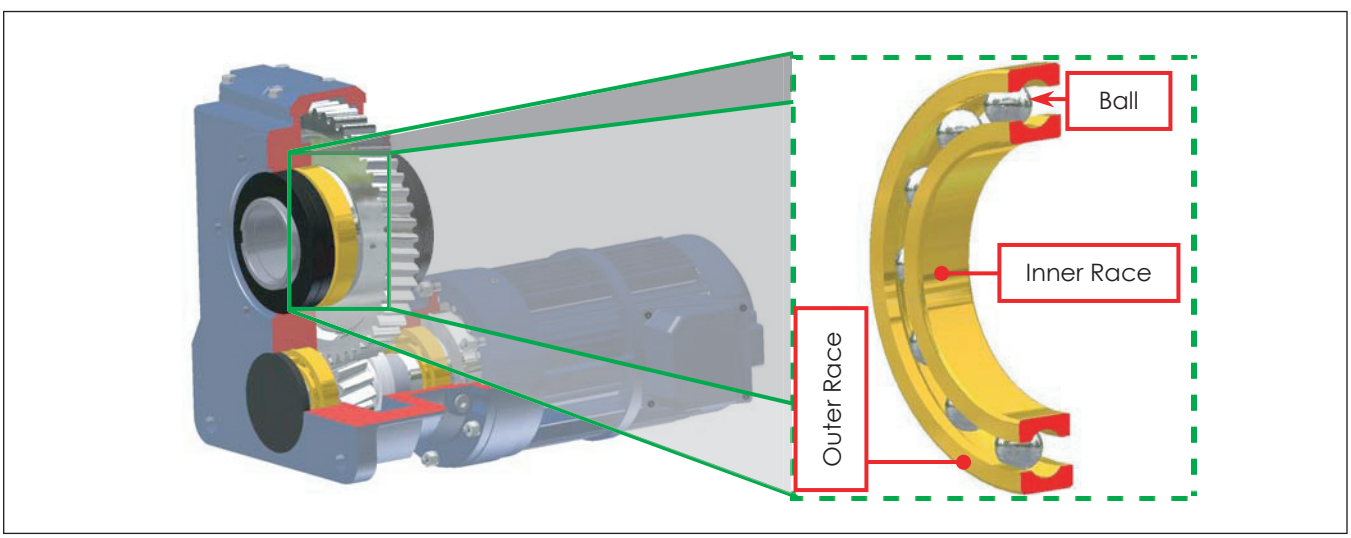


Figure 3—Speed reducer with detail of inner and outer race rings.

tain amount of lubricant adheres to the surface of the gear itself. Since the gear is rotating, centrifugal forces cast the lubricant adhering to the gearing into the enclosed atmosphere of the speed reducer casing. This action may serve to create a lubrication "mist" through which the gearing must pass. In essence, this mist is another barrier for the gear to pass through, thereby requiring (or diverting) power, which otherwise could have been utilized as usable output torque.

To quantify the effects of lubricants on speed reducer efficiency, testing has been conducted by Sumitomo Drive Technologies on a planetary gearbox of a given size and reduction ratio (4:1). This efficiency testing was conducted twice: once with the gearbox lubricated with a grease of NLGI Grade # 2 (a moderately soft grease with the approximate consistency of peanut butter), and again with a grease of NLGI Grade # 00 (a semi-fluid grease with an approximate consistency of applesauce). Other than the lubricant, no other components within the test units were changed. Post-test results revealed that the speed reducer lubricated with the NLGI # 00 grease had an efficiency of 92.1%, whereas the same unit lubricated with the NLGI # 2 grease was 90.9% efficient.

This is not to say, however, that oil lubrication for a gearbox is distinctly preferred over grease. Grease has the advantage in that it may provide for universal mounting of the gearbox (i.e., output shaft vertical up or vertical down), and its replenishment/replacement interval may be longer than a comparably sized oil lubricated unit. And last, grease is less likely to leak through the shaft seals of the unit.

Conclusions

As discussed, many components incorporated into the gearbox construction and its subsequent operation influence the overall efficiency of the speed reducer itself. While the greatest loss in efficiency is typically associated with the interaction of the gears in mesh, other factors and components also serve to influence the overall efficiency of the system.

Speed reducers can be designed to minimize efficiency losses within the product through a variety of means. Utilization of high-quality gearing with superior surface finish on the gear teeth, combined with the incorporation of low-friction seals and bearings, all serve to maximize the power efficiency of enclosed gearing products.

From the point of view of the user (or potential user), perhaps one of the most important factors in selecting a unit is to assure that its efficiency is being optimized for the application. In short, make sure that the gearbox is properly sized for the application. Prior to ordering the speed reducer from the manufacturer, it is imperative that the application power requirements and demands are clearly understood. Utilization of the appropriate service factor for the speed reducer must be taken into consideration and applied. If the gearbox is unnecessarily oversized—i.e., if the power capacity of the gearbox greatly exceeds the power of the applied motor, combined with the application service factor—much of the motor power will be used to overcome the constant losses within the gearbox, thereby leaving little additional, usable power/torque for the application itself. As such, this would be a situation where the speed reducer is yielding a very low efficiency. Conversely, however, a gearbox undersized for an application runs the risk of low life expectancy due to overload conditions, despite a seemingly high efficiency.

Also, follow the manufacturer's recommendation for the correct type of lubricant to be used within the speed reducer, along with its recommended change interval. Be it oil or grease, over time all lubricants lose their effective properties and, due to this, the overall gearbox efficiency stands to decrease over time as well.

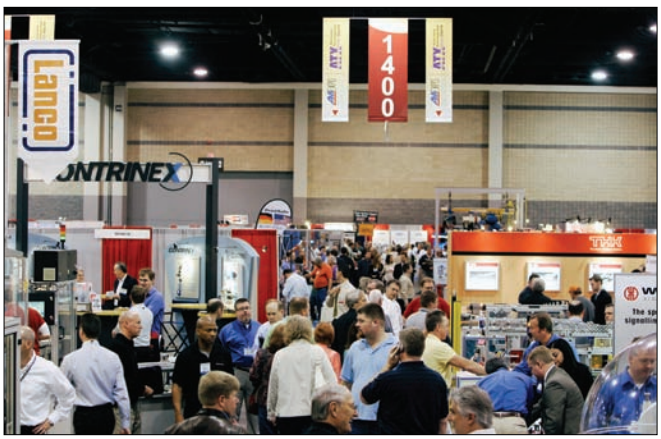
Finally, consider the method by which the gearbox is attached to the driven shaft. Is it possible to couple the output shaft of the reducer directly to the driven shaft? This may be preferred from an efficiency point-of-view, since the use of belts and/or chains generates friction or possibly slippage at their interface, which, in turn, leads to additional efficiency losses.

References

1. *Power Transmission Handbook*, First Edition, 1993.
2. *SKF General Catalog*, Catalog 6000EN, 2005.
3. *Dudley's Gear Handbook*, Second Edition, McGraw-Hill, Inc., 1991.
4. Radial shaft seal information from SKF website—*www.skf.com*.
5. *NTN Ball & Roller Bearing Catalog*, Catalog Number 2200/E, 1990.
6. *Sumitomo Drive Technologies Test Report: TR-G-97020* (08.28.97).

Design and Manufacturing

DRAWS REGIONAL PLAYERS DOWN SOUTH



18,000 attendees are expected to fill the exhibition hall at AM Expo/ATX South to check out the latest automation technology. (Courtesy of Canon Communications.)

Come one, come all. The largest advanced design and manufacturing event in the Southeast, AM Expo/ATX South, is at the Charlotte Convention Center for the second year in a row. The exhibitors are suppliers of custom automation/assembly systems, robotics, vision inspection systems, control software and hardware, sensors, motion control, drives, motors and more. Quality and productivity are the keywords for manufacturers investing in the latest automation to stay competitive.

"This once-in-a-generation economy that we are in has created an urgent need for manufacturers to make improvements to their processes and business models," says Peter DiLeo, Canon Communications group marketing manager. "Attendees to AM Expo/ATX South will find that it is a buyers' market, and suppliers will be sharper and more competitive than ever with their products and services. Now is the time to make their business stronger and more profitable, and the number one reason for buying equipment is cost reduction."

The attendees will include production and manufacturing managers, packaging and process engineers, engineering managers, project managers, design engineers, operations managers, purchasing staff and corporate managers.

Charlotte was chosen for the show because there are more than 15,000 manufacturing outlets in the region, which annually produce $240 billion in manufacturing output, according to show organizer Canon Communications. Organizers received much positive feedback from the previous year. "Charlotte and the Charlotte Convention Center are very convenient to get to—far more so than Atlanta was the year before," DiLeo says. "It is also convenient for the attendees from South Carolina, where many past/loyal visitors are from due to the show being there for so many years."

The entire event comprises six shows—SouthPack, Design and Manufacturing South, PLASTEC South, Green Manufacturing Expo and two new additions: MetalTec and Plant Engineering South. Attendees are free to wander more than 700 exhibiting companies using over 120,000 net square feet of exhibit space. One badge provides access to all the shows, and conference admission is open to any of the sessions.

A new feature to the show in 2009 is the Lean Factory,

FANUC robotic equipment in action. (Courtesy of Canon Communications.)

which consists of demonstrative, educational sessions that are free with the expo hall admission. Some of the topics discussed include the importance of a data-driven approach to line design, the need to create an environment that supports lean with the right equipment and infrastructure and the tools to create a visual factory. Demonstrations include a step-by-step creation of a utopian lean production environment and a build display on an optimum lean line. The Lean Factory is produced by Bosch Rexroth, Orgatex, Leonardo Group Americas and Automation Technology. Interested attendees are recommended to reserve a space on the show website, *www.AM-Expo.com*.

Lean manufacturing is an overarching theme present in each of the conference sessions. "Lean manufacturing is the number one requested conference session at all our shows," DiLeo says. "In these tough economic times, nearly one-third of manufacturing facilities will dedicate resources to implement lean manufacturing in 2009. At our flagship assembly event, Assembly Technology Expo, September 22–24, 2009 in Rosemont, IL, we will have nearly 40 sessions addressing all facets of lean manufacturing."

The Advanced Manufacturing Expo and Conference/ Automation Technology Expo South takes place March 11–12, 2009 at the Charlotte Convention Center. For more information, visit *www.AM-Expo.com* or call (310) 445-4200.

One show onlooker pauses to inspect vacuum technology on display by PIAB. (Courtesy of Canon Communications.)

calendar

February 17–19—Expo Manufactura. Cintermex, Monterrey, Mexico. This international manufacturing trade show is Mexico's rendition of IMTS in its 14th installment. The event includes more than 350 companies, representing over 600 brands from around the world. 8,500 professionals are expected to attend in search of equipment, machinery, processes and solutions for industries that include automotive, aeronautical, electrical appliance and medical devices. A conference program includes keynote speeches, seminars, presentations and manufacturing solutions on Six Sigma practices and other efficiency standards. For more information, visit *www.expomanufactura.com.mx*, or contact Shane Poblete at (301) 493-5500.

February 24–26—Houstex 2009. George R. Brown Convention Center, Houston. Organized by the Society of Manufacturing Engineers, this event looks to stimulate ideas, expertise and business connections in manufacturing technology. On showcase will be advanced machine tools and production systems for industries including energy, medical and aerospace. An advanced technology conference will address "Manufacturing Processes for Oil and Gas." Houstex is co-located with the International Pump Users Symposium, and attendee badges provide full access to both shows. For more information, visit *www.sme.org/houstex*.

March 3–4—Motor, Drive and Automation Systems Conference. The Walt Disney World Resort in Orlando, FL. This two-day conference is focused on the latest advancements and economics in electric motor, drive automation and power systems efficiency and technology. The topics include new motors, drives and automation systems, system design and integration for optimum performance, power systems efficiency & power electronics technology, new components & materials, advancements in electronics and control, testing systems and techniques. The sessions will also cover market and financial aspects such as supply and demand pricing for motors, drives, controls, materials and components as they relate to total system economics. The conference is intended for OEM design engineers and product developers that integrate motors, drives and automation systems into their products and equipment; developers and manufacturers of motors, drives and integrated systems; component, material and technology providers. For more information, visit *www.e-driveonline.com*.

March 9–12—AGG1 Aggregates Forum & Expo. Orange County Convention Center, Orlando, FL. AGG1 Aggregates Forum & Expo focuses exclusively on the aggregates industry and features industry-focused educational programming and exhibits showcasing the latest technologies and innovations in aggregates-related equipment, products and services. AGG1 is geared to the decision makers and buyers from the companies that produce crushed stone, sand and gravel in the marketplace, including company owners, senior managers, plant managers, superintendents, regional managers, engineers, technical professionals and safety managers. The expo is co-located with the World of Asphalt 2009, and product pavilions include environment, safety and health; dredging; finance/lease; testing; and information technology. More than 400 exhibitors will span 100,000 net square feet of space, and 6,000 visitors from around the world are expected to attend. The exhibits display a wide range of aggregate-related equipment, products and services, and some incorporate demonstrations and technology. For more information, visit *www.agg1.org*.

April 20–24—Hannover Messe. Hannover Fairgrounds, Hannover, Germany. The 2009 Hannover Messe comprises 13 trade shows: INTERKAMA; Factory Automation; Industrial Building Automation; MDA - Motion, Drive & Automation; Digital Factory; Subcontracting; Energy; Wind; Power Plant Technology; ComVac; Surface Technology; MicroTechnology; and Research & Technology. This is the first year the event includes the Wind fair, and it is set to take place every two years. About 2,000 congresses, discussion forums, seminars and workshops take place, including a world energy dialogue, which will focus on sustainable future energy supplies. For more information, visit *www.hannovermesse.de*.

April 27–30—International Fastener and Precision Formed Parts Manufacturing Exposition and Conference I-X Center, Cleveland, OH. This four-day event attracts buyers looking for the latest in equipment, products, systems and services for bringing fasteners and precision formed parts to customers. IFE is co-located with Interwire, the largest wire and cable event in the United States, sponsored by Wire Association International. All attendees can attend the complimentary conference program consisting of seminars on the newest technology, application studies and industry developments. Between the two events, more than 600 exhibitors are anticipated to span 150,000 square feet. For more information, visit *www.ifetradeshow.com* or e-mail *info@ifetradeshow.com*.

Meyer

APPOINTED PRESIDENT OF THOMSON

Ron Meyer

Ron Meyer is now president of Thomson, a Danaher Motion company. Meyer is responsible for driving the strategy and management of Thomson's facilities in North America, Europe and Asia. He first started with Danaher Corporation in 1997 as the president of Qualitrol, and he is maintaining his previous responsibilities for Qualitrol's business. Meyer will be based out of his Fairport, NY office. He has a bachelor's degree and a master's degree from the University of Minnesota.

"Over the past 10-plus years, Mr. Meyer has exhibited strong leadership skills reflecting Danaher's core principles. Under his leadership, Qualitrol has continually provided innovative solutions to their customers resulting in consistent, profitable business growth," says Dan Daniel, executive vice president for Danaher Corporation. "He is a champion of the Danaher Business System, resulting in excellent on-time delivery, quality and innovation. And under his leadership, Qualitrol has successfully integrated a number of strategic acquisitions that enabled the company to evolve into a global business that continually delivers customer value."

New Way

INTRODUCES NATIONAL SALES MANAGER

Clark Coulston has been appointed national sales manager for New Way Air Bearings. Coulston has more than 15 years of experience in the automation and motion control industries, mostly as a field sales engineer for fluid power and motion control components at Rankin Automation.

Coulston is responsible for developing, supporting and expanding the scope and capabilities of the domestic distribution channel at New Way. The entire sales group at New Way will be able to provide more-focused support for international customers and channel partners.

Coulston has already added high-level distributors in parts of the United States that previously lacked coverage. Along with Tim Claffey, vice president of sales, Coulston helped organize New Way's first international sales meeting, where representatives from around the world convened at the Aston, PA headquarters for training and information.

"The addition of Clark to head up our sales channel here in the U.S. will be a great benefit to our current customers, distributors and future customers. Clark will have an immediate impact on the business," Claffey says. "He fits in well with our internal team and is also well received by our distribution channel. Expanding the New Way family of sales representatives and focusing on assisting the current sales base will be his top priority. Putting more effort into helping support our sales channel is overdue, and Clark will help them spread the word about air bearing technology."

Clark Coulston

Bonfiglioli

ANNOUNCES PRESIDENT

Greg Schulte has been appointed president of Bonfiglioli USA. Schulte has held numerous positions in the power transmission distribution market and planetary gear industry over the past 15 years. He previously served as Bonfiglioli USA's vice president of sales. He was also sales manager of the mobile solutions division, where he exceeded the company's ambitious growth strategy.

In five years, Bonfiglioli USA's sales grew by more than 1,000 percent with Schulte at the helm. He received a bachelor's degree in business management and an associate's degree from The Ohio State University.

Vacon Sales Office

OPENED IN SOUTH KOREA


Jae Kyn Lee

A subsidiary of the global AC drives manufacturer Vacon started operations on January 1 in Seoul, South Korea. The sales office serves distributors and partners in the East Asian market, where Vacon intends to increase its market share.

"Establishing a subsidiary in South Korea is a part of our global strategy and profitable growth program," says Heikki Hiltunen, executive vice president of Vacon. "Within the framework of this program, we have been increasing the number of Vacon offices globally in the recent years. This allows us to offer the best possible service and to find new partners."

"Vacon has for many years been partnering with a local brand label customer and with several local distributors, and the partnerships with them will continue in the future," says Jae Kyu Lee, managing director of Vacon's South Korea subsidiary. "Our goal is to support our present partners and expand our business in cooperation with them in East Asia.

"Local presence also provides us with better opportunities to conquer new markets among OEM customers, who require highly advanced AC drives know-how. Our main segments in South Korea will be the marine and offshore industry, cranes and the metal and chemical industries."

Altra

APPOINTS ENGINEERED COUPLINGS GROUP VP

Mark Klossner was appointed vice president and general manager of the Altra Engineered Couplings Group, according to Carl Christenson, Altra's president and COO. Klossner joined Altra in 2004 as a strategic marketing analyst, and he was promoted to strategic marketing manager and concentrated on improving Altra's electromagnetic clutch/brake (ECB) business platform. In October 2006, Klossner was named managing director for the Matrix International business group in Brechin, Scotland.

"I am extremely excited to be part of the largest provider of couplings in the world. Altra Engineered Couplings has tremendous opportunities to better serve the market by more closely integrating our diverse product offerings, knowledgeable design and application teams and our global manufacturing organizations," Klossner says. "With brands such as TB Wood's, Bibby Transmissions, Ameridrives Couplings and Ameridrives Power Transmission, Altra Engineered Couplings brings together a wide range of industry leading brands, products and solutions under one structure enabling us to better meet the needs of the market."

ICS Triplex

WINS INNOVATION IN TECHNOLOGY AWARD


Allan Rentcome

AADvance, a safety and critical control solution from ICS Triplex, a Rockwell Automation company, won the InTech award for Innovation in Technology, presented by ISA. The award judges the innovation a new product offers compared to other similar ones, leading-edge technology utilized, originality, reliability and cost.

AADvance is designed to bring customers high availability and reliability. It is scalable in size, safety and fault tolerance. The system provides centralized control over plant-wide safety management routines.

"We are delighted to accept this award and are thrilled to have won the Innovation in Technology category," says Allan Rentcome, CTO for ICS Triplex. "ICS Triplex prides itself on developing leading-edge technology, and we are always trying to push the boundaries. We put a great deal of resources into R&D, and this award proves that our engineering experience is second to none."

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Who Needs a Social Life When You Can Mine the Moon?

Dust, soil broken rock and other related materials that blanket planetary surfaces—known as regolith—have great potential to contribute to space observation research, but the physical properties of lunar regolith are unique and very difficult to excavate from a technical perspective. A group of students at the Missouri University of Science and Technology, dubbed the Lunar Miners, decided to step up to the plate—that is, by entering the 2008 NASA Regolith Excavation Challenge.

"We entered this design competition to put the knowledge and skills we learned in the classroom to use in a real world simulation," said Joel Logue, a member of the Lunar Miners team from Missouri S&T. "By participating in such events, we want to prove to ourselves and to others that the young engineers of today can compete and challenge the engineers and the scientists in industry who have many years' more experience than we do."

In alliance with the NASA Centennial Challenges Program, the Regolith Excavation Challenge, co-hosted by the California Space Education Workforce Institute (CSEWI), California Space Authority (CSA) and California Polytechnic University in San Luis Obispo promotes new technologies to excavate lunar regolith. The 2008 prize purse stood at $750,000.

Logue's teammate, Masafumi Iai, described the group's machine, referred to as a Binary Autonomous Continuous Excavation System (BACES). "This mobile unit is powered with a pair of small motors driving two, custom-fabricated tank-like tracks. One mobile base carries the excavation conveyor that can be driven into the regolith with another motor for higher pressure and greater performance capability. The excavated regolith is carried to the back of the machine, where it's transferred onto an expandable transportation conveyor suspended between the two mobile bases. The remaining mobile base seeks the collector bin and serves as an anchor and offloading point for the regolith. The unique part of our robot is that the excavation process is completely continuous. This continuous process has been found to be the most efficient method in the mining industry."

Team leader Cory Smith stressed the extensive time devoted and money that came out of their pockets. "We spent countless hours in this machine shop," Smith said. "We would usually start on Saturdays at noon and probably wouldn't go home until two or three in the morning, and then the same thing on Sundays. We rarely took breaks."

The project required a variety of structural and motion control components, including axle shaft, drive chain, gears and bearings. The Lunar Miners received some financial help from an alumni association, and Misumi supplied them with shaft bearings, chain and gears. "The fact that on their website they have CAD models of every part they stock helped immensely because we could import them directly into our model and find out what worked."

The realization that the machine wouldn't be completed in time to compete in California came about two months before the big day in August. Twenty-five teams registered for the challenge, only 16 teams traveled to San Luis Obispo to compete, and all but eight withdrew due to last-minute mechanical and logistical problems. "We still completed parts of it even though we knew it wasn't going to work," Smith says.

Joel Logue (bottom) attaches the excavation scoops to the BACES machine's supports on the excavation chain. The machine in its entirety is pictured (top). (Courtesy of Misumi.)

Smith has heard buzz of participating in the 2009 competition, but nothing official on this note. Details of what next year's challenge will consist of have not yet been released by the California Space Authority.

The group received no technical assistance and no school credit for the project. Smith said his social life and grades suffered due to the project, but when asked if he would do it all over again, he didn't have to think twice before responding, "definitely."

"It consumed so much of my time, but it was so worth it," Smith says.

"It took a long time, and I'll never forget it. It's so memorable to tell someone 'Hey, I entered a robot in a NASA challenge'…It's just way fun."

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